Color Image Enhancement using Contrast Stretching on a Mobile Device

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Abstract— Low quality digital images are still a common problem to all of us. It happens under low lighting condition, interference of atmospheric veil and other conditions. Automated enhancement on a mobile device is still a challenge. This research introduced and implemented an enhancement tool using contrast stretching method. Pixels are stretched within the non-outlier range from the input image. Higher quality images with less noise were produced. This tool is embedded into a mobile device, namely Beagleboard-XM on a Linux environment.

Keywords — contrast stretching, mobile device, color enhancement, embedded, Beagleboard-XM.

I. INTRODUCTION

Digital images are always affected by noise, blurring, incorrect color balance and poor contrast [1]. Most of digital images that can be produced through scanners, digital cameras, video cameras, Charged Coupled Devices (CCD cameras) and web-cam can be easily affected by the these problems. This will lead to low quality images. Image enhancement will be used to minimize the effects of these degradations. This can be done by using a number of image enhancement techniques. Specifically, an enhancement of color image is to process the luminance and color information to make an image has sharp details, rich in color and better visual effect without any distorting or shifting of color [2].

Image processing technique can be divided into two parts which is global and local processing techniques. Contrast enhancement algorithms can be grouped into four main types that global, local, hybrid, and fuzzy methods.

In this research our aim is to propose a contrast stretching method for a mobile device. The method has been implemented and tested under a Linux environment on a mobile device, namely Beagleboard-Xm. It shows a significant improvement in the output images. It is a portable image enhancement device that can be useful in isolated areas.

II. RELATED WORK

In image processing it is well known that the processing technique can be divided into two parts which is global and local processing techniques. The most commonly known contrast enhancement algorithms can be grouped into four main types that are global, local, hybrid, and fuzzy methods.

A. Global Enhancement

Many image processing techniques were developed to handle the problem of high contrast images. Some of the global processing techniques are histogram equalization, gamma correction and logarithmic compression and levels/curves methods. Global methods improve an image from the information of whole image. Duan and Qiu [3] used hierarchical division procedure to divide the luminance range [0, 255] into 256 and control the mapping by using a control parameter. Sun et. al [4] recommended a dynamic specific histogram algorithm to enhance contrast of image for a real-time system due to its simplicity. Mostly the limitation of global processing technique is some features of the images may be lost and some cannot be enhanced properly [5].

B. Local Enhancement

E. Land’s theory [6] which is Retinex based algorithms are efficient techniques working on dynamic range compression and color human constancy [5]. However, although Retinex method is efficient for dynamic range compression, it does not provide good tonal rendition [7].

This is then followed by a Single-Scale Retinex (SSR) model that has been introduced. SSR relies on the ratio of the lightness of a small central field in the region of interest to the average lightness of an extended field [8]. However, the drawbacks of SSR model are the counting with halos and graying out, since the filter size, the optimal value of which depends on the input image [8].

Then, another way to overcome the SSR problem, Multiscale Retinex (MSR) model has been proposed [9]. This method is implemented by processing an input image several times using the SSR with Gaussian filters of various sizes, and the resulting images are weighted and summed to reduce the halos and enhance the local contrast. Color restoration process also is added to reduce the graying out caused by contrast enhancement and averaging of the resulting images. This multiresolution method combines several SSR outputs to produce a single output image which provides good

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dynamic range compression and fine color constancy [9]. In other words, color constancy may be defined as the independence of the perceived color from the color of the light source [10]. In addition, MSR also softens the strongest edges and keeps the faint edges almost untouched [9]. However, the problem of MSR model is no method currently exists for optimizing the parameters of the Gaussian filters.

Another method that is Histogram Equalization (HE) is nonlinear method that usually being implemented for image enhancement. The equalization process is considered as histogram transformation. Here, the target histogram is transformed to its reference histogram which is designated as the uniform distribution [11]. This technique is implemented by collecting the statistics of the image and represents it in a histogram. Commonly, color images are delivered from cameras in red-green-blue (RGB) spaces.

Pizer et al. [12] have developed Adaptive Histogram Equalization (AHE) which is a method that focused on contrast enhancement for both natural images and medical images that are initially poor contrast [11]. Recently, Nilsson et al., 2005, presented the Successive Mean Quantization Transform also known as SMQT. This SMQT technique can be applied on the image enhancement as well as speech processing. In addition, the SMQT can maintain the luminance histogram shape of test image respect to gray-scale image enhancement.

Pei et al. [11] introduces a modified approach of the successive mean quantization transform called Weighted Histogram Separation (WHS). In addition, Pei et al. [11], also proposed a local enhancement approach by using WHS, known as Adaptive Weighted Histogram Separation (AWHS). Besides, a local equalization method has been developed to enhance the contrast of color image and also to extract the details that not deliverable by global histogram equalization [13]. Generally, this method is conducted in three major steps. The steps are independently equalize image sectors or blocks, reduce intensity differences along sector boundaries and lastly, aggregate an enhanced image using a weighted-sum scheme [13].

Guanzhang [14] have proposed a fusion enhancement algorithm. The method aims at color image where the arithmetic inherits the advantage of extending gray level of HE algorithm. Therefore, it is capable to overcome color distortion rather than to enhance image details [14]. Plus, the computation of this method also is not complicated. Thus, it can be applied to real time image processing.

A novel approach called Spatially Controlled Histogram Equalization (SCHE) has been proposed [15], SCHE algorithm employs a partitioning operation over the input histogram to chop it into some sub-histograms. So that, no components is dominated in sub-histograms. Then each subhistogram will run HE algorithm and is allowed to occupy a specified gray level range in the enhanced output image [15]. As the result, SCHE provides consistent detail preservation even in tiny image as well as avoid from over enhancing noises too [15].

