Enhancement of Mobile Application Images Using Wavelet Transformation

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Abstract

This article introduces a new image Enhancement approach suitable for mobile 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 using wavelet transformation 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 wavelet transformation 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, wavelet transformation and mobile applications**.**

1. Introduction

In the modern information system, digital images have been widely used in a growing number of mobile applications. The effort on image enhancement has been focused mostly on improving the visual perception of images that are unclear because of blur. Contrast of an image is determined by its dynamic range, which is defined as the ratio between the brightest and the darkest pixel intensities. Contrast enhancement techniques have various application areas for enhancing visual quality of low contrast images [1,2].

Noise removal and preservation of useful us information are important aspects of mobile applications image enhancement. A wide variety of methods have been proposed to solve the edge preserving and noise removal problem. Recently, researchers have focused their attention on nonlinear smoothing techniques in the spatial domain. Most of these techniques are local smoothing filters, which replace the center pixel of the neighborhood by an average of selected neighbor pixels.

Mainly focusing on the clarity of the image and the number of computations done for enhancing the image, we developed a novel approach. The edge enhancement done by smoothing filters decreases the complexity and also increases the quality of the image [3]. The basic aim of edge enhancement is to modify the appearance of an image to make it visually more attractive or to improve the visibility of certain features specially the mobile images. The edge enhancement technique enhances all high spatial frequency detail in an image, including edges, lines and points of high gradients. In this approach, the details of edges in an image can be obtained by subtracting a smoothed image from the original. This subtractive smoothing method has been used as the simplest way to obtain high spatial frequency image and this method of edge enhancement makes the image brighter and real edges are detected.

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. 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 and mobile applications 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, Ulead Photoimpact, 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 spite of all these efforts, none of the proposed operators are fully satisfactory in real world mobile applications. They do not lead to satisfactory results when used as a means of identifying locations at which to apply image sharpening. In this paper, the enhancement is applied through a framework of threshold decomposition. This has two advantages: it reduces the edge detection to a simple binary process; and it makes the estimation of edge direction straightforward. Edge detection and direction estimation may be carried out by identifying simple patterns, which are closely related to the Prewitt operators.

Therefore, the quality evaluation was still un-identical in order to compare the results. In this study we proposed a novel approach camera mobile applications image sharpening, we developed new algorithms in intensity evaluation and compare its quality with its original version. The processes were composed of image brightness, edge detection and the standard deviation of the image intensity performed by the Peak Signal to Noise Ratio (PSNR).

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

2. Methodology

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 size and format of the image, to crop and rotate the image to choice, to compress the image for digital transmission, etc. 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].

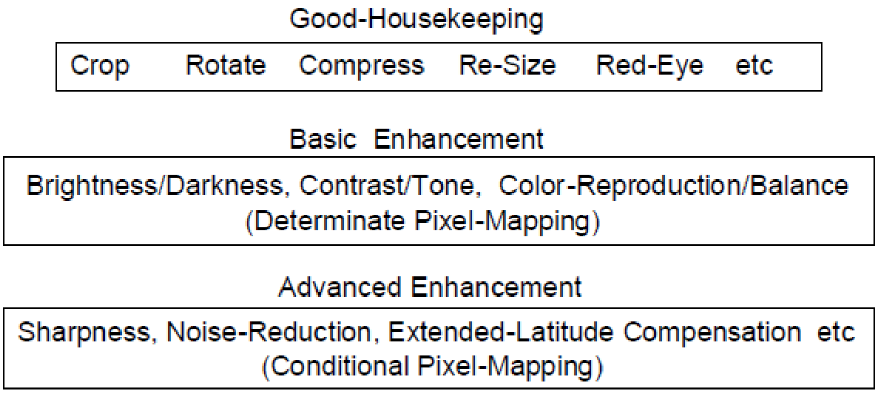


Figure 1. Classification of image-enhancement activities and manipulations

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 [9].

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 lowpass and highpass 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 lowpass branch outputs only. The process is typically carried out for a finite number of levels K and the resulting coefficients, $d_{i1}(n)$, $i \in \{1,\ldots,K\}$ and $d_{K0}(n)$, 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.

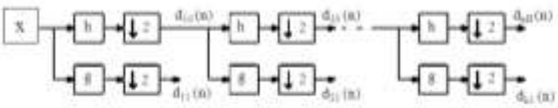


Figure 2: A K-level, 1-D wavelet decomposition.

