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A review Content-Aware Dark Image Enhancement in Image Fusion Techniques

Raksha Chouhan[1] and Prof. Abhilasha Vyas[2]
[1]Research Scholar, Department of Computer Science & Technology,
Patel College of Science & Technology Indore (Madhya Pradesh), INDIA
[2]Assistant Professor, Department of Computer Science & Technology,
Patel College of Science & Technology Indore (Madhya Pradesh), INDIA

(Corresponding author: Raksha Chouhan)
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ABSTRACT: This paper introduces a new image Enhancement approach suitable for digital cameras. High contrast images are common in the scenes with dark shadows and bright light sources. It is difficult to show the details in both dark and light areas simultaneous on most display devices. For solving this problem, there are many methods of image enhancement proposed to improve the quality of the images. However, most of them often get poor results if the images are high contrast and have wide dynamic range. This method for enhancing the high- contrast digital camera images, which enhances the global brightness and contrast of images while preserving details. It is based on a two-scale decomposition of the image into a base layer, encoding large-scale variations, and a detail layer. The base layer is obtained using an edge preserving filter that is a weighted average of the local neighborhood samples, where the weights are computed based on temporal and radiometric distances between the center sample and the neighboring samples. Only the base layer image is enhanced automatically by using histogram equalization method, thereby preserving detail. The experimental results show the proposed method provides a significant enhancement for the high-contrast images and requires no parameter setting. And also in this work processing cost reduction when the new approach is followed.

Keywords: High-contrast image, automatic enhancement, camera images, histogram equalization and weighted filter.

I. INTRODUCTION

Image enhancement process consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or machine. Image enhancement means as the improvement of an image appearance by increasing dominance of some features or by decreasing ambiguity between different regions of the image. The objective of enhancement is to process an image so that the result is more suitable than the original image for a specific application. Image enhancement is one of the most interesting and visually appealing areas of image processing. Image enhancement is broadly divided into two categories: spatial domain methods and frequency domain methods. Spatial domain method refers to the image plane and approaches in this category are based on direct operation of pixels in an image. Frequency domain methods are based on adapting the Fourier transform of an image.

Image enhancement, which is one of the significant techniques in digital image processing, plays important roles in many fields, such as medical image analysis, remote sensing, high definition television (HDTV), hyper spectral image processing, industrial X-ray image processing, microscopic imaging etc. Image enhancement is a processing on image in order to make it more appropriate for certain applications. It is mainly utilized to improve the visual effects and the clarity of the image, or to make the original image more conducive for computer to process [1]. Generally, an image may have poor dynamic range or distortion due to the poor quality of the imaging devices or the adverse external conditions at the time of acquisition. this property is not a desirable one in certain applications. The technologies of digital cameras have a great progress recently. We can get the digital photos easily and directly since the digital cameras save the trouble of film processing.

However, when we photograph a scene by the digital cameras and obtain a two-dimensional array of “brightness” value, these values are rarely the true measurements of the relative radiance in the scene [3]. In general, the range of light luminance the human eye can sense is much larger than the dynamic range of most digital cameras and display devices. And the human visual system also has the brightness adaptation ability, it accomplishes the large variation by changes in the overall sensitivity [4] [5]. However, the range of light brightness we can produce by the cameras or image sensors spans at a very limited dynamic range. It means that we will lose the detail information in either light or dark areas when we take a photo in the scenes with dark shadows and bright light sources, i.e., it has high dynamic range. Obviously, some enhancement methods are necessary for improving the photos effectively [6] [7]. The traditional photographers usually need to enhance their photos in the darkroom; however, the processing is not only time-consuming but also expensive. In recent years, the digital cameras are very popular; we can get the digital photos directly. Now we can adjust our photos easily by using the commercial image-editing software, for example Adobe Photoshop, U lead Photo impact, etc., in the computer. Unfortunately, most of these works require professional knowledge for many parameter settings. Obviously, it is not friendly and suitable for most end users of digital cameras. Some software provides the automatic enhancement function for simplifying the process, but in practice they don’t work well in many cases, especially for the photos with high contrast or high dynamic range. In many signal and image processing applications, it is necessary to smooth the noisy signals while at the same time preserving the edge information. The most commonly used smoothing techniques are linear filtering, averaging filtering and median filtering. The linear filters smooth the noisy signals and also the sharp edges. The median of a group, containing an odd number of elements, is defined as the middle element, when the elements of the group are sorted. The median computed at this operation is called the running or the moving median. Since the size of the window is constant, the number of incoming elements is equal to the number of outgoing elements. The structure of the paper is arranged as follows: section 1 included the introduction and section 2 included the methodology of the proposed scheme. The proposed method is explained with many details in Section 3. Section 4 included the results. Conclusions are shown in Section 5.