Another method for local enhancement is contrast stretching, also known as Normalization is to enhance an image contrast by stretching the range of intensity values it contains. It is different from histogram equalization; contrast stretching is restricted to a linear mapping [16]. The goals of contrast enhancements is to improve the intensity contrast in the input image, highlighting the defect regions whilst leaving the unimportant background regions intact. Thus it improves the interpretability of human perception and provides better input for automated image processing techniques [17]. It is proven that contrast stretching is one of the simplest and efficient methods for enhancing a low quality images.

C. Hybrid Enhancement

Hybrid method is a combination of both global and local enhancement techniques. In these methods, an image will be divided into non-overlap or overly regions, where each region is conquered by global methods. One of hybrid enhancement approaches is partially overlapped sub-block HE (POSHC) technique to achieve contrast enhancement [18]. However, the POSHC face problems in visual quality and computational speed-up [19].

D. Fuzzy Enhancement

The concept of fuzzy contrast enhancement [20] is based on mapping a grayscale image onto a fuzzy plane. This method uses some form of membership function to enhance image also known as fuzzification. The membership values are modified to improve the contrast and then will be inversely transformed through the process of defuzzification to produce the enhanced image. Besides, most of fuzzy enhancement methods need adjustable parameters to have better quality of the final result [19].

III. METHODOLOGY

In order to address the problem of image enhancement in images and to achieve the research objectives, a systematic methodology phases are defined as shown in Fig. 1.

A. Image Acquisition

In this phase, we will use experimental set-up camera to obtain a set of images. The proposed methods will be used to enhance the low quality images. The captured images will provide input to the suggested system and the system will process the images to improve the visibility.

B. Contrast Stretching

From the study it shows that contrast stretching is the most suitable technique to be used in a mobile device. This method will be implemented using the appropriate model.

Contrast stretching method will be developed using object oriented programming language that is Java. This will enable us to easily embed the proposed method into a mobile device.
C. Embed into a Mobile Device

The implemented contrast stretching method will be embedded into a mobile device, that is a Beagleboard-XM, as shown in Fig. 2. Beagleboard-XM is a pocket-sized reference board containing a Texas Instruments Open Multimedia Application Platform (OMAP) 3 system-on-a-chip (SoC) processor, which includes an ARM Cortex-A8 core, Texas Instruments C64x+ digital signal processor (DSP), and onboard graphics engine, as well as integrated dual data rate (DDR) random-access memory (RAM). It is useful and suitable for small projects and for the one who are learning Linux and working on small systems.

The BeagleBoard-xM measures in at 82.55 by 82.55 mm and has a faster CPU core (clocked at 1 GHz compared to the 720 MHz of the BeagleBoard), more RAM (512 MB compared to 256 MB), onboard Ethernet jack, and 4 port USB hub. The BeagleBoard-xM lacks the on board NAND and requires the memory and OS to be stored on to a microSD card.

D. Testing

Testing will be conducted to test the performance of the suggested system. The testing of the system will be based on quality of output image.

IV. IMAGE ENHANCEMENT

The contrast stretching algorithm uses the linear scaling function to the pixel values. Each pixel is scaled using the following function [21]:

\[
P_o = \frac{(P_i - c) \times (b - c)}{(d - c)} + a
\]

Where \(P_o\) is the normalized pixel value; \(P_i\) is the considered pixel value; \(a\) is the minimum value of the desired range; \(b\) is the maximum value of the desired range; \(c\) is the lowest pixel value currently present in the image; \(d\) is the highest pixel value currently present in the image.

Lower and upper limits will be called \(a\) and \(b\), respectively. Next, the histogram of the original image is examined to determine the value limits, where \(c\) determines lower limit and \(d\) determines upper limit in the original picture.

Fig. 2. Beagleboard-XM

Fig. 3. The Contrast Stretching Method

The algorithm works by firstly calculating the maximum and minimum pixel analyzing from the histogram graph. Then, the user needs to define the non-outlier range desired according to the quality of the image. The higher range chosen, the brighter image obtained. The non-outlier range is the range of values or distribution characteristics of values of a selected variable which fall below the upper limit and above the lower limit.
outlier limit. The red and green channel is balanced to be slightly the same to the blue channel. When the contrast stretching algorithm is applied to color images, each channel is stretched using the same scaling to maintain the color ratio [21].

Fig 3, shows the coding for contrast stretching method. The highlighted red box is the main formula or algorithm for this method. The intensity of the RGB color is calculated according to the non-outlier prompted by the user.

V. RESULTS

The testing is carried out on the low quality images affected by low-light intensity and cloudy weather. We have categorized the results according to the value of non-outlier range input by the user.

![Original Image of Cloudy Weather](a)

![Output Images](b)

![Output Images](c)

**Fig. 4. Original Image of Cloudy Weather**

**Fig. 5. Output Images**

<table>
<thead>
<tr>
<th>Non-outlier range</th>
<th>Results</th>
</tr>
</thead>
<tbody>
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<td>1-30</td>
<td>Figure 5 (a)</td>
</tr>
<tr>
<td>31-52</td>
<td>Figure 5 (b)</td>
</tr>
<tr>
<td>53-92</td>
<td>Figure 5 (c)</td>
</tr>
</tbody>
</table>

**TABLE I**

**RESULTS OF CLOUDY IMAGE**

![Original Image of Low-light Intensity](a)

![Original Image of Low-light Intensity](a)

**Fig. 6. Original Image of Low-light Intensity**

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VI. CONCLUSIONS

The proposed tool has shown a significant improvement for images on a mobile device. A contrast stretching method is capable of enhancing low quality images. This was developed and embedded into a mobile device. The tool is suitable to be used at any remote area. Future enhancement can be applied on the existing method by looking at the global contrast stretching method.

REFERENCES


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