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Wavelet based transition region extraction for image segmentation

Priyadarsan Parida*, Nilamani Bhoi[1]

Department of Electronics & Telecommunication Engineering, Veer Surendra Sai University of Technology, Burla 768018, Sambalpur, India

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Abstract

Transition region based approaches are recent hybrid segmentation techniques well known for its simplicity and effectiveness. Here, the segmentation effectiveness depends on robust extraction of transition regions. So, we have proposed a transition region method which initially decomposes the gray image in wavelet domain. Two existing transition region approaches are applied on approximate coefficients to extract transition region feature matrix. Using this feature matrix the corresponding prominent wavelet coefficients of different bands are found. Inverse wavelet transform are then applied on the modified coefficients to get edge image with more than one pixel width. Otsu thresholding is applied on it to get transition regions. Further, morphological operations are applied to extract the object regions. Finally, the objects are extracted using the object regions. The wavelet domain approach extracts robust transition regions resulting in better segmentation. The proposed method is compared with different existing image segmentation methods. Experimental results reveal that the proposed method achieve 0.95 overall segmentation accuracy. It also works well for extraction of single as well as multiple objects from images.

Keywords: Transition region; Otsu thresholding; Wavelet transform; Edge linking

1. Introduction

Image segmentation is an important pre-processing step for all computer vision and image understanding tasks. It has wide range of applications such as biometrics [1], medical image analysis [2], crop disease detection and classification [3] etc. Image segmentation is the process of separating the object (foreground) from background considering certain features of image such as colour, intensity, texture etc. In the past decade, a wide variety of segmentation techniques are available in literature. In recent era a number of hybrid segmentation techniques have been emerged which provide better segmentation results in comparison to that of the traditional methods. These hybrid segmentations are classified as model based segmentation approaches [4,5], machine learning approaches [6], graph-cut methods [7], active contour and level set methods [8−10] and transition region based approaches [11−18]. In model based approaches, the image is characterised by a statistical model and the model parameters are used as features for segmentation [19]. The machine learning process is basically a training process where a network is trained to optimize the weights of the network from training features of images like texture, brightness etc. After training, the network is presented the query image and it performs classification based segmentation from the tuned weights and learned weights [6]. Graph cut based approaches consider the image as a weighted graph with nodes and vertices, where nodes represent pixels or voxels and vertices represent neighbourhood relationship between pixels. A cost function which represents the cut is optimal in the sense that it effectively separates the object from the background [7]. Active contour based approaches deform its shape in the presence of

* Corresponding author. Fax: +06632430204
E-mail addresses: priyadarsan.vssut@gmail.com (P. Parida), nilamanib@gmail.com (N. Bhoi).
[1] Fax: +06632430204.
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external and internal forces leading the contour towards object [8]. In edge-based active contour methods image gradient is used to detect object boundaries [9] whereas region-based active contours use the object and background regions to find an energy optimum where the model fits the image to its best [10]. Level set methods usually make use of an edge indicator to pull the zero level set in the direction of the desired object boundaries [8]. Transition region based methods [11−18] uses transition region for segmentation of images. In local entropy (LE) based method [13] the entropy of a neighbourhood is considered to determine the transition region. It has a limitation that in the event of frequent changes in gray level in a local area, it increases the local entropy and the pixels in the neighborhood is identified as the transition region and it belongs to the foreground or the background. To overcome these disadvantages, Li et al. [14] developed a method for local extraction of the transition region based on the gray level difference (LGLD) which takes into account both changes in gray levels and the extent of these changes. However, the parameter selection unit for determining the threshold value is a problem. The modified local entropy method (MLE) [15] was then put in place to improve the extraction of the transition region. This method also suffers from the same problem as in LGLD. These techniques are ineffective when the foreground and background are of varying intensities. Furthermore, these are mainly used for images that contain a single object. A recent transition region based method named robust single-object image segmentation (RIB) proposed by Zuoyong Li et al. [16] is based on salient transition region provides good segmentation results. But, it only applies to images that contain a single object. In order to mitigate the limitation, Parida et al. [17] proposed local variance and morphological operator based method to yield better performance for both single and multiple object segmentation. In this method the images are categorized into four classes based on whether the background and foreground are simple or textured. The performance of the method degrades when the method is applied on images with (i) textured background and (ii) overlapping gray levels between foreground and background. In order to improve the performance, Parida et al. [18] proposed a novel method using 2-D Gabor filter for transition region. This method works well for overlapping gray levels between background and foreground. The method is unable to perform well when the image contains textured background. Also, it has been found that the proposed method [18] cannot outperform Parida et al. [17] when both the background and foreground are simple. Fig. 3 show the transition regions extraction in the wavelet domain. Fig. 4 shows the segmented output by various methods. From Fig. 4 (d) it is evident that the output is better as compared to other methods. So far the transition region based techniques developed do not perform well when both foreground and background are textured. So, we have proposed a method which overcomes the aforementioned disadvantages. Hence, a method can be developed by taking the common transition region by Refs. [17,18]. The method will work for different types of images in wavelet domain but unable to perform well for images with textured background and foreground as methods [17,18] give inferior

