A New Desired Histogram Method for Contrast Enhancement of SAR Images

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ABSTRACT

In this paper a new desired histogram method is proposed to enhance the contrast of bimodal SAR images using histogram specification with Gamma distribution. The method is aimed to estimate the statistical parameters of the original histogram as the means and *prior* probabilities of the two modes using the Maximum Likelihood Gamma Distribution technique (ML). Next, we separate the two modes by shift (modify) the first mode left or shift (modify) the second mode right or perform both shifts. After that we generate a new histogram called "Desired Histogram" using the modified statistical data. By applying a histogram specification method, a high contrast image will be produced. The new method of contrast enhancement has been tested on SAR images and showed good results.

Key Words: Contrast SAR image enhancement, Histogram specification, Gamma distribution.

1. Introduction

Syntactic Aperture Radar (SAR) is an imaging technique used in remote sensing application to produce high quality images. It is very necessary to enhance the contrast of such images before further processing or analysis can be conducted [8]. Image enhancement is a major area of image processing. Its principal objective is to process an image so that the result is more suitable than the original image for a specific application. There are several techniques to enhance an image [1]. Histogram equalization and specification have been widely used to enhance information in a gray scale image. The histogram specification technique has the advantage of allowing the output histogram to be specified as compared to histogram equalization, which attempts to produce an output histogram that is almost uniform. The problem of contrast enhancement using histogram specification method is the desired histogram of the enhanced image. In this paper, we used Gamma distribution in order to generate the desired histogram. Gamma distribution is more general than the Gaussian. It showed a good result in the case of radar images [4,10,11]. The idea of our method is to estimate the statistical parameters of the histogram using ML then we separate the two modes by shift the first mode left or shift the second mode right or perform both shifts. After that we will generate a new histogram called "Desired Histogram" using the new data. By applying a histogram specification method, a high contrast image will be produced. In section 2, we explain the feature of Gamma distribution. Section 3, presents the new method in details. Section 4 presents the results of the new method applied on SAR images. Finally, we conclude in section 5.

2. Gamma Distribution

The probability density function of the Gamma distribution in homogeneous area is known to be [4, 10, 11]:

$$f(x,m,L)=\frac{2q}{m}\frac{L^L}{\Gamma(L)}\left(\frac{qx}{m}\right)^{2L-1}e^{-L(qx/m)^2}$$

where $q=\frac{\Gamma(L+0.5)}{\Gamma(L)\sqrt{L}}$, and x is the intensity of the pixel, m is the mean value of the distribution and L represents the parameter shape of the distribution. The shape of the Gamma distribution could be symmetry or skewed to the right. Gamma Distribution is better than Gaussian because Gaussian works only with symmetric histograms but in the case of Gamma distribution, if we want a symmetric histogram, we set L to a high value. By using Gamma distribution we can get a histogram skewed to the right by setting L to a small value [4, 10, 11]. In the next section we will explain in details the basic idea of the new method of desired histogram generation using Gamma distribution.

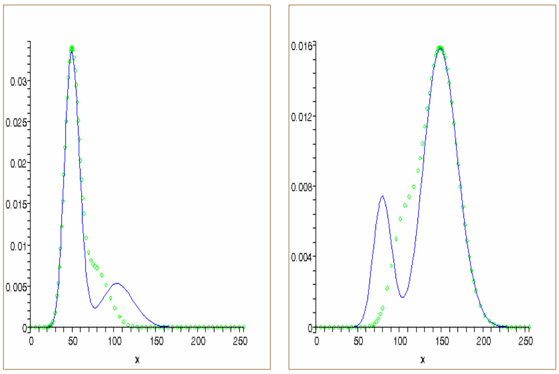
3. New Desired Histogram Method Using Gamma Distribution

The main idea of our new method is to generate the desired histogram from the original histogram by separation the modes. First, we estimate the statistical parameters of the histogram using ML technique in order to obtain the shape of the original histogram. Second, we can derive a desired histogram that must be close to the original histogram by shifting one or more than one mode in order to have a reasonable separation (high contrast).

We consider an original bimodal image *I(x,y)*. Let *h(x)* be its histogram. This histogram can be written as a combination of two Gamma distributions.

$$h(x)=p_1 f(x,m_1,L)+p_2 f(x,m_2,L)$$

Where p_i and m_i represents respectively the *prior* probability and the *mean* of the i^{th} mode of the histogram. The low contrast in image is caused by close values between m_1 and m_2 i.e. the difference values is small. There is no effect of *prior* probabilities p_1 and p_2 on the contrast level. For that, our method concentrates on the *mean* values. We have to make change on contrast from low to high by setting the difference values between *means* to a high value. Figure 1 shows two cases of low contrast or overlap between two modes where the dotted curve is the original (overlapped) histogram and continues curve is the desired histogram. In figure 1(a) the original histogram is formed by (m_1=50, p_1=0.75, m_2=80, p_2=0.25 and L=8).



