SAR Images Segmentation Using Mixture of Gamma Distribution

Ali El Zaart[1], Djemel Ziou[1], Shengrui Wang[1], Qingshan Jiang[1], Goze Bertin Bénié[2]
[1]Laboratoire de vision et traitement d'images
[2]Centre d'applications et de recherches en télédétection (CARTEL)
Université de Sherbrooke
Sherbrooke, Quebec, Canada J1K 2R1
{elzaart, ziou, wang, jiang}@dmi.usherb.ca and gbenie@courrier.usherb.ca

Abstract

This paper presents a new algorithm for SAR images segmentation based on thresholding technique. Histogram of SAR images is assumed to be a combination of Gamma distribution. The maximum-likehood technique is therefore used to estimate the histogram parameters. Thresholds are selected at the valleys of a multi-modal histogram by minimizing the discrimination error between the classes of pixels in the image. When this algorithm is tested on artificial histograms, an accurate estimate of their parameters is obtained. The algorithm is applied to several RADARSAT SAR images, with the number of looks for each image being 4 or 8. The results obtained are promising.

Keywords: SAR image segmentation, Gamma distribution, multi-modal histogram.

1 Introduction

The speckle appearing on SAR images is a natural phenomenon generated by the coherent processing of radar echoes [1, 7, 8]. The presence of speckle not only reduces the interpreter's ability to resolve fine detail, but also makes automatic segmentation of such images difficult. Generally, segmentation of a SAR image falls into two categories: 1) segmentation based on grey levels and 2) segmentation based on texture. The present paper deals with SAR images segmentation based on grey levels. We classify pixels into classes by selecting thresholds T_i at the valleys of a multi-modal histogram (see figure 1). The rule for thresholding an image $I(x,y)$ is given as:

$$R(x,y) = \begin{cases} L_1 & \text{if } I(x,y) > T_{M-1} \\ L_2 & \text{if } T_{M-2} < I(x,y) \leq T_{M-1} \\ \cdot & \\ \cdot & \\ L_M & \text{if } I(x,y) \leq T_1 \end{cases} \quad (1)$$

where M is the number of modes in the histogram. The problem of segmentation in this case is thus a problem of estimating the thresholds. Many threshold selection methods have been proposed and are summarized in [10]. Several methods use a camera image such that the distribution function is Gaussian [2, 3, 9]. In our case, we assume that the distribution function of filtered SAR images is a Gamma function. Usually, speckle distribution in amplitude SAR images can be modeled by K-distribution. If the image contains only one class, we can estimate the statistics of the histogram by using K-distribution. In ship detection for example, we are interested in only one region, so we can use K-distribution in this case [6]. But if the image has more than one class, estimation of the statistics using K-distribution is difficult. We propose a solution for this problem by using a Gamma distribution. The Gamma function in homogeneous areas is known to be [5]:

$$f(x,\mu,N) = \frac{2q}{\mu}\frac{N^N}{(N-1)!}\left(\frac{qx}{\mu}\right)^{2N-1} e^{-N(\frac{qx}{\mu})^2} \quad (2)$$

where $q = \frac{\Gamma(N+0.5)}{\sqrt{(N)}\Gamma(N)}$, x is the intensity of the pixel, μ is the mean value of the distribution and N is the number of looks. Consequently, the SAR image histogram is a linear combination of several Gamma functions. Each mode in the histogram is a Gamma function and represents a class in this image. Thus, each class is defined by its mean μ and *a priori* probability P values (see Figure 1). In this paper, the maximum-likelihood technique is used to estimate these statistics. We assume that N and M are known. After estimating the histogram parameters, we select thresholds at the valleys of a multi-modal histogram by minimizing the error in discrimination between the classes in the image.

The paper is organized as follows, section 2 will describe the estimation of the histogram parameters. In section 3, we will present the method of estimation thresholds. Finally, in section 4, we will test the thresholding method on artificial histograms and apply it to real SAR images.