Image Processing Project

Satellite Image Contrast Enhancement Based On Discrete Wavelet Transform and Singular Value Decomposition

Master in Medical Imaging and Applications

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1 Introduction

Satellite images are used in many applications such as geosciences, meteorology, astronomy, geographical information systems, just to mention some. One of the most important quality factors in satellite images comes from their contrast. Contrast can be defined as the difference between maximum and minimum pixel intensity of an image. If the contrast of an image is uniform and highly concentrated on a specific range, some information can be lost. The image processing challenge is to optimize the contrast to avoid this loss of information.

Several techniques have been proposed to overcome this issue, such as General histogram equalization (GHE), Local histogram equalization (LHE), Brightness preserving dynamic histogram equalization (BPDHE) and Singular value equalization (SVE). Although this techniques do improve the contrast of the original image, information laid on the histogram of the image is lost. Therefore there is an urge to find a method who can do both things: optimize the contrast, and preserve the histogram information.

2 Objective

Propose a new method to optimize the contrast of satellite image in order to represent all the information of the original input.

3 Algorithm

The proposed method consists in two main parts:

The first part (showed in Figure 1) consists on performing Discrete Wavelet Transform (DWT) to separate the input low contrast satellite image into different frequency subbands: HH, HL, LH, LL. The illumintation information is concentrated in the LL subband. Therefore it wil be the only subband manipulated in order to enhace the contrast.

In the second part (Figure 2), Singular Value Decomposition (SVD) is performed on the LL subband. The singular value matrix obtained by SVD contains the illumination information. Hence, manipulating the singular values will directly affect only the illumination of the image, leaving the rest of the information intact.

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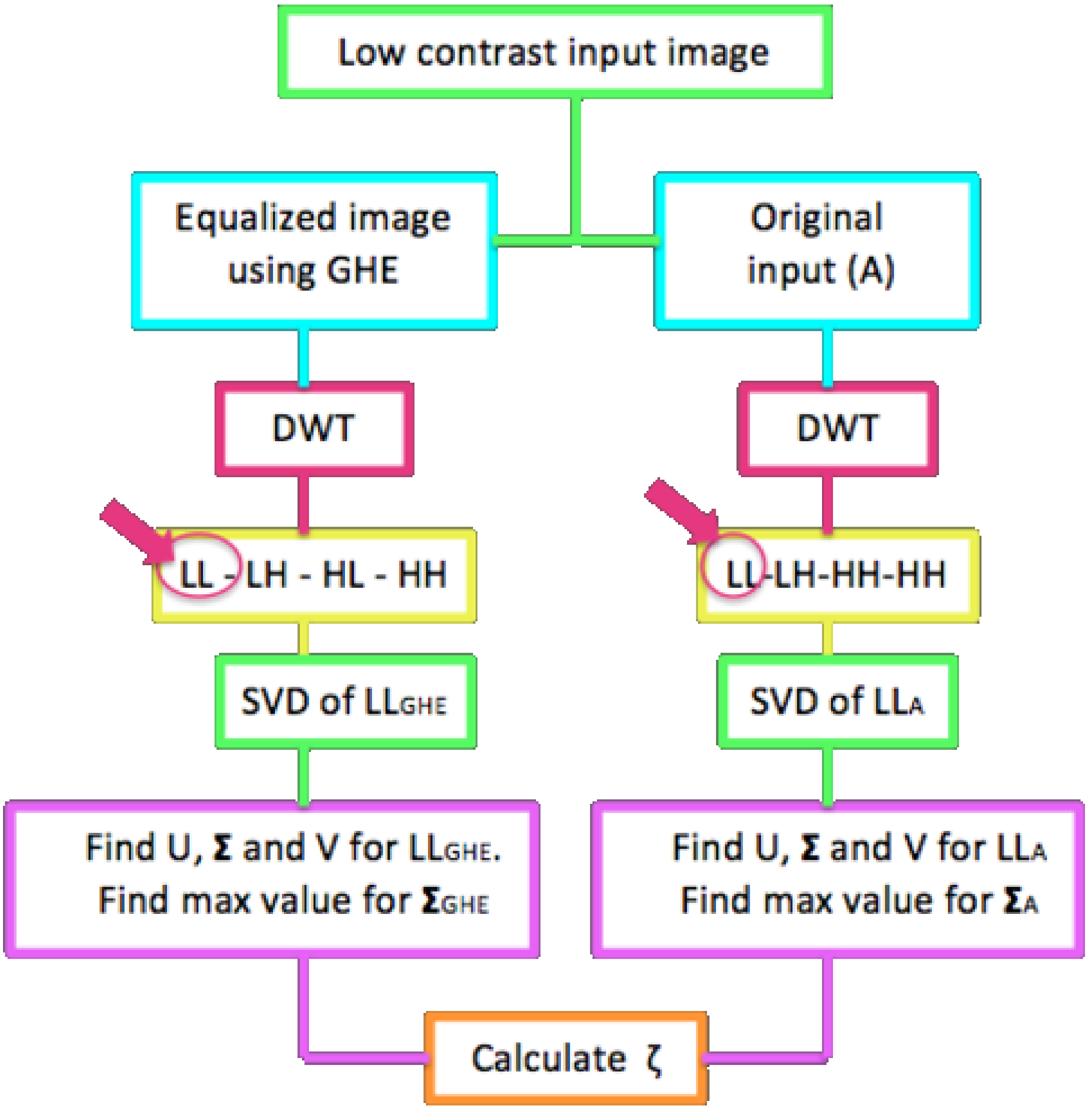