(a) (b)

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

Wavelet Packets

The concept of wavelet packets (WP) extends the octave-band tree structured filter bank to consist of all possible frequency splits, so that best decomposition topology can be chosen to suit the individuality of different images. Figure (4) shows all of the possible representations of a wavelet packet decomposition of maximum depth two, among which the full tree is at the first position from left.

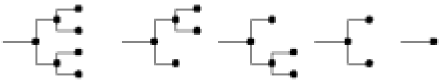


Figure4: Possible wavelet packet trees, maximum depth=2

The best basis subtree is chosen among the entire library of wavelet packet bases. The problem of bit allocation for the decomposed subbands at a target bit rate is concerned with a set of given admissible quantization choices.

Each decomposition divides an image into four quadrants. Two-dimensional frequency partition produces four subbands: LL, LH, HL and HH. General space-frequency segmentation applies the general time-frequency-pruning algorithm to choose between the four-way splits in space or frequency in a space-frequency tree. This algorithm should generate a better optimal basis than both the single-tree and the double-tree. Its basis must be at least as good as the best double-tree/single-tree basis, because the set of possible double-tree/single-tree bases is a subset of the possible SFS bases [10][11].

An example for this partition is shown in Figure (5). It has maximum decomposition depth of five. The white lines indicate that the sub-image is space split, while the black lines indicate that frequency segmentation is applied. If there is no line inside the sub-image, this will indicate that there is no splitting performed on the sub-image.

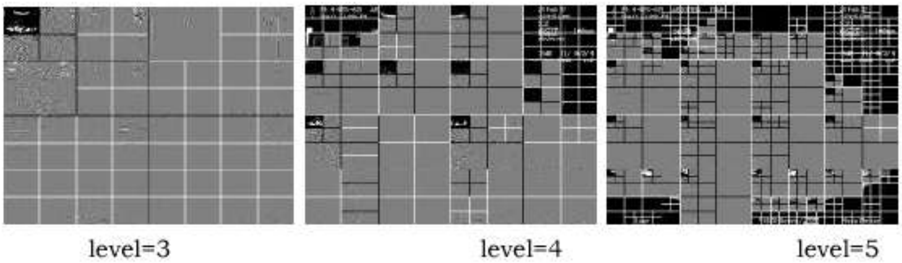


Figure5: partitions

The adaptive partitioning is done as follows:

1. Decompose an image component into blocks of fixed size (say 128 or 64).
2. If the size of the considered subblock is greater than MinSiz then this subblock must be tested to determine whether it requires further partitioning or not.
3. Initial subblocks will be partitioned, either as spatial (space) partitioning or as frequency (DWT) partitioning.
4. The Median Adaptive Predictor (MED) is utilized to evaluate whether the partitioning is performed in space or frequency.
5. There is one parameters have a great effects on selecting an appropriate partitioning types (the threshold). This operation is performed after doing the space and frequency partitioning on the same block, and then selecting partitioning type whose error is less than other and it is higher than a selected threshold.
6. According to these conditions, the partitioning operation is done on all the image block. These operations continue until the block size reaches the MinSiz or they are uniform and the error of MED predictor doesn’t exceed the threshold value.

The algorithm of smoothing is as follows:

1. A block (space partitioning) which is homogeneous is to be filtered by the moving of mean filter.
2. A block (frequency partitioning) which has relative weak edges or un-continued edges, are filtered by the mode filter.
3. A block (reminder) which has sharp edges is to be filtered by the median filter.

3. Proposed Algorithm

The contributions of the paper for enhancing the high-contrast mobile 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 a weighted 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 6.

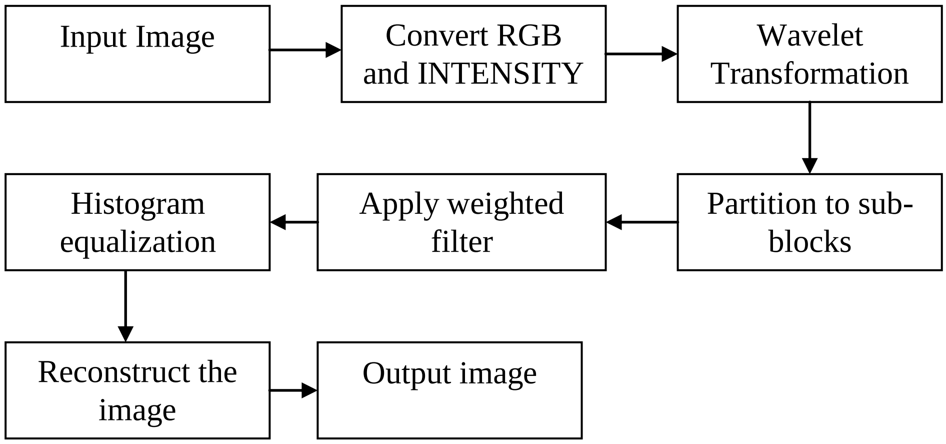


Figure 6. The proposed algorithm

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.

