

A Method to Improve the Image Enhancement Result based on Image Fusion

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Abstract—Image enhancement can improve the perception of information. An image taken from a real scene can be divided into several regions according to the need for enhancement. One particular enhancement method improves some regions and actually deteriorates the other regions which have no need for such enhancement or any enhancement at all. This paper proposes a method to improve the enhancement result with image fusion method with evaluation on sharpness. Several different evaluation methods and fusion policies are discussed and compared. The experiment results show that the fusion improves the enhancement results.

Keywords—Image Enhancement; Image Fusion; MSR; Histogram Equalization; Image Quality Measure

I. INTRODUCTION

The aim of image enhancement is to improve the perception in images for human viewers or the image quality evaluated under different application purposes. An image taken from a real scene can be divided into several regions according to the need for enhancement. Most images taken from scenes with nonuniform distributed illumination show the problem of being too contrasty. The images then can be divided into several different regions according to their need for enhancement. Some regions need to be enhanced as contrast compression, some regions need to be enhanced as contrast stretch and some regions need no enhancement at all. The goal to achieve is to improve the overall perception or quality which can hardly be achieved by one single enhancement. As shown in Fig.1(a), the cameraman image, the coat and glove region is too dark and the distant building in the background seems a little faint. Fig.1 (b) is the edge map (detailed in section III) of the origin image. It shows the sharpness of each pixel representing. We find both the coat region and the building regions has low sharpness. Fig.1(c) shows the histogram of image here for future comparing. The coat region and building region both need enhancement, but in contrary directions.

The image enhancement as we know so far can be divided into two big categories: spatial domain methods and frequency domain methods. The spatial domain methods directly operate on image pixels. Gamma correction adjusts the image contrast with a parameter γ , when $\gamma > 1$ the correction compresses the contrast and when $\gamma < 1$, the

correction stretches the contrast. Histogram modification methods stretch the contrast [1][2]. The particular Retinex [3] method offers a good enhancement results on various images varies in illumination condition. But the deficiency still can be observed as shown in Fig.2. Frequency domain methods operate on the results in the transformed domain of frequency. Adaptive filters are studied to provide good detail enhancement [4], Homomorphic filtering method diminishes the effect of nonuniform distributed illumination [5], it compress the dynamic range and result in relatively low contrast as shown in Fig.2. There are various enhancement methods that not listed here, most of them effectively improve the perception of the images, but they do have deficiency. The most intolerable among these problems is the loss of details which jeopardizes the information represented.

The idea of using image fusion to combine different enhanced results comes from the using of fusion technology in combining bracketed exposure images by Mertens et al [6]. Then the fusion method is introduced to improve the deficiency of image enhancement result by Chen et al [7]. To achieve a better fusing performance, we propose an image fusion method based on the evaluation of local image quality. In this paper we use local sharpness for its assumption on evaluation: higher sharpness represents better perception and its simplicity.

The proposed method blends images according to the sharpness evaluation of each pixel neighborhood. The candidate of fusion can be enhanced result by different enhancement methods or the origin image. The selection of candidates will be further discussed in the following content.

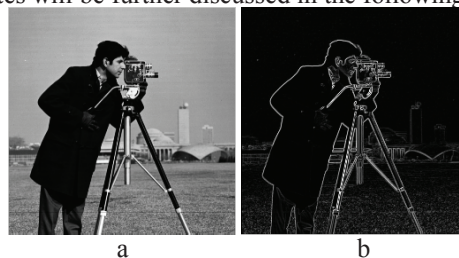


Figure 1. The image that can be divided into different regions according to the need for enhancement: (a) Origin image:cameraman (b) The sharpness map

Experiment results on sample images are shown and the quality measurement results are listed and compared from

which, it can be concluded that the fusion method improves the perception and image quality.