II. METHODOLOGY

A. Image Enhancement

Image enhancement operation improves the qualities of an image. They can be used to improve an image’s contrast and brightness characteristics, reduce its noise content or sharpen its details. In view of the wide usage of loosely defined terms covering the general topic of image-enhancement, it is appropriate to give a precise definition of what this term denotes within the present context. Other terms such as image-processing are often used as synonyms, along with those such as image-restoration and image-manipulation, and catch-all phrases such as photo-editing are now widely used in the an ever-growing modern circle of consumer digital-imaging. But all these and other common terms are frequently used interchangeably, and mean quite different things in different contexts. For the present purposes we define image-enhancement, in the sense used here, with the help of Figure 1. Due to common usage, it is first necessary to separate out those common and already well-served and widespread image-manipulations that may be thought of as falling under the general heading of digital “good-housekeeping”. These include the ability to change the si and format of the image, to crop and rotate the image to choice, to compress the image for digital transmission, etc.

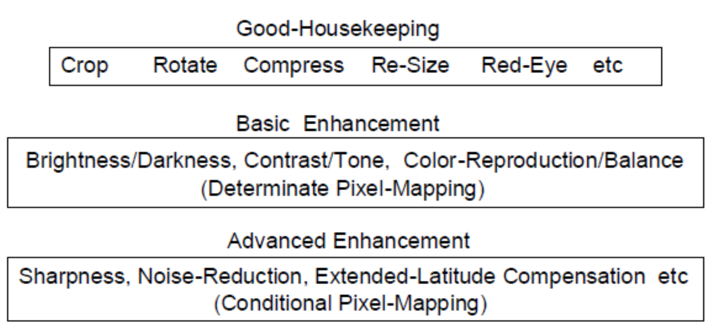

Fig. 1. Classification of Image-Enhancement Activities and Manipulations.

Perhaps curiously at first sight, we include here for convenience what is actually an advanced topic of image-segmentation, namely that of red-eye reduction and removal, since due to shrinking digital camera sizes and optics this problem has revisited the world of photography in its new digital guise, and in some imaging software packages this is actually the dominant remedial component [8].

Under the heading of basic enhancement in Figure 1, we include all those image attributes that may be thought of as the digital surrogates in the translation from classical analog tone- and color- reproduction theory. These represent all aspects of the image relationship to the original scene in terms of its perceived brightness across all regions of the image, likewise the color reproduction, and the tone or contrast associated with each brightness region of the image. This area of image enhancement that we label here as „basic" now has the special further assumed property whereby all image manipulations within this domain are obtained within the rule of determinate pixel mapping. In other words, only enhancements are assumed permissible which operate in a predetermined manner on each pixel, independent of the state of any adjoining pixel, or groups of pixels. The classification of these latter techniques as „Basic Enhancement".

Image enhancement plays a fundamental role in many image processing applications where human beings (the experts) make decisions depended on the image information. But some problems arise in the interface between the observer and the machine. In the image processing, we usually use some objective quality criteria to ascertain the goodness of the results. Histogram Equalization.

