2009 International Conference on Advances in Recent Technologies in Communication and Computing

Image Segmentation - A Survey of Soft Computing Approaches

N. Senthilkumaran* and R. Rajesh†

School of Computer Science and Engineering
Bharathiar University, Coimbatore - 641 046, India.
*senthilkumaran@ieee.org
†kollamrajeshr@ieee.org

***Abstract*—Soft Computing is an emerging field that consists of complementary elements of fuzzy logic, neural computing and evolutionary computation. Soft computing techniques have found wide applications. One of the most important applications is image segmentation. The process of partitioning a digital image into multiple regions or sets of pixels is called image segmentation. Segmentation is an essential step in image processing since it conditions the quality of the resulting interpretation. Lots of approaches have been proposed and a dense literature is available In order to extract as much information as possible from an environment, multicomponent images can be used. In the last decade, multicomponent images segmentation has received a great deal of attention for soft computing applications because it significantly improves the discrimination and the recognition capabilities compared with gray-level image segmentation methods. In this paper, the main aim is to understand the soft computing approach to image segmentation.**

***Index Terms*—Image Segmentation, Fuzzy logic, Genetic Algorithm, Neural Network.**

I. Introduction

The process of partitioning a digital image into multiple regions or sets of pixels is called image segmentation[1][2]. Actually, partitions are different objects in image which have the same texture or color[3]. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image[1]. All of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture[4]. Adjacent regions are significantly different with respect to the same characteristics[3].

This paper is organized as follows. Section II is focused on showing the different approaches of soft computing for image segmentation. Section III presents the conclusion for soft computing approaches to image segmentation.

II. Soft Computing Approaches

Three different soft computing approaches to image segmentation which are most frequently are used for comparison. These are (1) Fuzzy based Approach [2][7], (2) Genetic Algorithm based approach[6][2][10] and (3) Neural Network based Approach [4][8]. The details of Approaches as follows,

A. Fuzzy based Approach

The different theoretical components of fuzzy image processing provide us with diverse possibilities for development of new segmentation techniques[1]. The different fuzzy approaches to image segmentation are Fuzzy Clustering Algorithms[2], Fuzzy Rule-Based Approach[3], Fuzzy Integrals[7],Measures of Fuzziness, image information and Fuzzy Geometry[8].

Fuzzy set theory gives a mechanism to represent ambiguity within an image[2]. Each pixel of an image has a degree of belongingness (membership) to a region or a boundary[7]. A number of fuzzy approaches for image segmentation are reported in[8]. Kanchan proposed an unsupervised algorithm for color image segmentation[3].

A fuzzy entropy is a function on fuzzy sets that becomes smaller when the sharpness of its argument fuzzy set is improved[7]. The notion of entropy, in the theory of fuzzy sets, was first introduced by Luca and Termini[1]. There have been numerous applications of fuzzy entropies in image segmentation[2].

Based on the idea of Zhao, a new three-level thresholding method for image segmentation[7]. The image is partitioned into three parts, namely dark, gray and white part, whose member functions of the fuzzy region are Z-function and P-function and S-function respectively[2]. The width and attribute of the fuzzy region can be decided by maximum fuzzy entropy, in turn the thresholds can be decided by the fuzzy parameters, for getting optimal thresholds, and to find the optimal combination of all the fuzzy parameters[1]. Thus, the segmentation problem can be formulated as an optimization problem. The fuzzy entropy of the image has been chosen as the objective function[7].

One approach in designing such a fuzzy system is an expert to look at training data and try to manually develop a set of fuzzy rules[1]. Two drawbacks with such method are that first it is very cumbersome and time consuming and second there is no guarantee that the produced fuzzy rules are the best possible ones[7]. So, there is need for a method which could produce fuzzy rules and membership functions automatically. Several methods have been proposed in literature for automatic production of fuzzy rules like genetic algorithms and ANFIS[6].

978-0-7695-3845-7/09 $26.00 © 2009 Crown Copyright
DOI 10.1109/ARTCom.2009.219

Fig. 1. Original Image

Fig. 2. Using Fuzzy Approach

One problem with these methods is that they generate a large number of fuzzy rules which causes slow classification and processing speed[10].

