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A ROBUST ADAPTIVE HAAR WAVELET TRANSFORM GLOBAL CONTRAST ENHANCEMENT

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ABSTRACT

Image compression is an approach designed to compress the image size and improve the visibility of image by increasing the image contrast. Several methods have been proposed to solve the visualization issue of compressed image; however, these techniques are problem-specific and hence their robustness are questionable. A robust lossy image compression method called Robust Adaptive Haar Wavelet Transform (RAHWT) augmented with Adaptive Multi Scale Retinex (AMSR) has been proposed to enhance the quality of compressed image. This paper proposes a new image compression technique for colour RGB images. This technique is developed to produce images of better contrast and smaller size. The output image is evaluated by using Peak-Signal-To-Noise Ratio (PSNR), Mean Square Error (MSE) and image size before and after compression (in KB).

Keywords: Image processing, adaptive multi-scale retinex, compression.

1. INTRODUCTION

Nowadays, digital image processing has become one of the most important sciences. Digital image exists in almost every social media such as Facebook, Tweeter, Instagram, Snapchap etc. These applications are normally installed in smart phones. In 2016, the number of smartphone users worldwide is about 2.16 billion (e.g. ~1.79 billion Facebook users and ~500 million Instagram users), whereby digital images are sent, received and posted in a very frequent basis. Also, it's significate in web based application and increasing performance of wireless in higher institution [14] [15] [19]. The transport layer of 4G and in the VANET network similarly delivers good performance [16] [17] [18]. The optimization concept of algorithms impacted by digital processing [20]. In medical science, X-rays and MRIs are used every day and image processing is helpful in diagnosing the illness[1]. Also, image processing is employed in security systems such as those installed in airports, country borders, banks, shopping malls, jewellery shops and ATM machines, etc, in order to monitor and capture the criminals. High-resolution images are normally large in size; therefore, it is desirable to compress the images without sacrificing the image qualities. Several methods had been applied for image compression, which can be generally divided into two main categories: (a) lossy image compression and (b) lossless image compression. Lossy compression technique is very common and it is suitable for natural images where minor loss of fidelity is acceptable. On the other hand, lossless compression technique can fully recover the original image from the compressed image (noiseless) by relying on statistics/decompression technique to eliminate/minimize redundancy. This technique is preferred for compressing artificial images such as drawing, comics etc. [2] [3] [4] [5] [6].

An image compression method involves three general stages, i.e. (1) compression; (2) transfer/store and (3) decompression [2]. Several techniques had been used to compress the images while maintaining the image quality after compression. Haar wavelet transform is one of the earliest and widely used transform functions in image compression [7] [8].

2. RELATED WORK

Wavelet transform had been widely used in image compression schemes such as Vector Quantization (VQ) [9], Adaptive transforms [10], zero-tree encoding [11] [12] and edge-based coding [13]. Haar functions were introduced by the Hungarian mathematician Alfred Haar in 1910. Haar wavelet is discontinuous and resembles a step function. It represents the same wavelet as Daubechies db1. Haar used these functions to give an example of an orthonormal system for the space of square-integrable function on the unit interval [0, 1]. For an input represented by a list of numbers, the Haar wavelet transform may be used to simply pair up input values, store the difference and pass the sum. This process is repeated recursively to pair up the sums in order to provide the next scale for differences and final sum. The Haar Wavelet Transformation is a simple form of compression which involves averaging and differencing terms, storing details of coefficients, eliminating data and reconstructing the matrix such that the resulting matrix is similar to the initial matrix. Haar wavelet is the simplest type of wavelet. In discrete form, Haar wavelets are related to the mathematical operation called Haar transform. The Haar transform serves as a prototype for all other wavelet transforms. Like other wavelet transforms, the Haar transform decomposes a discrete signal into two sub-signals of equal length. One sub-signal is a running operation such as average or trend while the other sub signal is running operations such as difference or fluctuation.

