휴대단말기용 소형 디스플레이의 영상 컨트라스트 향상을 위한 변형된 HE 기법 연구

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A Modified HE Technique to Enhance Image Contrast for Scaled Image on Small-sized Mobile Display

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Abstract - This paper proposes the modified image contrast enhancement technique for small-sized display of mobile handset. Sample images are user interface images, in which scaled up wVGA(800×480) from qVGA(320×240) that we can see easily in mobile handset. The display size of mobile handset is relatively small, so the goal of this paper is to simplify image contrast enhancement algorithm based on conventional HE (Histogram Equalization) algorithm and improve computational effectiveness to minimize power consumption in real hardware IC. In this paper, we adopt HE technique, which is classical and widely used for image contrast enhancement. At first, the input frame image is partitioned to temporal sub-frames and then analyzes gray level histogram of each sub-frame. In case that the analyzed histogram of some sub-frames deviates so much from reference level (it means that the sub-frame image components consist of too bright ones or dark ones), apply DHE(Dynamic Histogram Equalization) algorithm. In the other case, apply classical Histogram Linearization (or Global HE) algorithm. Also we compare the HE technique with gamma LUT (Look-Up Table) method, which is known as the simplest technique to enhance image contrast.

Keywords: Histogram Equalization, Mobile Display, Contrast Enhancement, Look-Up Table

1. Introduction

Histogram equalization (HE) is a very popular technique for enhancing the contrast of an image [1]. It is widely used for medical image processing and as a preprocessing step in speech recognition, texture synthesis, and many other image/video processing applications [1,2].

Nevertheless, HE technique is not commonly used in consumer electronics such as small sized mobile display, TV receiver and computer monitor. Many researches have been done on HE and it is found that HE has better performance on almost all types of images. HE performs its operation by remapping the gray levels of the image based on the probability distribution of the input gray levels [4].

HE method can be categorized into two types: global and local histogram equalization. Global histogram equalization uses the histogram information of the whole input image as its transformation function. This global HE method is simple and powerful, but it cannot be adapted to local brightness features of the input image because it uses only global histogram information over the whole image.

This fact limits the contrast-stretching ratio in some parts of the image, which causes significant contrast losses in the back ground and other small regions. To overcome this limitation, a local histogram equalization method has been developed, which can also be termed block-overlapped histogram equalization [5]. In this method, a rectangular sub-block of the input image is first defined and histogram of that region is obtained, then its HE function is determined.

In HE, higher histogram components dominate the lower parts. On the other hand, in dynamic histogram equalization technique, a partitioning operation is performed over the input histogram to chop it into some sub-histograms so that they have no dominating component in them. Then each sub-histogram goes through HE and is allowed to occupy a specified gray level range in the enhanced output image [6]. Although most of the researches are performed for VGA image, wVGA image is not explored yet. Recently, image contrast enhancement on scaled wVGA image for small-sized mobile display is an important research issue.

To perform the image contrast enhancement on scaled wVGA image, we propose a modified histogram equalization technique in this paper. The proposed HE technique employs a partitioning operation over the input scaled image not over the input histogram unlike the existing DHE [6]. Then each sub-image is converted to corresponding histogram and each histogram is compared with a reference value. Depending upon the difference between each sub-image histogram value with the reference histogram value, and all the histograms are combined to generate the resultant contrast enhanced image output by applying DHE.

2. HE Techniques Overview

2.1 Global Histogram Equalization (GHE)

In histogram equalization [5], the transformation function $C(r_k)$ is given in (1)

$$s_k = C(r_k) = \sum_{i=0}^{k} P(r_i) = \sum_{i=0}^{k} \frac{n_i}{n} \tag{1}$$

where, $0 \le S_k \le 1$ and $k = 0, 1, 2, \cdots, L-1$, here L is the maximum gray level value. In (1), n_i represents the number of pixels having gray level r_i, n is the total number of pixels in the input image, and $P(r_i)$ represents the Probability Density Function (PDF) of the input gray level r_i. Based on the PDF, the Cumulative Density function (CDF) is defined as $C(r_k)$. This mapping is called Global Histogram Equalization (GHE) or Histogram Linearization [6].

2.2 Local Histogram Equalization (LHE)

LHE, so-called block-overlapped histogram equalization [5], can obtain overall contrast enhancement, regardless of the location in the input image. LHE defines a sub-block and retrieves its histogram information. Then, histogram equalization is applied for the center pixel of the sub-block using the CDF of that sub-block. Next, the sub-block is moved by one pixel and sub-block histogram equalization is repeated until the end of input image is reached [6]. Since the histogram equalization is performed with each sub-block's local histogram, this local histogram-equalization method can adapt well to the partial light condition of the image. Therefore, the difference of contrast enhancement between objects and background can be omitted.

2.3 Dynamic Histogram Equalization (DHE)

While GHE processes the whole histogram with the transformation function at a time. DHE divides it into a number of sub-histograms until it ensures that no dominating portion is present in any of the newly created sub-histograms. Then a dynamic gray level range is allocated for each sub-histogram to which its gray levels can be mapped by HE [6]. This is done by distributing total available dynamic range of gray levels among the sub histograms based on their dynamic range in input image and cumulative distribution of histogram values. This allotment of stretching range of contrast prevents small features of the input image from being dominated and washed out and ensures a moderate contrast enhancement of each portion of the whole image. At last, for each sub-histogram a separate transformation function is calculated based on the traditional HE method and gray levels of input image are mapped to the output image accordingly.

