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Chapter XIV

Review of Fuzzy Image Segmentation Techniques

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This chapter provides a comprehensive overview of various methods of fuzzy logic-based image segmentation techniques. Fuzzy image segmentation techniques outperform conventional techniques, as they are able to evaluate imprecise data as well as being more robust in noisy environment. Fuzzy clustering methods need to set the number of clusters prior to segmentation and are sensitive to the initialization of cluster centers. Fuzzy rule-based segmentation techniques can incorporate the domain expert knowledge and manipulate numerical as well as linguistic data. It is also capable of drawing partial inference using fuzzy IF-THEN rules. It has been also intensively applied in medical imaging. These rules are, however, application-domain specific and very difficult to define either manually or automatically that can complete the segmentation alone. Fuzzy geometry and thresholding-based image segmentation techniques are suitable only for bimodal images and can be applied in multimodal images, but they don't produce a good result for the images that contain a significant amount of overlapping pixels between background and foreground regions. A few techniques on image segmentation based on fuzzy integral and soft computing techniques have been published and appear to offer considerable promise.

INTRODUCTION

The usage of digital images is increasing rapidly due to quick development of Internet and multimedia technologies, so the recent research interests are being directed towards the fields of digital image processing. There are various types of digital images, as they are generated from the diverse fields of application. Most commonly used are light intensity (LI) images, range images (RI), computed tomography (CT) images, thermal images and magnetic resonance image (MRI). Image segmentation can be defined as the process for separating the mutually exclusive homogeneous interested region(s) from other regions of an image. Image segmentation is becoming an active and promising field of research since it is the most challenging and difficult task of image processing and computer vision systems. Much research to date has been done in this field, but it is highly dependent on the type of image, its dimension and its applications. None of them is suitable for all types of images. Image segmentations are being extensively used in the various types of applications such as automatic car assembly in robotic vision, airport identification from aerial photographs, object-based image identification and retrieval, object recognition, second-generation image coding, criminal investigation, computer graphic and medical science (cancerous cell detection, segmentation of brain images and intrathoracic airway trees, etc.) (Phan and Prinle, 1999; Pal and Pal, 1993).

Image segmentation may be achieved in a large variety of ways. Generally it is divided into two approaches: region-based approach and boundary or contour-based approach (Ballard and Brown, 1982; Chakrabotry, Staib and Duncan, 1994). The first one uses the homogeneity of the pixel or features while the later one finds the contour or the boundary of the interested region. The two types of contours mainly used are: active contours (Kass, Witkin and Terzopoulos, 1988; Cohen and Cohen, 1993; Ronald, 1994; Caselles, Kimmel and Shapiro, 1995). and deformable contours (Chakrabory et al., 1994; Grzeszczuk and Levin, 1997; Grzeszczuk and Levin, 1993).

Haralic (1985) divided the image segmentation techniques into four classes: measurement space guided spatial clustering, region growing (single linkage, hybrid linkage and centroid linkage region growing approaches), spatial clustering, and split and merge. Measurement space guided spatial clustering assigns each pixel a label of a cluster of the measurement space in which it feels right. The pixels bearing the same label are treated as the connected component and in the same class. Generally clustering and histogram mode-seeking techniques are used in this approach. This method does not work well when the gray label intensity of an object in the interest of segmentation varies extensively and the background is not uniform. In region growing the image is divided into some regions. The gray level intensity variation of all the pixels of a region lies within the limit of the specified threshold. The region is grown by taking a pixel as a starting point and then adding all pixels into the region whose gray level intensity variation lies within the selected threshold (Reid, Millar and Black, 1997). This technique is expensive in terms of computation and memory (Moghaddamzadeh and Bourbakis, 1997). The single linkage region growing approach uses the graph theory to segment the image. Each vertex of the graph represents each pixel of the image. Pixels containing similar characteristics are connected by the links of the graph. This approach suffers from the problem of chaining. If the chain cuts, it loses all the pixels of the other part. Hybrid linkage region growing approach allocates a property vector to each pixel, which is a function of its kxk neighborhood values. One of the hybrid linkage approaches used information on the edges to connect the link, but this depends on the edge detection method used. In the centroid linkage region growing approach, the image is first scanned and then a region is formed by comparing the pixel value with the mean of that region. Pixels are added into the region if they are close enough and then update the mean of the region. The similar regions (if any) are merged. The effectiveness of this approach depends on the combing criteria. The spatial clustering approach forms the cluster by considering both the measurement space as well as spatial space between the parent pixels and their neighbors. Initially, split and merge approach assumes the image as one segment and then divides the image into some subdivisions (number of subdivision=4^n where

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