3. THE PROPOSED METHOD

In this work, we aim to compress the image size as much as possible while preserving the detail of output image. This task is accomplished by using the hybrid Haar Wavelet Transform method called Adaptive Haar Wavelet

Transform (RAHWT). The enhancement method such as Adaptive Multi Scale Retinex (AMSR) is adopted as well. Single-scale Retinex method works based on image global contrast enhancement. On the other hand, multi-scale Retinex is a local contrast image enhancement technique and multi-scale Retinex color restoration works generally on color images.

3.1 Robust adaptive haar wavelet transform (RAHWT)

The idea of adaptive Haar Wavelet Transform method is stemming from the Haar Wavelet Transform (HWT) method which is built based on a 4 × 4 matrix. This method works by dividing the image into m × n blocks and applying HWT on each block individually. The original HWT is a sequence of rescaled "square-shaped" functions that forms a wavelet family or basis. Wavelet analysis is similar to Fourier analysis in that it allows a target function over an interval to be represented as an orthonormal. The Haar sequence is now recognized as the first known wavelet basis and it is extensively used as a teaching example. The Haar wavelet's mother wavelet function *ψ(t)* can be described as

$$\psi(t) = \begin{cases} 1, \ 0 \le t < \frac{1}{2}, \\ -1, \ \frac{1}{2} \le t < 1, \\ 0, \ otherwise. \end{cases} \quad (1)$$

$$F_n(x, y) = C_n \exp[-(x^2 + y^2)/\sigma_n^2] \quad (2)$$

Conceptually, a wavelet transform is an inner product of time series of scaled and translated wavelets $\psi(t)$, which is usually an n-th derivative of a smoothing kernel $\theta(x)$. The scaling and translation actions are performed by two parameters. The first parameter is s that 'adapts' the wavelet width to the required microscopic resolution, thus changing its frequency contents. The second parameter is b, which determines the location of the analysed wavelet:

$$W\, f(s, b) = < f, \psi > (s, b) = \frac{1}{s}\int_\Omega dx\, f(x)\psi\left(\frac{x-b}{s}\right), \quad (3)$$

Here, $\{s,\ b\} \in$ R and $s <$ 0 for the continuous version (CWT). For the discrete version (DWT, or just WT), the parameters are taken from the discrete, usually hierarchical (e.g. dyadic) grid of values. Ω is the length of the time series.

3.2 Adaptive multi scale retinex (AMSR)

Adaptive Multi Scale Retinex (AMSR) is one of the most commonly used algorithms in image enhancement. It can maintain the image fidelity while achieving the dynamic range of image compression. AMSR can realize the image color constancy, local dynamic range compression, color enhancement and overall dynamic range compression. Therefore, it is commonly used in medical image processing, remote sensing images, fog and low contrast images. The AMSR output is defined as the weighted sum of outputs of several SSRs, which leads to:

$$R_{AMSR_i} = \sum_{n=1}^{N} w_n R_{n_i} = \sum_{n=1}^{N} w_n [log I_i(x, y) - \log\left(F_n(x, y) * I_i(x, y)\right)] \quad (4)$$

where $F(x, y)$ is defined as:

$$F(x, y) = \left[\frac{C \exp[-(x^2 + x^2)}{2\sigma^2}\right] \quad (5)$$

Here, the filter standard deviation σ controls the retained amount of spatial detail, defined as:

$$\sigma = \sqrt{\frac{\Sigma(x-\mu)^2}{N}} \quad (6)$$

where x represents each value in the population, μ is the mean value of the population, Σ is the summation (or total), N is the number of values in the population and C is a normalization factor such that:

$$C = \int F(x, y)dxdy = 1 \quad (7)$$

For the AMSR approach, parameters such as 1) suitable scales to choose, 2) quantity of weights, and 3) ideal values for each weight must be determined. From the numerical experiments, five scales are sufficient for most images and the weights can be identical. The scales are 51, 102, 153, 204 and 255. Figure-1 presents the diagram of AMSR method where the scales: $F_1(x, y)$ to $F_5(x, y)$ contain values of 51, 102, 153, 204 and 255, respectively.