For a given image X, the probability density function p (Xm) is defined as

$$p(X_m) =$$

For m = 0, 1, …, L – 1, where nm represents the number of times that the level Xm appears in the input image X and n is the total number of samples in the input image. Note that p (Xm) is associated with the histogram of the input image which represents the number of pixels that have a specific intensity Xm. In fact, a plot of nm vs. Xm is known histogram of X. Based on the probability density function; the cumulative density function is defined as

$$c(x) = \sum_{j=0}^{m} p(X_j)$$

Where Xm = x, for m = 0, 1, …., L – 1. Note that c (XL-1) = 1 by definition. HE is a scheme that maps the input image into the entire dynamic range, (X0, XL-1), by using the cumulative density function as a transform function. Let's define a transform function f(x) based on the cumulative density function as

$$f(x) = X_0 + (X_{L-1} - X_0)c(x)$$

Then the output image of the HE, Y = {Y (i, j)}, can be expressed as

$$\mathbf{Y} = f(\mathbf{X}) = \{\mathrm{f(X(i, j)} \mid \forall X(i.j) \in X\}$$

The high performance of the HE in enhancing the contrast of an image as a consequence of the dynamic range expansion, besides, HE also flattens a histogram. Based on information theory, entropy of message source will get the maximum value when the message has uniform distribution property.

B. Wavelet Transform

The generic form for a one-dimensional (1-D) wavelet transform is shown in Figure 2. Here a signal is passed through a low pass and high pass filter, h and g, respectively, then down sampled by a factor of two, constituting one level of transform. Multiple levels or "scales" of the wavelet transform are made by repeating the filtering and decimation process on the low pass branch outputs only. The process is typically carried out for a finite number of levels K and the resulting coefficients, di1(n), i□ {1,….,K} and dK0(n), are called wavelet coefficients.

Referring to Figure 2, half of the output is obtained by filtering the input with filter H(z) and down-sampling by a factor of two, while the other half of the output is obtained by filtering the input with filter G(z) and down-sampling by a factor of two again. H(z) is a low pass filter, while filter G(z) is a high pass filter. The 1-D wavelet transform can be extended to a two-dimensional (2-D) wavelet transform using separable wavelet filters. With separable filters the 2-D transform can be computed by applying a 1-D transform to all the rows of the input and then repeating on all of the columns. Using the Lena image in Figure 3a shows an example of a one-level (K = 1), 2- D wavelet transform. The example is repeated for a two-level (K = 2) wavelet expansion in Figure 3b.

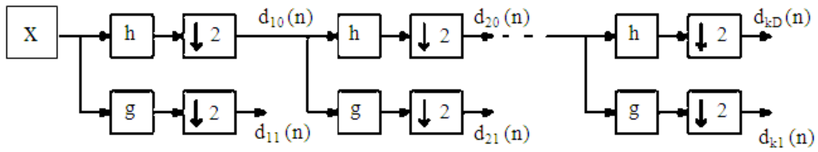

Fig. 2. A K-level, 1-D Wavelet Decomposition.

Fig. 3. (a) One level wavelet transform in both directions of a 2D signal; (b)Two levels of wavelet transform in both directions.

From Figure 3a sub band LL is more important than the other 3 sub bands, as it represents a coarse version of the original image. The multiresolutional features of the wavelet transform have contributed to its popularity.

III. PROPOSED ALGORITHM

The contributions of the paper for enhancing the high-contrast digital photos automatically, which enhances the overall brightness and contrast of images while preserving detail. It is based on a separate the colors of the image by decomposing the image into the color image and the intensity image, two-scale decomposition of the image into a base layer, encoding coarse or large-scale image, and a detail layer. The base layer is obtained using an edge preserving filer. This filter is merely a weighted average of the local neighborhood samples, where the weights are computed based on temporal and radiometric distances between the center sample and the neighboring samples. The histogram equalization method is used to improve the brightness and contrast of the base layer image. The wavelet transformation is used to enhance the color information. Finally, we restore the details back. The overall flowchart of the proposed method is shown in Figure 4.