(a) (b)

Fig. 1 (a) Shift to right and (b) Shift to left.

To generate a desired histogram for this case, we can only shift the value of m_2 to right. For example, we can add 25 to m_2. The new desired histogram is formed by (m_1=50, p_1=0.75, m_2=105, p_2=0.25 and L=8).

The second overlap histogram in figure 1(b) is formed (m_1=105, p_1=0.2, m_2=150, p_2=0.8 and L=8). In this case of low contrast, we can only shift the value of m_1 to left. For example, we can subtract 25 from m_1. The new desired histogram is formed by (m_1=80, p_1=0.2, m_2=150, p_2=0.8 and L=8).

The third overlap original histogram is presented in figure 2. It is formed by (m_1=90, p_1=0.25, m_2=130, p_2=0.75 and L=10). In this case of low contrast, we can shift the value of m_2 to right and the value of m_1 to left. For example, we can add 12 to m_2 and subtract 12 from m_1. The new desired histogram is formed by (m_1 =78, p_1 =0.25, m_2 =142, p_2 =0.75 and L=10).

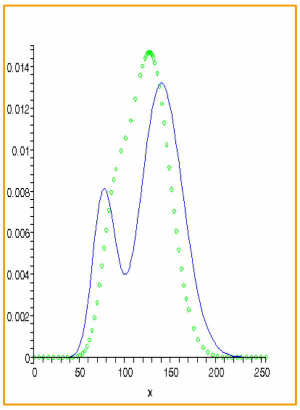


Fig. 2 Shift to right and left

In figures 1 and 2, we separated between two modes by adding or subtracting some values from the means. In our method, we used the shifting rules as follows:

1 - We can shift the first mode to left by modifying the value of m_1 as: $m_1 = m_1 - C1$
2 - We can shift the second mode to right by modifying the value of m_2 as: $m_2 = m_2 + C2$
3 - We can also make both shifts left and right as: $m_1 = m_1 - C1$ *and* $m_2 = m_2 + C2$
Where *C1=min/2* *and* *C2=(255-max)/2*. *max* and *min* are respectively the maximum and minimum gray level in the original image. (p_1, m_1) and (p_2, m_2) are estimated by ML. After modifying the value of m_1 and/or m_2, we then generate the desired histogram from the modified values by keeping the values of p_1 and p_2. The desired histogram is thus used to construct the enhanced image.

In the following, we will cite the algorithm of our method:

1- *Compute* the histogram : *h(x)*
2- *Estimate* the statistical parameters (p_1, m_1) and (p_2, m_2) of the original histogram *h(x).*
3- *Separate* the modes by shifting right and/or left.
4- *Generate* the desired histogram using data from the step 2 and 3.
5- *Construct* the construct image using the specification histogram method presented in [1].

4. Experimental Results

In this paper images are enhanced based on histogram specification using Gamma distribution. We have tested our method on various SAR images. In this section, however, we only show two examples of SAR images and demonstrate the enhanced results.

Figure 3 shows the input image before enhancement. Figure 4 displays the enhanced image using the shift to right for separation between modes. Figure 5 shows the original histogram (red) with the desired histogram (green) after applying shift right only.

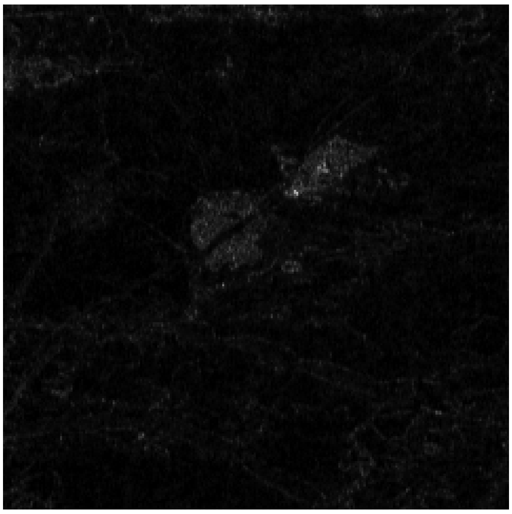


Fig. 3 Original low-contrast SAR image

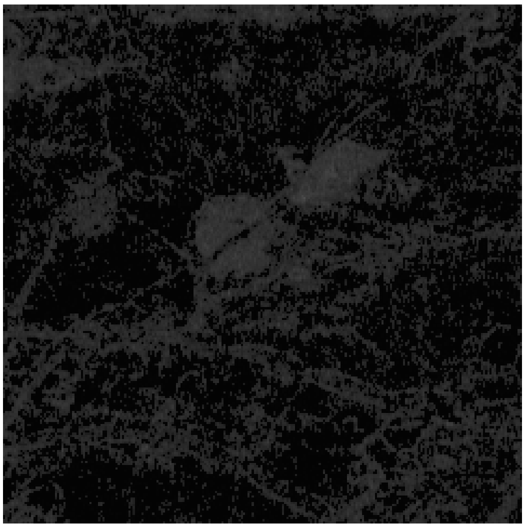


Fig. 4 enhanced image using desired histogram in figure 5.