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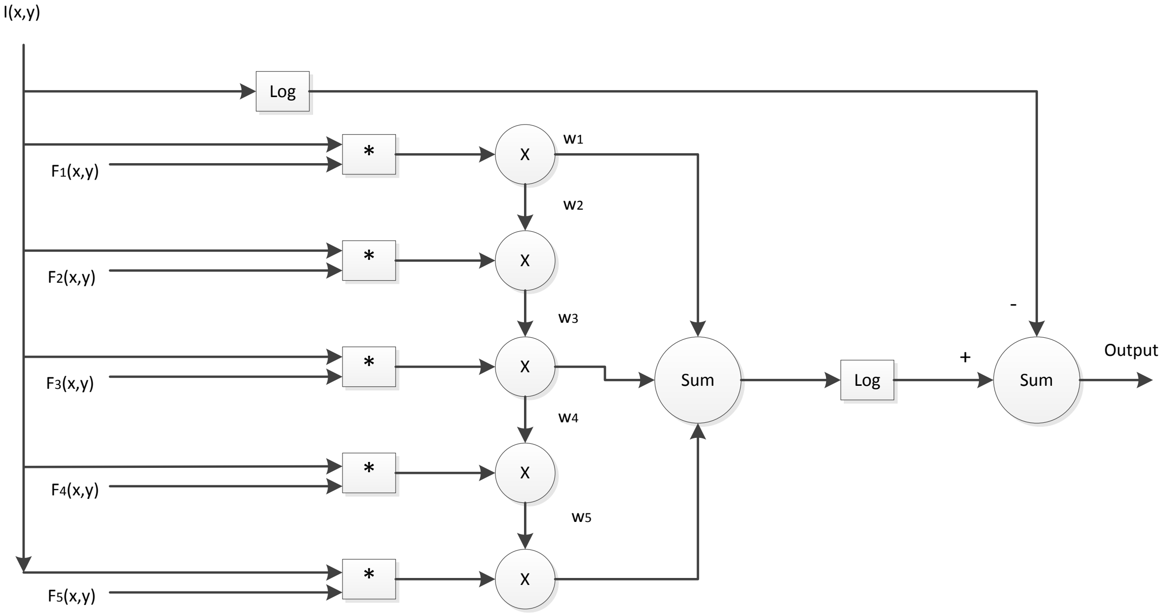

Figure-1. Adaptive multi scale retinex (AMSR) diagram.