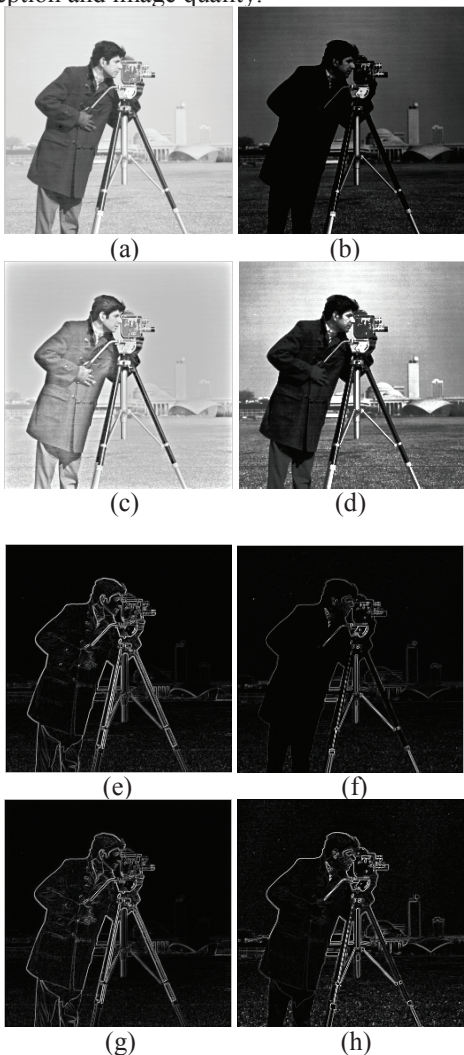


Figure 2. Enhancement results and sharpness maps: (a) gamma correction result ($\gamma=0.3$), (b) gamma correction ($\gamma=3$) result, (c) MSR result, (d) Histogram equalization result. (e)(f)(g)(h) are the sharpness map referred to (a)(b)(c)(d)

II. SELECTION OF FUSION CANDIDATE

The candidates to be fused should be somehow “different”. The candidates can be enhanced results from different enhancement method that represents different characteristics or can be enhanced result and the origin image. It depends on the problems that exist in the image. As shown in Fig1. The coat region is too dark while the building region in the distant scene does not have such a problem. To some degree, we even consider the building region to be too faint that we need to raise the contrast in that region. So in this case, the two “different” candidates should be one: contrast compressed result so the coat region is improved and two: contrast stretched result so the building region is improved. It is easy to find such a couple of candidates: apply gamma correction as in Eq.1 with different gamma

coefficient $\gamma > 1$ and $\gamma < 1$, where γ represents the origin image and s represents the corrected result

$$s = cr^\gamma \quad (1)$$

Here we take $c=1$ and $\gamma=0.3$, $\gamma=3$ respectively represents for the contrast compression result and contrast stretch result. As shown in Fig.2. The fusion results of gamma correction shows: (1) In Fig.2(a) the coat region is lightened compared with the origin image which makes it better for perception, but the building region become more faint. (2) In Fig.2 (b), the building region is strengthened but the coat region become too dark.

Fig.2(c) and Fig.2 (d) shows the result enhanced by MSR as Eq.2 [3] and histogram equalization using the Matlab function as described in Eq.3, we can observe the same problems in these enhancement results. Fig.2(e)~Fig.2(h) show the sharpness map of the enhancement results shown in Fig.2(a)~Fig.2(d), we can find how the enhancement method affect on the results in detail information.

$$R_i(x, y) = \sum_{k=1}^K \omega_k \left[\log I_i(x, y) - \log (F_k(x, y) * I_i(x, y)) \right] \quad (2)$$

where $F(x, y) = C \cdot \exp\left(\frac{x^2 + y^2}{2\sigma^2}\right)$ and we take $K=3$ and $\sigma = [5 \ 50 \ 100]$, $\omega = [1/3 \ 1/3 \ 1/3]$.

$$\tau = |c_1(T(k) - c_0(k))| \quad (3)$$

where c_0 is the cumulative histogram of A, c_1 is the cumulative sum of hgram for all intensities k .

Among these enhancement results, we consider the MSR result and histogram equalization result to be a pair of ideal candidates. We will discuss other factors that affect the fusion performance on these two candidates in the following context.

III. IMAGE FUSION

A. Image Quality Measures

Entropy, standard deviation, average gradient, sharpness and contrast are typical statistic parameters of an image to represent pacific features. In Mertens’ work, they used a weight combining the measures of saturation, well-exposedness and contrast and the contrast is obtained by applying a Laplacian filter on the image [6]. In Goshtasby’s work, he used entropy as the measure to select the most informative pictures among images of a static scene obtained at different exposures [8].

