Enhancing Contrast for Image Using Discrete Stationary Wavelet Transform and Non-linear Gain Operator

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Abstract. Having implemented discrete stationary wavelet transform (DSWT) to an image, combining generalized cross validation (GCV), noise is reduced directly in the high frequency sub-bands which are at the better resolution levels and local contrast is enhanced by combining de-noising method with non-linear gain operator (NGO) in the high frequency sub-bands which are at the worse resolution levels. In order to enhance the global contrast for the image, the low frequency sub-band image is also enhanced employing in-complete Beta transform (IBT) and simulated annealing algorithm (SA). IBT is used to obtain non-linear gray transform curve. Transform parameters are determined by SA so as to obtain optimal non-linear gray transform parameters. In order to avoid the expensive time for traditional contrast enhancement algorithms, which search optimal gray transform parameters in the whole gray transform parameters space, a new criterion is proposed with gray level histogram. Contrast type for original image is determined employing the new criterion. Gray transform parameters space is given respectively according to different contrast types, which shrinks gray transform parameters space greatly. Finally, the quality of enhanced image is evaluated by a total cost criterion. Experimental results show that the new algorithm can improve greatly the global and local contrast for an image while reducing efficiently gauss white noise (GWN) in the image. The new algorithm is more excellent in performance than histogram equalization, un-sharpened mask algorithm, WYQ algorithm and GWP algorithm.

1 Introduction

Traditional image contrast enhancement algorithms include: point operators, space operators, transform operators and pseu-color contrast enhancement [1]. Recently, some new algorithms for image enhancement have been proposed. Such as Ramar and Shang-ming Zhou gave two kinds of algorithms for contrast enhancement based on fuzzy operators respectively [2],[3]. However, the algorithm, which was proposed by Shang-ming Zhou, cannot be sure to be convergent. Ming Tang gave a kind of adaptive enhancement algorithm far infrared image sequences [4]. Performance of the algorithm is affected greatly by mathematic model. Lots of improved histogram equalization algorithms were proposed to enhance contrast for kinds of images[5-9]. algorithms have been proposed [5],[6],[7],[8],[9], however, the visual quality cannot be improved greatly with above algorithms. Tubbs gave a simple gray transform

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algorithm to enhance contrast for images [10]. However, the computation burden of the algorithm was large. Based on Tubbs algorithm, Zhou Ji-liu gave a new kind of genetic algorithm to optimize non-linear transform parameters [11]. Although the algorithm can enhance contrast for image well, the computation burden is larger. Many existing enhancement algorithms' intelligence and adaptability are worse and much artificial interference is required, which restricts their wide applications. Most of them only enhance either the global or the local contrast for image.

To solve above problems, a new algorithm employing incomplete Beta transform (IBT), DSWT and SA is proposed. To improve optimization speed and intelligence of algorithm, a new criterion is proposed based on gray level histogram. Contrast type for original image is determined employing the new criterion. Contrast for original images are classified into seven types: particular dark (PD), medium dark (MD), medium dark slightly (MDS), medium bright slightly (MBS), medium bright (MB), particular bright (PB) and good gray level distribution (GGLD). The new algorithm is still a kind of gray transform method. IBT operator transforms original image to a new space. A certain criterion or objective function is used to optimize non-linear transform parameters. SA, which was given by William, is used to determine the optimal non-linear transform parameters. Having made DSWT to the original image, the global contrast is enhanced directly employing IBT in the low frequency sub-band image. The local contrast is enhanced employing de-nosing algorithm combining IBT, which was proposed by Tubbs in 1997 [10]. We expand the IBT to SWT domain so as to extrude the detail in the original image. Noise is reduced directly at the better resolution levels by the de-noising algorithm. The de-noising asymptotic thresholds can be obtained employing GCV without the accurate statistic information of the noise. Local enhancement is enhanced combining de-noising algorithm with IBT. In order to evaluate the quality of the enhanced image, a new total cost criterion is proposed. Experimental results show that the new algorithm can enhance efficiently the global and local contrast for the image while the gauss white noise in the image can be reduced well. The total performance of the new algorithm is more excellent than the HIS, USH, GWP algorithm in [11] and WYQ algorithm in [12].

2 IBT

Usually, an image has three kinds of contrast types: particular bright, particular dark and all gray levels are centralized on the middle certain region in gray levels histogram. Different transform functions are used to enhance contrast according to different contrast types. Figure 1(a)-(c) shows gray transform curve corresponding to particular dark type, particular bright type and all gray levels are centralized on the middle certain region type respectively.

Tubbs employed unitary incomplete Beta function to approximate above three non-linear functions [10]. Parameter α and β control the shape of non-linear transform curve. The incomplete Beta function can be written as following:

$$F(u) = B^{-1}(\alpha,\beta) \times \int_0^u t^{\alpha-1}(1-t)^{\beta-1}dt, \quad 0 < \alpha,\beta < 10. \tag{1}$$