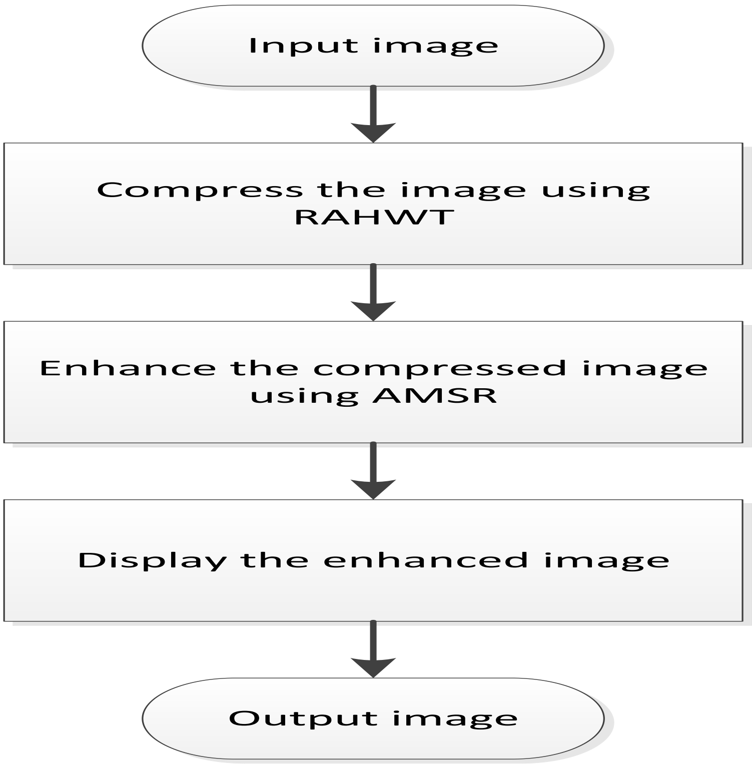

Figure-2. Robust adaptive haar wavelet transform method process steps.

4. RESULTS

In this section, the outputs of Robust Adaptive Haar Wavelet Transform method enhanced by Adaptive Multi Scale Retinex are presented. The experimental results are obtained from the California Institute of Technology Computational Vision database [28]. The experimental results are compared qualitatively and quantitatively with those obtained from the aforementioned techniques. This study involves 100 images. Three qualitative evaluations on indices such as entropy (*E*), Peak Signal-To-Noise Ratio (PSNR) and Mean-Square Error (MSE) are analysed. Table-1 presents the quantitative evaluation results. The best result is bolded and the second best result is underlined.

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Table-1. Comparison quantitative output result for 100 images.

Methods	PSNR	MSE	E
Original Image	0.333055	25.26612	4.254642
SSR	0.024217	23.43682	4.524079
MSR	0.056649	25.64684	4.736439
MSRCR	0.121755	9.828513	4.794123
AMSR	0.021464	13.398	4.926826

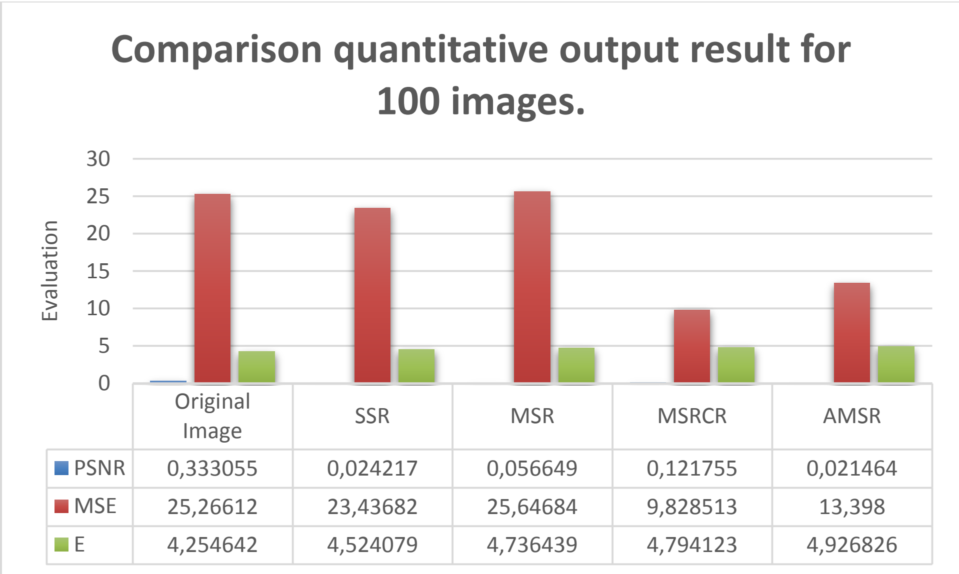

Figure-3. Graphical Comparison quantitative output result for 100 images.