B. Genetic Algorithm Approach

Genetic algorithm (GA) is able to overcome many of the defects in other optimization techniques[5] such as exhaustive techniques, calculus-based techniques, partial knowledge (hill climbing, beam search, best first, branch and bound, dynamic programming, knowledge based techniques (production rule systems, heuristic methods)[6]. Due to the generality of the genetic process, they are independent of the segmentation technique used, requiring only a measure of performance, which is referred to segmentation quality, for any given parameter combination. GA has been used to solve various problems in computer vision, including image segmentation[6], feature selection[10], image matching and object recognition[10].

Recently, researchers have investigated the application of genetic algorithms into the image segmentation problem. Perhaps the most extensive and detailed work on GAs within image segmentation is that of Bhanu and Lee. Many general pattern recognition applications of this particular paradigm can also be found in . One reason (among others) for using this kind of approach is mainly related with the GA ability to deal with large, complex search spaces in situations where only minimum knowledge is available about the objective function[6].

Bhanu and Lee used GA to optimize the parameters of a segmentation method under various conditions of image acquisition. Another illustration of the interest of GA for image segmentation is given by Yoshimura[6]. They combined GA and Kohonen's self-organizing map for the clustering of textured images[5]. The fuzzy C-means algorithm was used to generate a fine segmentation result. Andrey suggested an original approach as no objective fitness function is needed to evaluate segmentation results. Li and Chiao proposed a genetic algorithm dedicated to texture images where the fitness function is based on texture features similarity. Melkemi et al. use genetic algorithms to combine different segmentation results obtained by different agents[5]. A recent work proposed by Lai and Chang uses a fitness function that can be considered as an evaluation criterion in a hierarchical process[10].

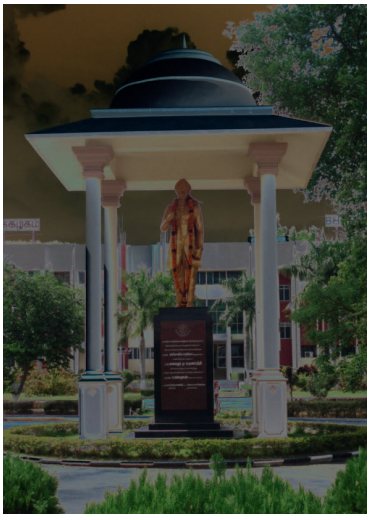

Fig. 3. Using Genetic Algorithm Approach

C. Neural Network Approach

Neural networks are formed by several elements that are connected by links with variable weights[8]. Artificial neural networks (ANN) are widely applied for pattern recognition. Their processing potential and nonlinear characteristics are used for clustering. Self organization of Kohonen Feature Map (SOFM) network is a powerful tool for clustering[9]. Ji and Park proposed an algorithm for watershed segmentation based on SOM. This method finds the watershed segmentation of

Fig. 4. Using Neural Network Approach

luminance component of color image. To solve the problem of over segmentation SOM network is used[4].

Image segmentation consists of two independent neural networks one each for saturation and intensity planes. The neural network consists of three layers namely input layer, hidden layer, and output layer as depicted in the following Figure 5.

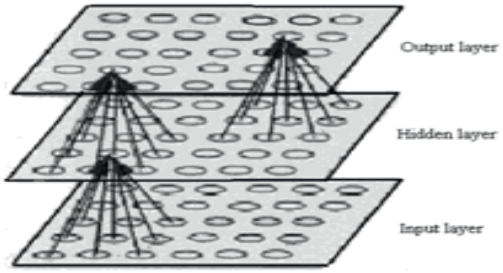

Fig. 5. Neural network approach for Image Segmentation Process

The input to a neuron in the input layer is normalized between [0-1][4]. The output value of each neuron is between [0-1]. Each layer is having a fixed number of neurons equal to the size (I x J) of the image. All neurons are having primary connection weight as 1[9]. Each neuron in one layer is connected to respective neuron in the previous layer with its dth order neighborhood as shown in the following Fig.6.

