Engineering Science and Technology, an International Journal ■■ (2016) ■■–■■

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Contents lists available at ScienceDirect

Engineering Science and Technology, an International Journal

journal homepage: http://www.elsevier.com/locate/jestch

Full Length Article

Transition region based single and multiple object segmentation of gray scale images

Priyadarsan Parida *, Nilamani Bhoi

Department of Electronics & Telecommunication Engineering, Veer Surendra Sai University of Technology (VSSUT), Burla, Odisha 768018, India

ARTICLE INFO

Article history:
Received 16 October 2015
Received in revised form
22 December 2015
Accepted 26 December 2015
Available online

Keywords:
Global threshold
Local variance
Transition regions
Region filling

ABSTRACT

Transition region based image segmentation has proved to be the simple and effective image segmentation technique. However, the methods have two shortcomings. First, they are applied mostly for image segmentation containing a single object. Second, the methods are effective only when the images contain simple background and foreground. The performance deteriorates when background and foreground are textured or of varying intensities. To overcome this, a novel method has been proposed for multi-object segmentation. In this method, a global threshold and the local variance is computed to achieve the transition regions. The transition regions thus obtained undergo morphological operations to get the object contours. The morphological filling operation is employed on object contours to extract object regions. Finally, the objects are extracted from the image from these object regions. The proposed method is compared with different methods for single-object segmentation, and experimental results show superior performance. The method also works efficiently for multiple object segmentation.

Introduction

Image segmentation is still a challenging problem in image processing and computer vision where segmented image undergoes further processing such as feature extraction, texture analysis and content based image retrieval [1,2]. It is an important pre-processing technique for extracting an object (foreground) from background based on some characteristics such as gray level, color, texture, etc. The existing image segmentation techniques can be classified into different types of approaches such as thresholding based approach [3,4], boundary based approach [5,6], region based approach [7,8] and hybrid approach [9–12]. Image segmentation by thresholding is the simplest technique, where there is an assumption that the objects and background in an image have distinct gray level distributions. This implies that the distributions have two or more distinct peaks and thereby a threshold can be used to separate the peaks. Thus, the segmentation can be performed by assigning regions having gray levels above the threshold as background and the region having gray levels below the threshold as objects or vice versa. Boundary-based or edge-based segmentation, extracts the transition zones, edges or boundaries of the images which separate the object from the background. Region-based segmentation algorithms operate iteratively by grouping together pixels which are neighbors and have similar values [13], and spitting groups of pixels (region splitting) [14] which are dissimilar in values or a combination of both (region splitting and merging) [15]. Hybrid image segmentation methods focuses on combining two or more approaches to achieve better segmentation. Transition region-based thresholding is a kind of hybrid approach for image segmentation in recent years [16–21]. It is a hybrid of region based and thresholding based method. The existence of transition region is demonstrated by Gerbrands [16] for the first time. Zhang et.al [17] proposed transition region based image segmentation where, effective average gradient (EAG) is applied as transition region descriptor. This method has limitation that it only reflects sudden gray level changes but not frequent gray level changes and therefore, not suitable for complex images. Also, gradient based method is much sensitive to noise. The descriptor EAG cannot extract transition region for an incorrect gray level interval as demonstrated by Groenewald et al. [18]. In order to overcome the limitation, the local entropy (LE) [19] based transition region extraction is proposed. However, the LE method has some disadvantages. One is in some real images, in a neighborhood if there are frequent gray level changes, it will increase the local entropy of the neighborhood and identify the pixel belonging to transition region though it belongs to foreground or background region. Another is high computational complexity because it involves many multiplications and logarithmic operations. To elevate, these drawbacks, Li et.al developed a novel local gray level difference (LGLD) [20] based transition

* Corresponding author. Tel.:+91 9861412884, fax: +0663 2430204.
E-mail address: priyadarsan.vssut@gmail.com (P. Parida).
Peer review under responsibility of Karabuk University.

http://dx.doi.org/10.1016/j.jestch.2015.12.009

Please cite this article in press as: Priyadarsan Parida, Nilamani Bhoi, Transition region based single and multiple object segmentation of gray scale images, Engineering Science and Technology, an International Journal (2016), doi: 10.1016/j.jestch.2015.12.009

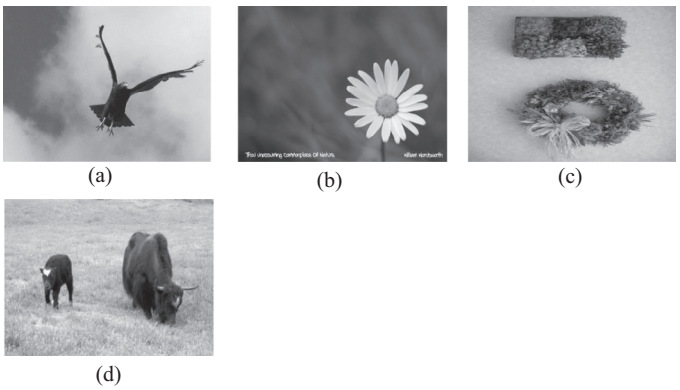

Fig. 1. Original gray images: (a) Eagle, (b) Flower, (c) Wall decor, (d) Yak.