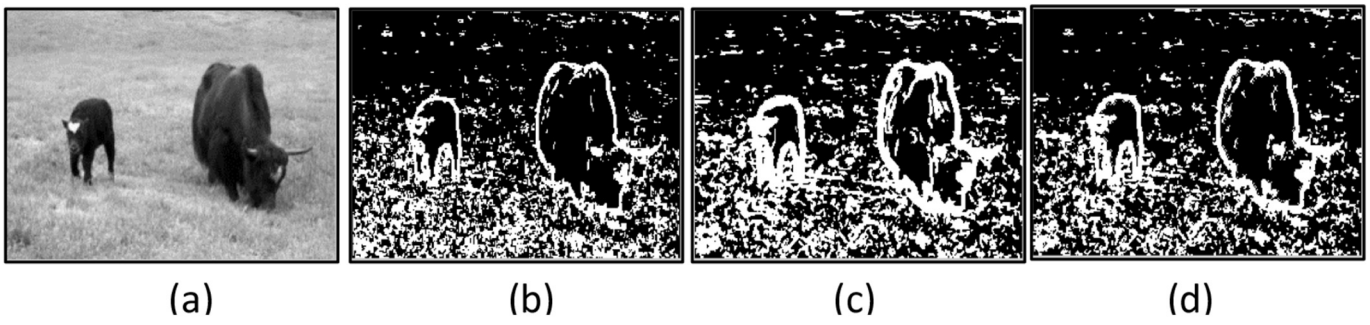

Fig. 1. Transition region extraction of Yak image in spatial domain: (a) Original image, (b) Parida et al. [17], (c) Parida et al. [18], (d) Intersection of (b) and (c) in spatial domain.

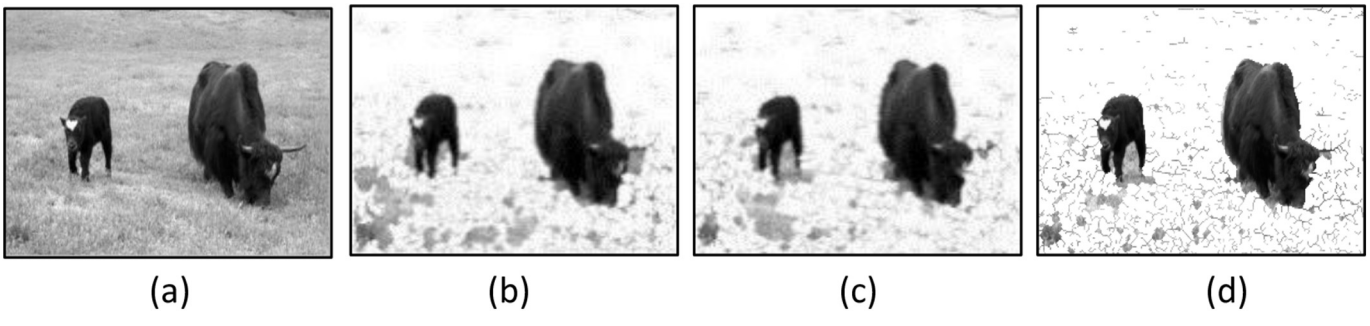

Fig. 2. Segmentation result of Yak image for various methods: (a) Original image, (b) Parida et al. [17], (c) Parida et al. [18], (d) Intersection of (b) and (c) in spatial domain.