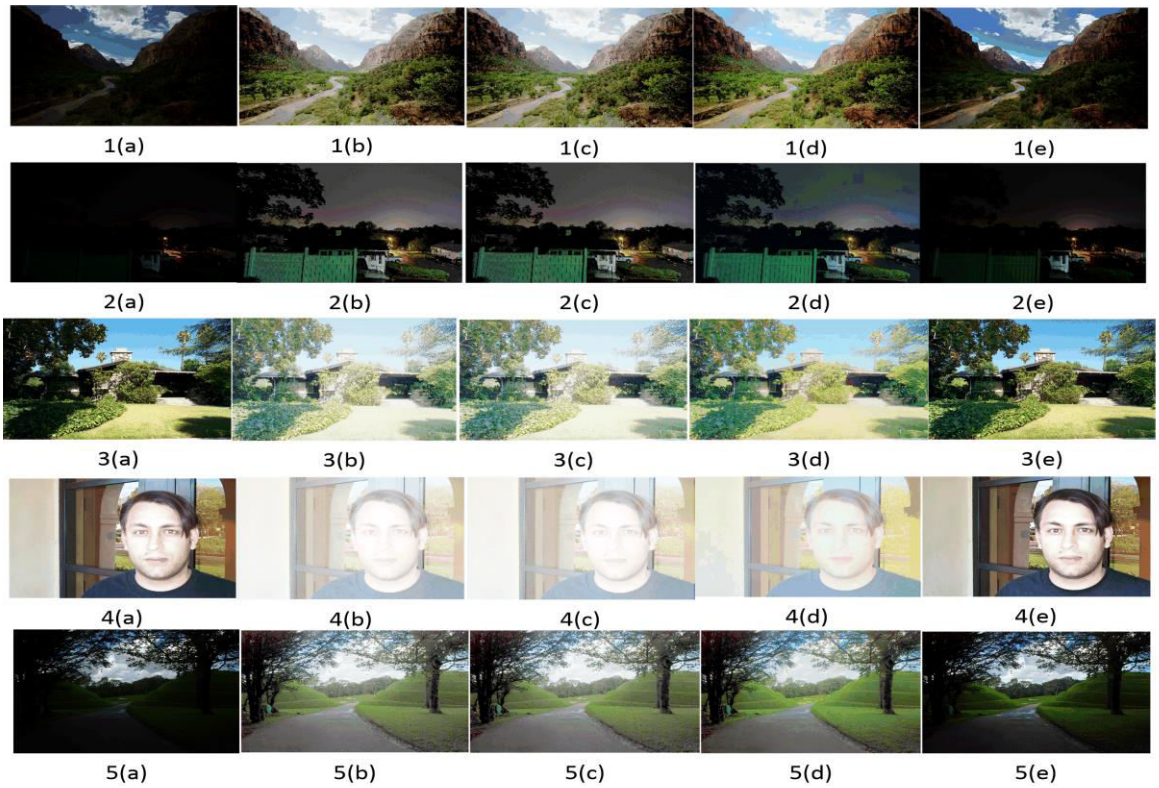

Figure-4. Five Qualitative random samples, (a) original image, (b) SSR, (c) MSR, (d) MSRCR, (e) AMSR.

Figure-4 compares the qualities of five images obtained from the proposed method and the state-of-the-art methods. The contrast levels of images obtained from the state-of-the-art methods are overexposed, while the contrast level of the image obtained from the proposed method is closer to that of the original image. Most of the images affected by underexposed brightness contain pixels that turn dark. The contract levels of images 5(b), (c), and (d) have been enhanced; however, the bright regions such as "sky" and "clouds" turn brighter. On the other hand, the contrast level of 5(e) is enhanced and the pixel contrasts are closer to those of 5(a). Image 3(a) contains both overexposed and underexposed regions. The pixels in images 3(b) and 3(c) turn brighter. Meanwhile, image 3(e) has the best contrast where the dark region becomes brighter. Image 2(a) suffers from underexposed contrast distribution. Images 2(b), 2(c) and 2(d) turn brighter while the regions in image 5(e) are enhanced in a more balanced manner. Therefore, the images obtained from the proposed technique are better in terms of contrast distribution.

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