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AUTOMATIC CONTRAST LIMITED ADAPTIVE HISTOGRAM EQUALIZATION VIA DUAL GAMMA CORRECTION

C. Anna Palagan[1], P. Sowjanya[2]
Associate Professor[1,2]
Department of ECE
Malla Reddy Engineering College

Abstract- An automatic contrast limited adaptive histogram equalization (CLAHE) for image contrast enhancement is proposed in this paper. We automatically set the clip point for CLAHE based on textureness of a block. Also, we introduce dual gamma correction into CLAHE to achieve contrast enhancement while preserving naturalness. First, we redistribute the histogram of the block in CLAHE based on the dynamic range of each block. Second, we perform dual gamma correction to enhance the luminance especially in dark regions while reducing overenhancement artifacts. Since automatic CLAHE adaptively enhances contrast in each block while boosting luminance, it is very effective in enhancing dark images and daylight ones with strong dark shadows. Moreover, automatic CLAHE is computationally efficient, i.e. more than 35 1024 for contrast enhancement.×frames/sec at 682 resolution, due to the independent block processing Experimental results demonstrate that automatic CLAHE with dual gamma correction achieves good performance in contrast enhancement and outperforms state-of-the-art methods in terms of visual quality and quantitative measures.

Index Terms- Contrast, Histogram, Image enhancement.

I. INTRODUCTION

IMAGE contrast enhancement is the key technology to improve visual quality of digital images. It has been widely used in computer vision, pattern recognition, medical imaging, remote sensing imaging and computational photography. Poor image quality is caused by many factors: Poor image sensors, non-uniform exposure, short shutter cycle, and weak ambient light (weather conditions such as heavy clouds, fog, and lack of sunlight or night scenes). Images captured under these circumstances contain contrast distortions, color fading, and low intensity. Above all, captured images under low light condition often have the characteristic of poor dynamic range, low contrast, and strong noise. In practice, the low light condition would result in confusions of textures and objects, poor performance of detection, segmentation and annoying visual experience. For better image quality, it is required to enhance the contrast of dark images.

Image compression uses algorithms to decrease the size of a file. High resolution cameras produce large image files, ranging from hundreds of kilobytes to megabytes, per the camera's resolution and the image-storage format capacity. High resolution digital cameras record 12 megapixel (1MP = 1,000,000 pixels / 1 million) images, or more, in true color. For example, an image recorded by a 12 MP camera; since each pixel uses 3 bytes to record true color, the uncompressed image would occupy 36,000,000 bytes of memory, a great amount of digital storage for one image, given that cameras must record and store many images to be practical. Faced with large file sizes, both within the camera and a storage disc, image file formats were developed to store such large images.

II. LITERATURE SURVEY

An image is a two-dimensional picture, which has a similar appearance to some subject usually a physical object or a person. Image is a two-dimensional, such as a photograph, screen display, and as well as a threedimensional, such as a statue. They may be captured by optical devices—such as cameras, mirrors, lenses, telescopes, microscopes, etc. and natural objects and phenomena, such as the human eye or water surfaces. The word image is also used in the broader sense of any two-dimensional figure such as a map, a graph, a pie chart, or an abstract painting. In this wider sense, images can also be rendered manually, such as by drawing, painting, carving, rendered automatically by printing or computer graphics technology, or developed by a combination of methods, especially in a pseudo-photograph.

An image is a rectangular grid of pixels. It has a definite height and a definite width counted in pixels. Each pixel is square and has a fixed size on a given display. However different computer monitors may use different sized pixels. The pixels that constitute an image are ordered as a grid (columns and rows); each pixel consists of numbers representing magnitudes of brightness and color.