Figure 1: Pipeline of proposed algorithm

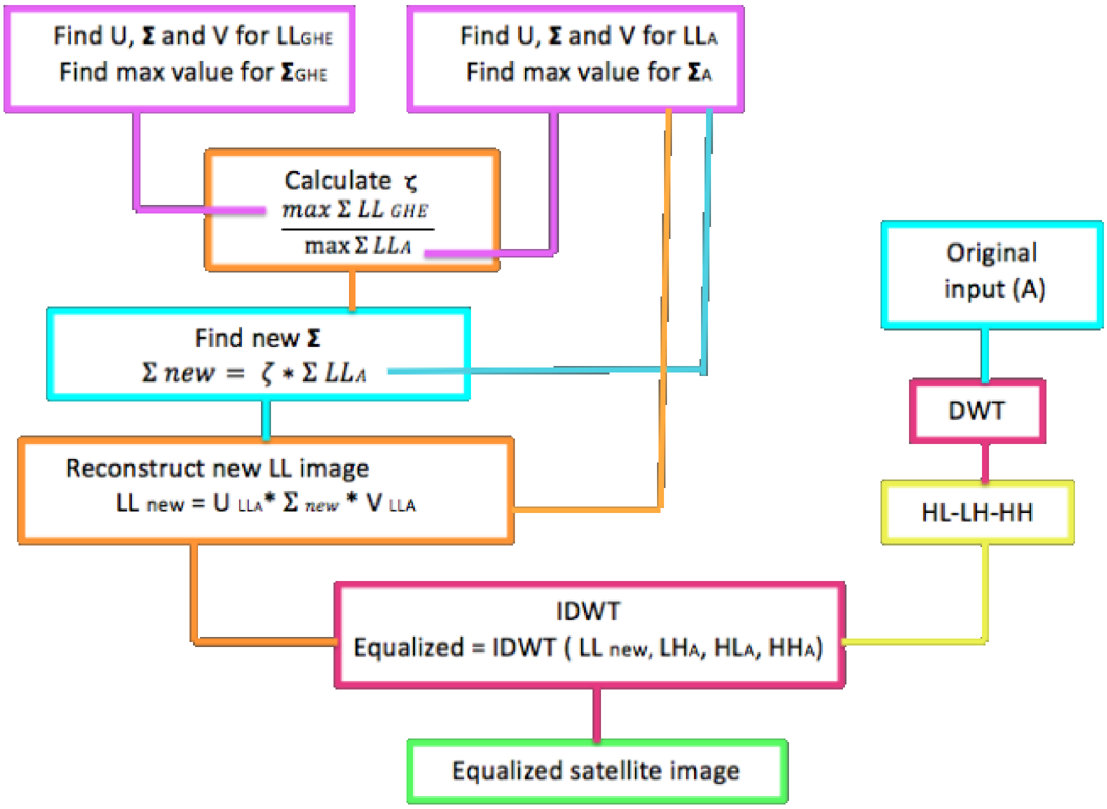

Figure 2: Continuation of pipeline of proposed algorithm

The detailed procedure of this method is as follows:

- Equalize the image by performing General Histogram Equalization (GHE).
- Perform DWT two times: one on the original image and the second on the GHE.
- Perform SVE on the two LL subbands. The SVE method will return three matrices: (1)U, (2)Sigma and (3)V.
- Find the maximum singular values from the sigma matrices.
- Calculate the zeta coefficient, which is the maximum singular value of the GHE, divided by the maximum singular value of the original image.
- Multiply the zeta coefficient by the sigma matrix of the LL subband of the original image.
- Multiply the new sigma matrix by U and V to obtain a new LL subband.
- Perform Inverse DWT to reconstruct the image.

4 Results

The method was performed in several images which confirmed the qualitative results. These images clearly show that the proposed equalization technique provides sharper and brighter images than the state of the art techniques (GHE, CLAHE, BPDHE and SVE).