region extraction method. In the method, it is found that gray level difference not only considers gray level change of transition regions but also takes the extent of this change into account. However, the selection of a parameter to determine the threshold is a great issue of the method LGLD. Later, a modified local entropy method (MLE) [21] is presented to improve the performance on transition region extraction and thresholding. Here, also both frequency and degree of gray level changes is taken into account to determine the threshold. The method MLE depicts the gray level changes more comprehensively as compared to LE and LGLD. But this method also suffers from suitable parameter selection to determine the thresholds for extraction of transition region. It is also noticed that weighted coefficient of local variance is usually larger than that of local complexity [21].

The transition region based methods LE, MLE and LGLD work efficiently for single object segmentation when images consist of simple background and foreground (object). These methods do not perform well when either or both background and foreground are textured or of varying intensities. The performances of these methods are also not satisfactory when applied on images containing multiple objects. So, a novel method is proposed using the transition region which overcomes the disadvantage lies in the former transition region based methods. The method can separate single as well as multiple objects from the background effectively.

The proposed method, along with other methods, is tested on some images having simple/texture foreground and background. The images: Eagle, Flower, Wall decor and Yak on which segmentation is performed are taken from MSRA [22] and Weizmann [23] database. Fig. 1 shows the original images, and Fig. 2 shows the segmented results of different methods. It can be seen from Fig. 2 that the proposed method can separate the foreground(s) from background effectively as compared to other methods.

The proposed algorithm

The proposed algorithm performs the segmentation task in five steps. First, it extracts the transition region considering local variance using global threshold. As the transition region is more than one pixel width, it is applied with thinning operation to extract the edges which is of single pixel width. The edges are discontinuous and hence undergo edge linking process to achieve continuous edge (object-contours). Next, the morphological filling operation is employed on object contours to find the object regions. Finally, the object regions are separated from the background in the original gray image using these object regions.

1.1. Extraction of transition regions

The proposed method begins with extraction of transition region. Transition region is geometrically located between object and background, and composed of pixels having intermediate gray levels between object and background [24]. Many descriptors [19–21] have been developed for extracting transition regions. It has been shown

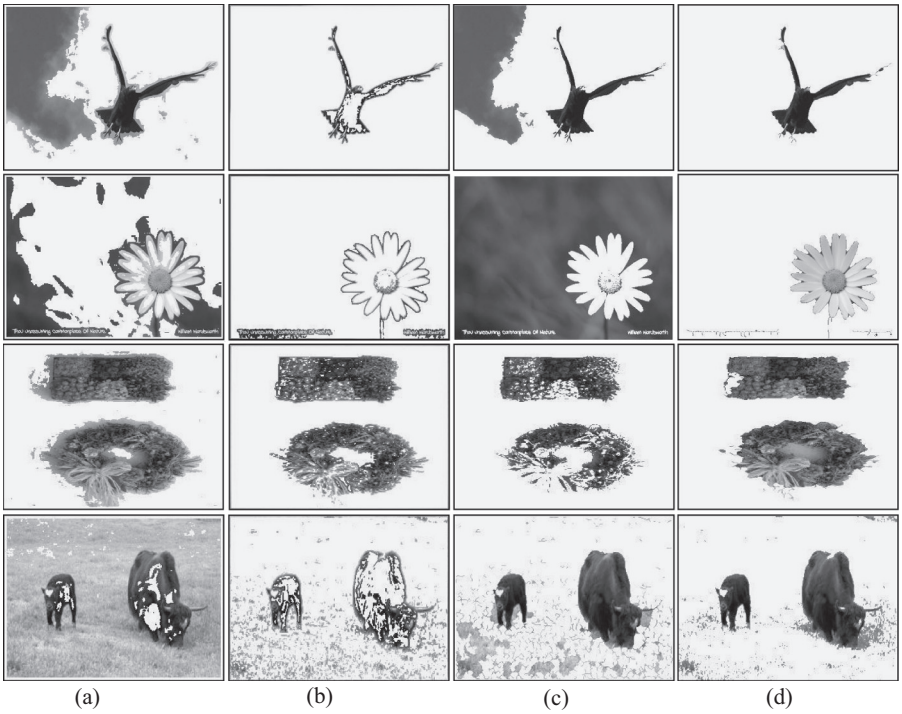

Fig. 2. Segmentation results of different transition region based methods applied on the images Eagle, Papaya, Wall decoration, Yak: (a) LE (b) MLE (c) LGLD (d) Proposed.

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