We calculate the statistical parameter in a small region to represent the features of the center pixel to construct a statistical image. We compared the fusion result using STD (standard deviation), contrast (local maximum minus local minimum), average gradient as the statistical parameter as shown in Eq.4-7. The statistical images are shown in Fig.3. Considering the simplicity and the efficiency of representing

the detail information, we use a sharpness parameter to construct the sharpness map with Eq.7. The brighter part of the image represents more sharpness and more detail information. We need to find a fusion method to blend these bright regions in to a better result.

$$STD(x_0, y_0) = \sqrt{(I(x_0, y_0) - \bar{I})^2} \quad (4)$$

Where $I(x_0, y_0)$ is the image pixel on (x_0, y_0) , \bar{I} is the average value of the 3×3 neighborhood pixels..

$$Contrast(x_0, y_0) = \max(N(x_0, y_0)) - \min(N(x_0, y_0)) \quad (5)$$

Where $N(x_0, y_0)$ is the 3×3 neighborhood of pixel in (x_0, y_0)

$$\bar{G}(x_0, y_0) = \frac{1}{9} \sum_{x=x_0-1}^{x=x_0+1} \sum_{y=y_0-1}^{y=y_0+1} \sqrt{\left(\frac{\partial I(x_0, y_0)}{\partial x}\right)^2 + \left(\frac{\partial I(x_0, y_0)}{\partial y}\right)^2} / 2 \quad (6)$$

$\bar{G}(x_0, y_0)$ represents the average gradient in the 3×3 neighborhood of the center pixel (x_0, y_0)

$$S(x_0, y_0) = \sqrt{\frac{(I(x_0, y_0) - I(x_0 - 1, y_0))^2 - (I(x_0, y_0) - I(x_0, y_0 - 1))^2}{2}} \quad (7)$$

$S(x_0, y_0)$ represents the sharpness measure of pixel in (x_0, y_0) .

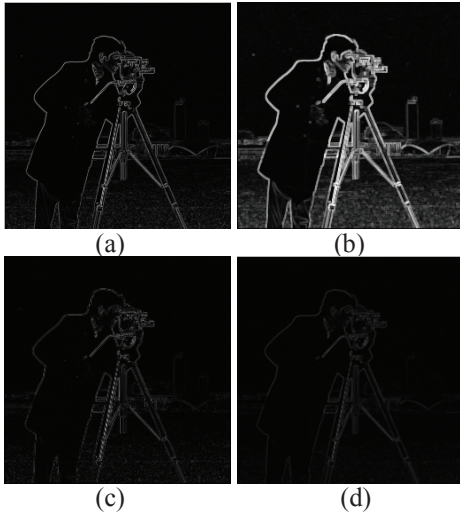


Figure 3. Statistical maps of the origin image: (a) Sharpness map (b) Contrast map (c) STD map (d) Average Gradient map

B. Image Fusion

Based on the sharpness map above, we propose a image fusion function as shown in Eq.8

$$\bar{R} = \bar{W} \cdot \bar{I}_1 + (1 - \bar{W}) \cdot \bar{I}_2 \quad (8)$$

where \bar{W} is the weight function and it is obtained by Eq.9.

$$W(x_0, y_0) = 1 / \left(1 + \exp\left(-\left(\bar{D}(x_0, y_0)\right)\right)\right) \quad (9)$$

Where $D = (x_0, y_0) = S_1(x_0, y_0) - S_2(x_0, y_0)$ and \bar{D} is the normalization result scaled to $[0 \ 1]$ of D .

By these equations we will get an image blend the candidates in a way that make the candidate who has more sharpness be in the dominant position in the fusion result.

C. For Color Image

The method mentioned above is for gray images, for color images, we transform the images into HSV color space and process on the luminance component V and then blend with the original hue and saturation, transform the image back to RGB space for showing.

IV. EXPERIMENTAL RESULTS

In this section, we test our fusion strategy for improving the overall clarity of the image.

As the reason mentioned in section II, we compared the fusion results blending MSR, Gamma Correction and Histogram Equalization result respectively with the origin cameraman image. Fig.4. shows the fusion result and their local sharpness map.

As a discussion of the selection of quality measure, we compared the measures of: contrast map, STD map, average gradient map and sharpness map, in Fig.3.

Fig.4 shows the experimental results on gray and color images using fusion with sharpness evaluation. The selection of fusion candidates are MSR and histogram equalization results.

V. CONCLUSIONS

In this paper, we discussed the method to improve the image enhancement result with fusion method. We discussed the selection of fusion candidates and the MSR result and histogram equalization result are considered an ideal pair of candidates. We discussed the selection of quality measure and we proposed a fusion strategy with the evaluation of local statistical feature: sharpness. Experimental results demonstrate that the image fusion improves the enhancement result efficiently as shown in Fig.4.



Figure 4. Fusion Results of MSR result and histogram equalization result: (a) Origin Images (b) Histogram equalization result (c) MSR result (d) Fusion result of MSR and histogram equalization.

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