Unsupervised Texture Segmentation Using Roughness in Wavelet Domain

Reza Farjam,[1] Reza Aghaizadeh Zoroofi,[1] Hamid Soltanian-Zadeh[1,2]

[1]Control and Intelligent Processing Center of Excellence,
Department of Electrical and Computer Engineering,
Faculty of Engineering, University of Tehran,
Tehran 14395-515, Iran
[2]Image Analysis Lab., Radiology Department,
Henry Ford Health System,
Detroit, MI 48202, USA

***Abstract* - In this paper, a wavelet based feature set is proposed and evaluated for texture segmentation. The wavelet transform (WT) of the image is taken to decompose the image into four frequency components (LL, LH, HL, HH). The roughness information of these components is then extracted in different scales. A Gaussian two-dimensional (2D) function is employed to extract the roughness information. The inverse WT is then applied to each component assuming other components are zero. This transforms the roughness feature from the frequency domain to the spatial domain. Thus, four distinct components are obtained for each scale. Some operators are finally applied to these components to get an informative feature set. For unsupervised segmentation of texture images, we use a *K*-means clustering algorithm in which the variance ratio is used to optimize the number of clusters. Since choosing inappropriate starting points in the *K*-means algorithm may create incorrect segmentation maps, we also propose a method to obtain the suitable initial points for starting the *K*-means algorithm. Our experimental results show the suitability of the proposed feature set for the 75 textures we studied. Also, the results show the robustness of the proposed method in choosing appropriate initial points for the *K*-means clustering.**

***Index terms* – Texture analysis, Wavelet transform, Roughness, *K*-means clustering.**

I. INTRODUCTION

Texture analysis is a research topic investigated by the researchers in the recent decades. The aim of texture analysis is to enhance the ability of human vision in the prognosis tasks and to increase the efficiency of the machine vision. Major tasks of texture analysis are segmentation, classification, and synthesis. So far, many attempts have been done towards analysis of textural images [1]-[4]. Charalampidis *et al.* [1] proposed a rotation invariant feature set for texture segmentation and classification based on the concept of fractal dimension. In [2], the author evaluated the effectiveness of the multi-scales Hurst parameters for texture segmentation and classification. In this research, the performance of the proposed feature set is evaluated using a set of SAR images. Choi *et al.* [3] introduce a texture segmentation algorithm based on wavelets and hidden Markov tree (HMT) model. This method is a tree-structured probabilistic graph which captures the statistical properties of the coefficients of the wavelet transform. In [4], a rotation-invariant texture classification method is proposed using the properties of the Gabor wavelets. This technique is based on a complete space-frequency method which characterizes the spatially localized amplitude, frequency, and directional behaviors of textures.

In this paper, we propose a new feature set for texture segmentation. We use the wavelet transform to decompose the texture images to their frequency components. We then extract the roughness information of these components and combine them to produce the informative feature set. We use these features along *K*-means clustering and variance ratio criterion for unsupervised texture segmentation. Since choosing inappropriate initial points for *K*-means algorithm may provide incorrect segmentation map, we propose a method to properly select the starting points for *K*-means.

The rest of this paper is organized as follows. In Section II, we explain the proposed feature set. In Section III, we present the segmentation method. The proposed method for choosing appropriate initial points for the *K*-means clustering algorithm is also explained in this section. We show the experimental results in Section IV and conclude in Section V.

II. PROPOSED FEATURE SET

A. Wavelet Transform (WT)

By WT, we mean the decomposition of signal with the family of orthogonal bases obtained through translation and dilation of a kernel function $\psi(t)$ known as the mother wavelet. To construct the mother wavelet, we first determine a scaling function $\varphi(t)$ which satisfies the following difference equation [5].

$$\varphi(t) = \sqrt{2}\sum_{k} h(k).\varphi(2t-k),\ \forall k \in Z \qquad (1)$$

The mother wavelet $\psi(t)$ is related to the scaling function via:

$$\psi(t) = \sqrt{2}\sum_{k} g(k).\varphi(2t-k),\ \forall k \in Z \qquad (2)$$