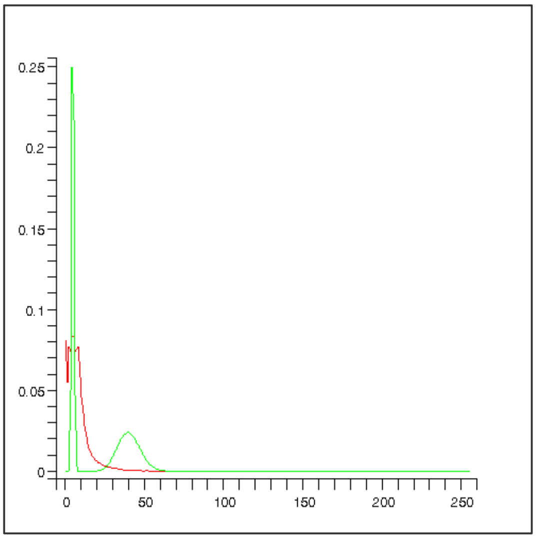


Fig 5. Original (red) and desired (green) histogram

Figure 6 shows the input image before enhancement. Figure 7 displays the enhanced image using the new method by shifting right to separate between modes. Figure 8 shows the original histogram (red) with the desired histogram (green) after applying shift right only.

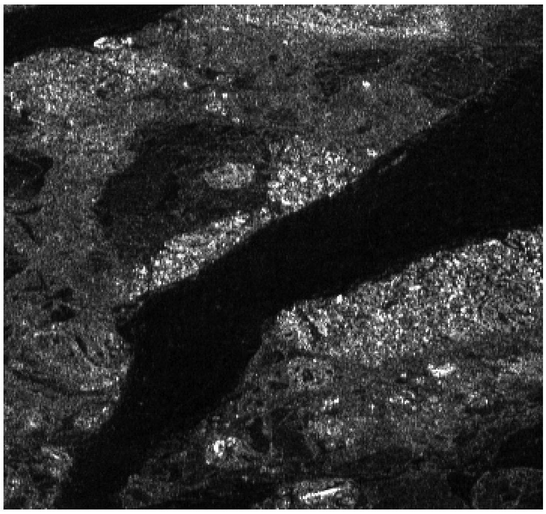
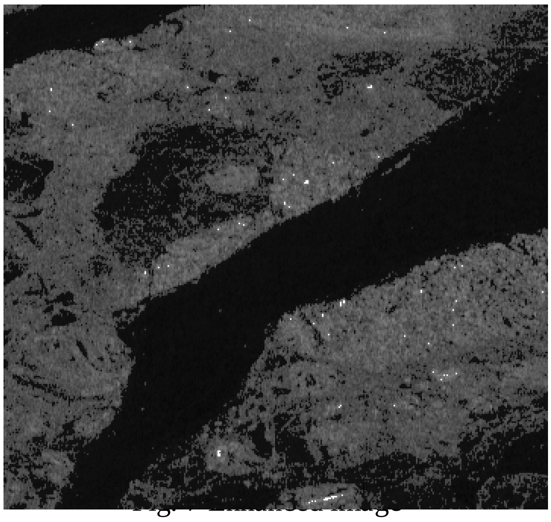


Fig. 6 Original low-contrast SAR image



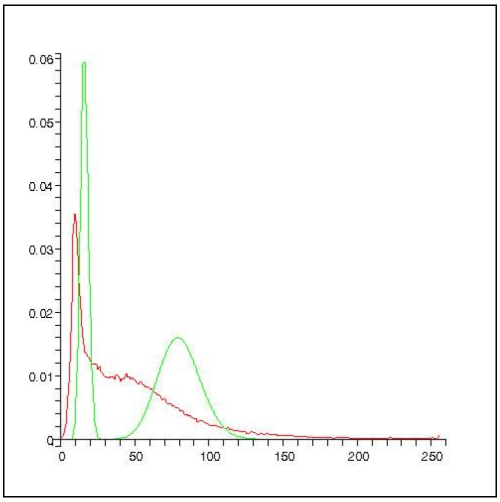


Fig 8. Original (red) and desired (green) histogram

5. Conclusions and Future Work

In this paper, we present a fast method for SAR images contrast enhancement by using histogram specification with Gamma distribution. The algorithm first, estimates the statistical parameters of the histogram using ML technique in order to have the shape of the original histogram. Second, the desired histogram can be obtained by shifting one or two modes of the original histogram. The algorithm proposed in this paper can enhance SAR images effectively. It has advantages over histogram equalization. Experimental results show that the quality of enhanced images is good. Our method presented in this paper works only for bi-modal histograms, as future work, we will generalize this method to separate M modes and test it on different type of SAR images.

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