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:

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

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

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

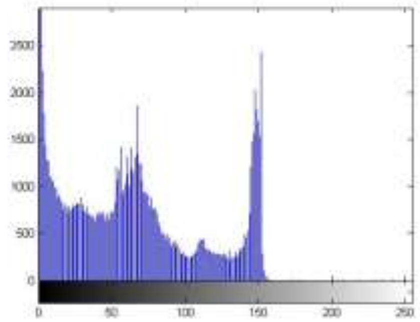
$$\hat{B} = B \div I$$

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 Figure7. 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.

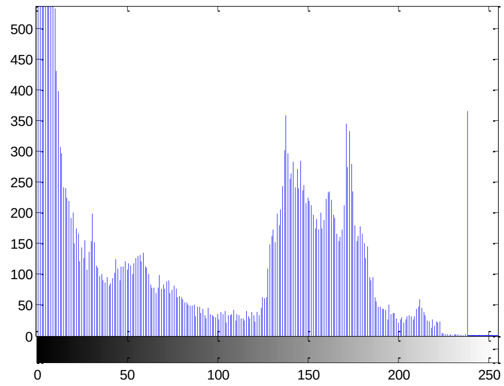
Histogram Equalization

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

 Source Image	 Source Image
 Coarse Image	 Coarse Image
 Detail Image	 Detail Image



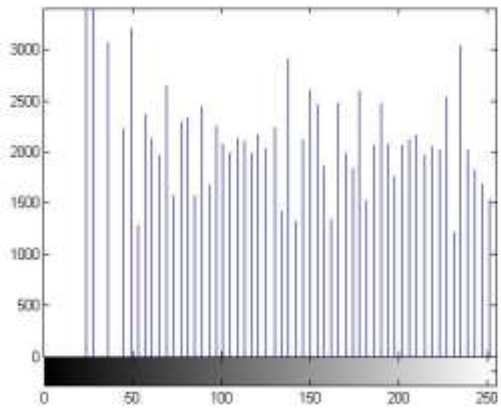
Histogram of Coarse Image before equalization



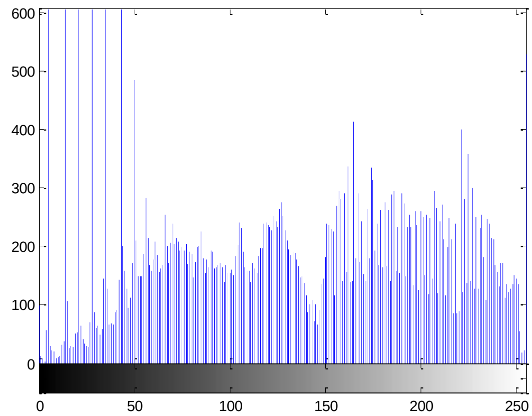
Histogram of Coarse Image before equalization

Coarse Image After Histogram Equalization

Coarse Image After Histogram Equalization

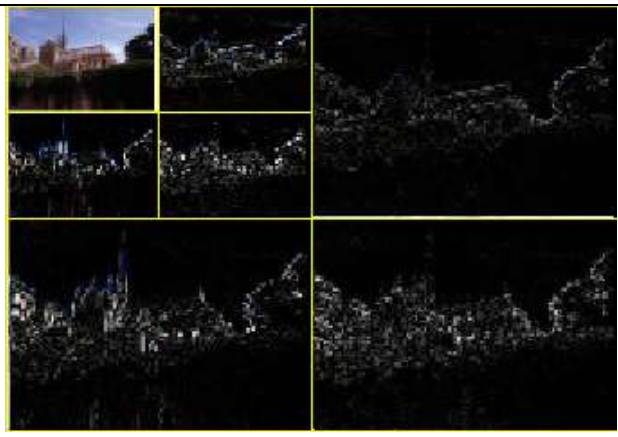


Histogram Equalization



Histogram Equalization

De-noise Image and Decomposition at level 2



De-noise Image and Decomposition at level 2

Final Result

Final Result

Figure7: Source Image, Coarse Image and Detail Image Respectively

4. 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. 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.

Figure8. (a) Original image. (b) Image enhanced by the proposed method.

5. Conclusion

In practice, the automatic enhancement function in the commercial image editing software such as Adobe Photoshop or Ulead Photoimpact 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 mobile applications images.

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