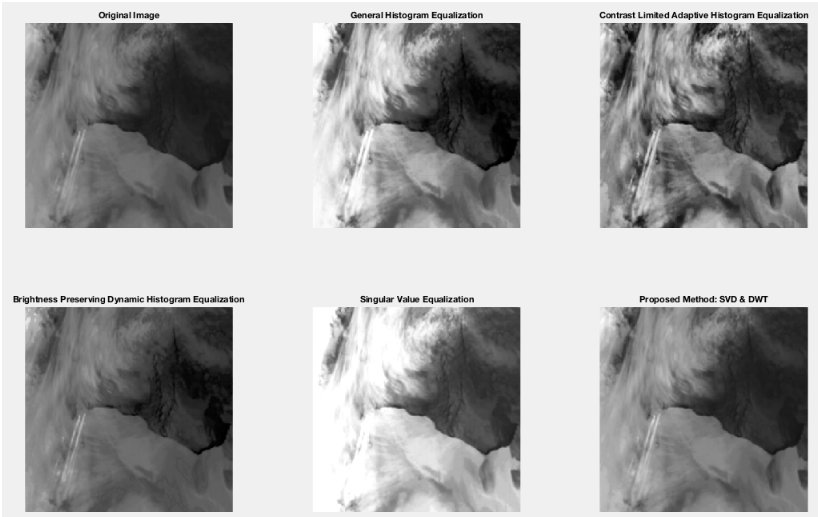

Figure 3: Comparison of resulting images between original and equalized images using proposed and state of the art methods

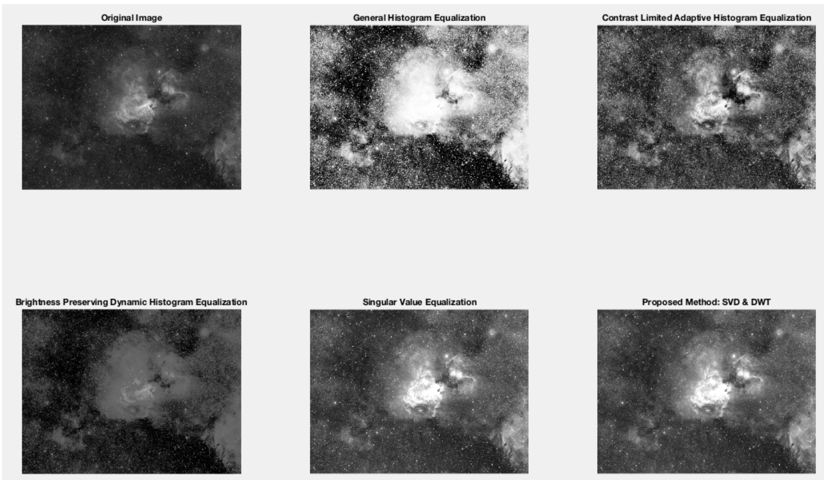

Figure 4: Comparison of resulting images between original and equalized images using proposed and state of the art methods

A quantitative analysis was also performed in order to support the qualitative results. This was done by plotting the Normal distribution of the histograms. From the obtained graphs it is visible that the proposed method covers a wider range of gray levels, hence its illumination is better.

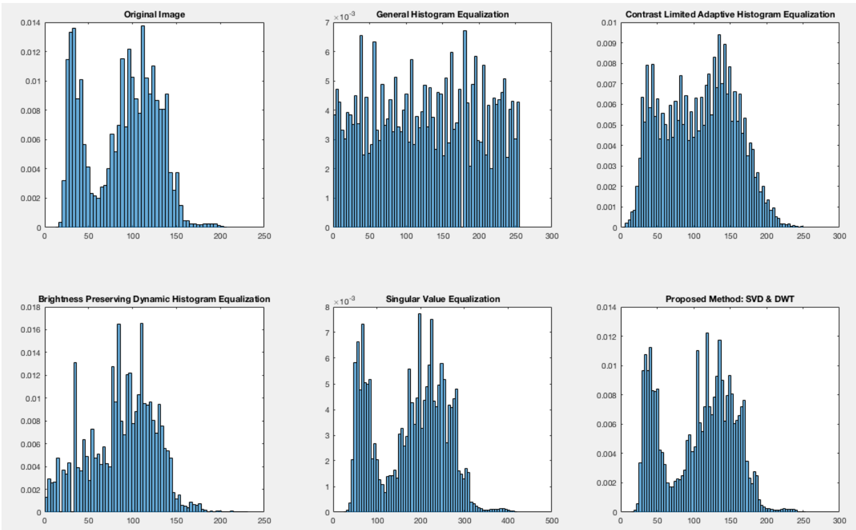

Figure 5: Comparison of resulting histograms between original and equalized images using proposed and state of the art methods

With both, the qualitative and the quantitative results, we can confirm that the proposed method using DWT and SVD successfully optimizes the contrast of the image while preserving the information of the original input.

5 Conclusions

A new contrast technique was proposed for obtaining sharper satellite images by enhancing their illumination information.

The technique decomposes the input image into the Discrete Wavelet Transform (DWT) subbands, updates the singular value matrix (SVD) of the LL subband and reconstructs the image by Inverse Discrete Wavelet Transform (IDWT).

The qualitative and quantitative results of the final image show the superiority of the proposed method compared to state of the art techniques.

6 References

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