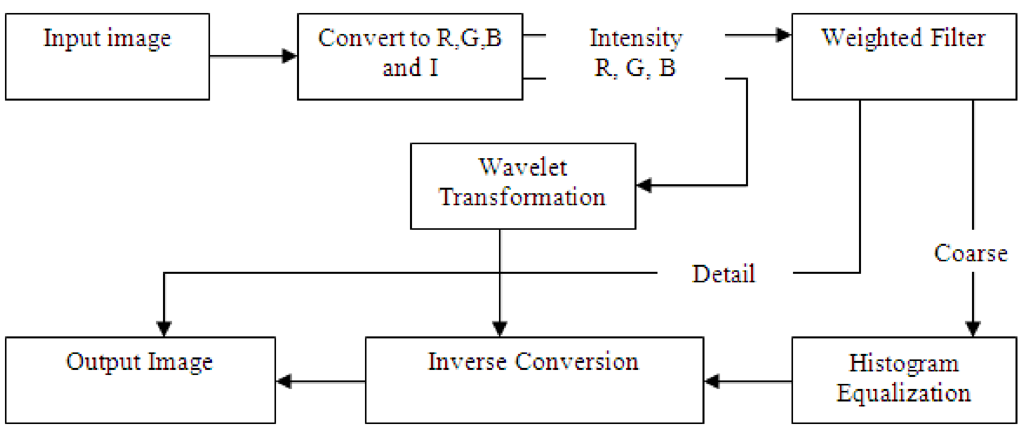

Fig. 4. The Proposed Algorithm.

A. Weighted Filter

Weight filtering is a non-linear filter. It is proposed for smoothing the noise and preserving edges in the image processing. It starts with standard Gaussian filtering in both spatial and intensity domains. The output of the weighted filtering is defined as follows:

$$\hat{X}(k)=\frac{\sum_{n=-w}^{w} W(k,n)X(k-n)}{\sum_{n=-w}^{w} W(k,n)}$$

Where,

X (k) is the original signal, $\hat{X}(k)$ is the smoothed signal by the weight filtering,

w is width of the filter, and W(k,n) is the kernel function of the filter, it can be expressed by

$$W(k,n)=W_S(k,n)\cdot W_R(k,n)$$

Where W_s and W_R are the Gaussian smoothing kernel function in the space domain and intensity domain respectively. Obviously, it suppresses the image noise and preserves the edges where there are large variations in the intensity domain.

B. Color and Intensity Separation

The first step of our method is decomposing the image into the color image and the intensity image. We calculate the intensity of the original image and separate the color information by:

$$I = 0.299 \cdot R + 0.587 \cdot G + 0.114 \cdot B$$

$$\hat{R} = R \div I$$

$$\hat{G} = G \div I$$

$$\hat{B} = B \div I$$

Where *R*, *G*, *B* are the intensity value of R, G, and B channels, *I* is the intensity image,and $\hat{R}$, $\hat{G}$, $\hat{B}$ are the separated color image. In the second step, we obtain the two- scale decomposition of the image into a base layer, encoding coarse or large-scale, and a detail layer by using the weighted filter and wavelet transform. The coarse image and the detail images are shown in Figure 5. Since the human visual system is interested in the detail image, only the base layer image is enhanced by using histogram equalization to improve the global brightness and contrast, thereby the details are preserved.

Fig. 5. Source Image, Coarse Image and Detail Image Respectively.

C. Histogram Equalization

For adjusting the image contrast and brightness, we propose to use histogram equalization to obtain the optimal coarse image. It has the general tendency of spreading the histogram of the input image so that the levels of the histogram-equalized image span a fuller range of the gray scale. The histogram distribution of the image before and after the histogram equalization is shown in Figure 6 and also shows the result of the base layer image enhanced by the histogram equalization. One of the useful advantages of histogram equalization is that it is fully automatic. It is obvious that the dark area is lightened.