The whole DHE technique can be divided into three parts. First, the histogram of the input image is partitioned into sub-histograms based on local minima. Then dynamic gray level is allocated to each sub-histogram. Finally, conventional HE is applied to each sub-histogram depending upon this dynamic gray level [6].

3. Modified HE Technique

In the proposed method, our main objective is to apply the image contrast enhancement technique with new algorithm on scaled image for small-sized mobile display. Our modified HE Technique is formally defined by the following procedures:

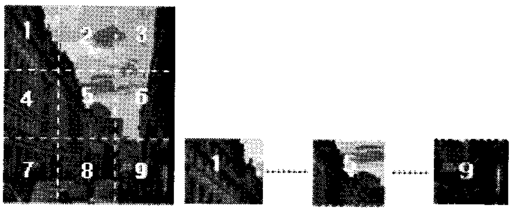
1. Conversion of qVGA to wVGA image.
2. Divide the wVGA image into 3×3 sub-images and represent each sub-image by their entity histogram.
3. Calculation of CDF of each sub-image and comparison of CDF of each sub-image with the reference value.
4. If CDF of each sub-image is greater than zero but less than the reference value, then perform the DHE. Otherwise, skip the DHE operation.
5. Finally, combine all the sub-image histograms and transform to the main image and compare the brightness of the contrast enhanced image with the existing gamma correction technique.

Step 1 is very important issue because in past days most of the mobile displays had been qVGA (320×240) resolution. But, recently, mobile display resolution becomes higher like, wVGA (800×480) and the size becomes bigger (2.8"~3.5"). After scaling, the original input image is partitioned into 3×3 sub-images as shown in Fig. 1. All the sub-images are considered as an individual image and cumulative density functions of the sub-images are denoted by $C_1(r_k)$, $C_2(r_k)$, $\cdots$, $C_9(r_k)$ and are defined as:

$$C_1(r_k) = \sum_{i=0}^{k} P_1(r_i) = \sum_{i=0}^{k} \frac{n_i}{n} \qquad (2)$$

where $k = 0, 1, 2, \cdots, L-1$

In (2) n_i represents the number of pixels having gray level r_i. n is the total number of pixels in each sub-image and $P_1(r_i)$ represents the PDF of the gray level r_i of the input sub-image 1. Based on the PDF, the CDF is defined as $C_1(r_k)$. Similarly the CDF of other sub-images are defined as $C_2(r_k)$, $\cdots$, $C_9(r_k)$. Steps 1 to 5 of the proposed modified HE Technique listed above are carried out. Since the modified HE technique provides more diversity than other techniques, there will be no probability of blocking effect in the image. Hence, modified HE technique makes excellent contrast enhancement for scaled image of small-sized mobile display.

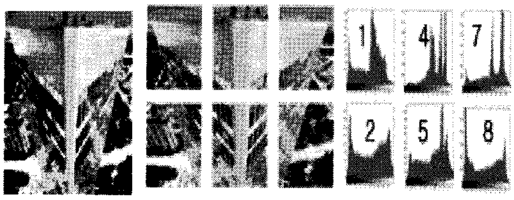


(a) (b)

Fig. 1. (a) wVGA (800x480) image, (b) sub-images.

4.Experimental Results

Fig. 2 shows the segmentation of an image and the histogram of each sub-image. Comparing all histogram with the reference value, it is found that the CDF of sub-images 1, 4, 5, 7, and 9 is less than the reference value. So, the proposed technique is applied on these sub-images and new histogram is found as shown in Fig. 3. The comparison of original image, GHE image and proposed modified HE image are shown in Fig. 4. However, contrast enhancement is not smooth at sub image boundary. So additional image processing is required.



(a) (b) (c)

Fig. 2. (a) original image, (b) 3x3 Sub-images, (c) sub-image histograms.

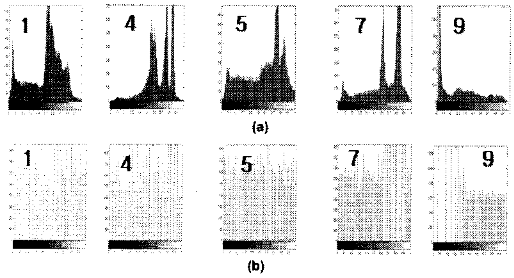
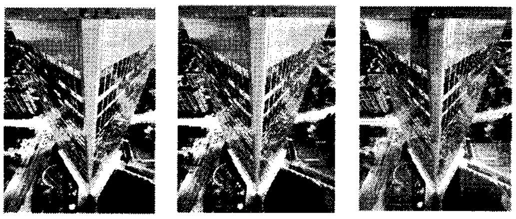


Fig. 3. (a) Original histogram, (b) Modified HEed histogram.



(a) (b) (c)

Fig. 4. (a) Original image, (b) GHEed image, (c) Modified HEed image.

5. Conclusion

We propose a modified approach for contrast enhancement of low-contrast small-size scaled images for mobile display. The ultimate goal of this paper is to propose an effective method that will be useful to improve the image contrast for small-sized mobile display and implement it in real time system.

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