III. Conclusion

This paper mainly focus on the study of soft computing approach to image segmentation, soft computing Techniques for image segmentation. The soft computing approachs, fuzzy based approach, Genetic algorithm based approach and Neural network based approach is applied on a real life example image of nature scene and the results show the efficiency of image segmentation.

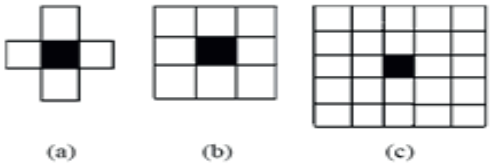

Fig. 6. Neighborhoods of a pixel (a) First order neighborhood (b) Second order neighborhood (c) Sequence of neighborhood.

Acknowledgment

The authors are thankful to all the staff members of the School of Computer Science and Engineering, Bharathiar University for their valuable support. The first author is thankful to UGC for the Rajiv Gandhi National Fellowship. The second author is also thankful to UGC for Major Research Project fund.

References

[1] Orlando J. Tobias and Rui Seara, "Image Segmentation by Histogram Thresholding Using Fuzzy Sets", *IEEE Transactions on Image Processing*, Vol.11, No.12, December 2002, pp. 1457-1465.

[2] M. Abdulghafour, "Image segmentation using Fuzzy logic and genetic algorithms", *Journal of WSCG*, vol.11, no. 1, 2003.

[3] Kanchan Deshmukh and G. N. Shinde, "An adaptive neuro-fuzzy system for color image segmentation", *J. Indian Inst. Sci.*, vol. 86, Sept.-Oct. 2006, pp.493-506.

[4] Jander Moreira and Luciano Da Fontoura Costa, "Neural-based color image segmentation and classification using self-organizing maps", *Anais do IX SIBGRAPI*, 1996, pp.47-54.

[5] Mantas Paulinas and Andrius Usinskas, "A Survey of Genetic Algorithms Applicatons for Image Enhancement and Segmentation", *Information Technology and Control*, Vol.36, No.3, 2007, pp.278-284.

[6] Xian Bin Wen, Hua Zhang and Ze Tao Jiang, "Multiscale Unsupervised Segmentation of SAR Imagery Using the Genetic Algorithm", *Sensors*, vol.8, 2008, pp.1704-1711.

[7] J. Maeda, A. Kawano, S. Yamauchi, Y. Suzuki A. R. S. Marcal and T. Mendonc, "Perceptual Image Segmentation Using Fuzzy-Based Hierarchical Algorithm and Its Application to Dermoscopy Images", *IEEE Conference on Soft Computing in Industrial Applications (SMCia/08)*, June 25-27, 2008, Muroran, JAPAN, pp.66-71.

[8] Metin Kaya, "Image Clustering and Compression Using An Annealed Fuzzy Hopfield Neural Network", *International Journal of Signal Processing*, 2005, pp.80-88.

[9] Hichem Talbi, Mohamed Batouche and Amer Draa, "A Quantum-Inspired Evolutionary Algorithm for Multiobjective Image Segmentation", *International Journal of Mathematical, Physical and Engineering Sciences*, Vol.1 No.2, 2007, pp.109-114.

[10] George Karkavitsas and Maria Rangoussi,"Object Localization in Medical Images Using Genetic Algorithms", *International Journal of Signal Processing*, 2005, pp.204-207.

[11] N. Senthilkumaran and R. Rajesh, "Edge Detection Techniques for Image Segmentation - A Survey of Soft Computing Approaches", *International Journal of Recent Trends in Engineering*, Vol.1, No.2, May 2009, pp.250-254.

[12] N. Senthilkumaran and R. Rajesh, "A Study on Edge Detection Techniques for Image Segmentation", *Proceedings of the International Conference on Mathematics and Computer Science, (ICMCS-2009)*, January 2009. pp.255-259.

[13] N. Senthilkumaran and R. Rajesh, "Edge Detection Techniques for Image Segmentation - A Survey", *Proceedings of International Conference on Managing Next Generation Software Applications, (MNGSA-08)*, December 2008. pp.749-760.

[14] N. Senthilkumaran and R. Rajesh, "A Study on Split and Merge for Region based Image Segmentation", *Proceedings of UGC Sponsored National Conference on Network Security, (NCNS-08)*, September 2008. pp.57-61.