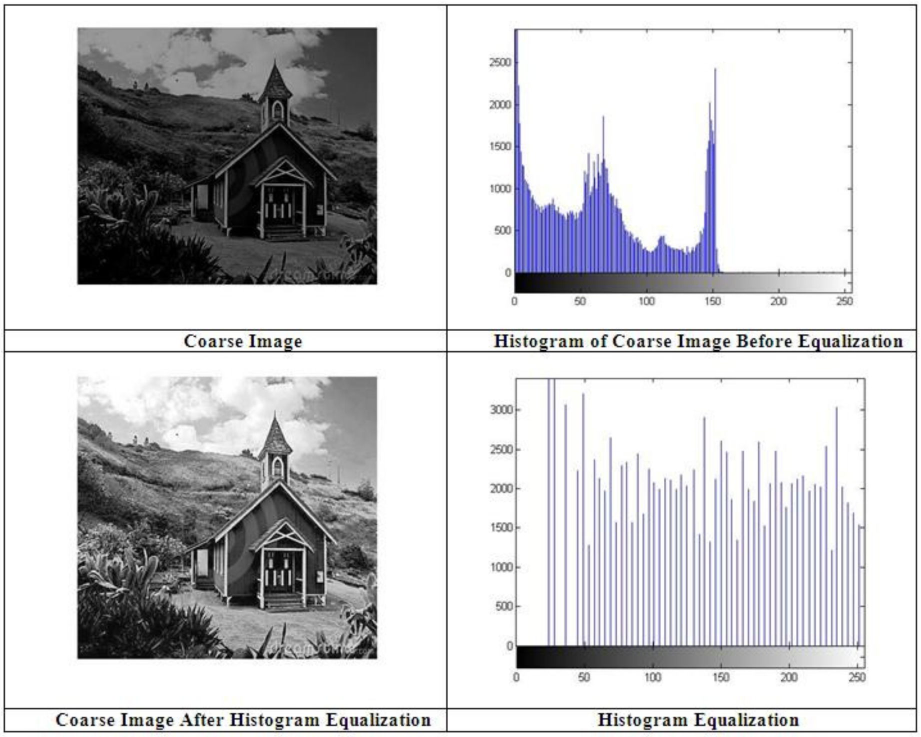

Fig. 6. The Base Layer Image before and after Histogram Equalization.

Then the color information is enhanced by using the wavelet transform and Haar transform as shown in figure 7.

Fig. 7. The Result after Applying Wavelet, Synthesized Image, De-noise Image and Decomposition at level 2.

Fig. 8. The Final Result.

Finally, we combines the detail image and color information back, it achieves the goal of adjusting overall brightness and contrast of image automatically and preserves the details. Figure 8 show the final result of proposed algorithm.

IV. RESULT AND DISCUSSION

Figure 8 shows the final result enhanced automatically by the proposed algorithm. It is clear that the proposed method gets an excellent result, it not only lightens the darker area on the red areas, the trees are visible clearly, but also preserves the details of the light area, the sky and clouds are retained. Compared with the result by using the automatic enhancement function in Adobe Photoshop, we found that the proposed method performs better than the auto-level function in the commercial image-editing software. Figure 9 shows another example of high-contrast photo and the result enhanced automatically by the proposed method. Obviously, the details in the dark area are brightened while the details in highlight area are preserved and not washed out. They demonstrate the powerfulness and effectiveness of the proposed method.

Fig. 9. (a) Original Image. (b) Image Enhanced by the Proposed Method.

V. CONCLUSION

In practice, the automatic enhancement function in the commercial image editing software such as Adobe Photoshop or Ulead Photo impact obtain poor results for the photos with high contrast or high dynamic range. In this paper, we present an image enhancement algorithm based on the weighted filter, histogram equalization and wavelet transformation to solve this problem. The experimental results show that the proposed approach can enhance the high-contrast images effectively; it not only improves the global brightness and contrast of images but also preserves details and remove noise. The other advantage of the proposed method is that it is fully automatic and requires no parameter settings. Therefore, it is useful and suitable for most digital camera users.

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