In general, image enhancement methods are classified into three categories [1]: Non-linear transfer functionbased schemes, histogram-based techniques, and frequency domain methods. Non-linear transfer functions, such as gamma correction and logarithm mapping, directly modify the pixel values based on regulation [2]. Due to their easy adjustment and efficient implementation, non-linear transfer functions are commonly used for contrast enhancement. Among the non-linear transfer functions, gamma correction, which effectively represents the properties of the human visual system (HVS), has been widely used in the past several decades. Gamma correction modifies the digital values of dark images to be comfortable for human eyes.

Histogram modification transforms a uniform distribution of the gray levels for image contrast enhancement [3, 4], which achieves good performance with low computational complexity. The histogram of an image indicates the relationship between gray levels and their corresponding frequency plays a role in obtaining different intervals corresponding to different regions of the input image. Cheng et al. [9] proposed a method based on histogram modification and bilateral Bezier curve (BBC). This method utilized Bezier curve to modify the CDF for smoother results. However, if the slope of the CDF at dark regions was excessively small, under-enhancement in dark regions was inevitable due to the property of the Bezier curve. Instead of using the first-order statistics, some researchers investigated exploiting the spatial information in images. Contextual and variational contrast enhancement (CVC) [10] applied a 2-D histogram to adjust different images, and thus images with high contrast were enhanced not as much as those with low contrast.

III. Proposed Work

Although CLAHE has a good performance in contrast enhancement, it is limited by strong cast shadows when we are processing dark images. Fig. 3 shows the results by CLAHE with different clip points. As the clip point increases, the luminance is enhanced more. However, this luminance enhancement causes over-enhancement in contrast. Thus, the global clip point is not suitable for the enhancement of dark regions. On the other hand, blocks with uniform gray level distribution, i.e. homogeneous regions such as sky and ground, are likely to be processed with a low clip point. Thus, once they are enhanced, halo artifacts appear around image details. On the contrary, the non-uniform block needs the higher clip point so that the texture and details would be effectively enhanced. In image enhancement, it is required to keep its tone. Obviously, CLAHE is not robust enough in boosting the pixel values. Hence, adaptively setting the clip point is of importance in image enhancement. lmax is set to a fixed value, i.e. 255 (8 bits). In this case, the very dark regions cannot be effectively enhanced in this way. Thus, it is required that lmax be set a larger value in certain dark blocks. To adjust the dynamic range of each block, we adopt gamma correction for lmax. In this work, we propose automatic CLAHE for image contrast enhancement that performs gamma correction on each block while adaptively setting the clip point according to the content.

IV. Results and discussion

We perform experiments on a PC with Core Duo 2.33 GHz CPU and 4G RAM using Visual Studio 2010 and Windows 7 operation system. For the tests, we use 5 dark images with a very dark tone (Carnival, Car, Basketball, Campus, Memorial Church), and two daylight images with strong shadows (DSCN and Alley). All test images are normalized to 8 bits, i.e. $0 \sim 255$. The test images have the size from 720×480 to 1368×1824 as shown in Fig. 6. We compare the proposed method with five other methods: CLAHE, AGCWD , ESIHE , MMSICHE , and channel division (ChDiv) . We select CLAHE and AGCWD for comparison because the proposed method improves CLAHE by introducing adaptive gamma correction. Similar to the proposed method, ESIHE and MMSICHE also redistribute the histogram by setting clip points. ESIHE and MMSICHE set the clip point based on mean or median value. Thus, we select them for performance comparison. Moreover, we select ChDiv because it also utilizes a ‘‘divide mechanism’’ which decomposes the dynamic range into three channels of dark, middle and bright. In the proposed method, the block size in CLAHE is 32×32. We empirically set $P = 1.5$ and $\alpha = 100$ in ; and Dthreshold = 50.

V. CONCLUSION

In this paper, we have proposed automatic CLAHE for image contrast enhancement with dual gamma correction. We have introduced dual gamma correction into CLAHE to enhance contrast in an image without tone distortion and overenhancement. First, we have redistributed the block histogram based on the dynamic range of each block in the CLAHE framework. Second, we 1 to boost the entire luminance in the image block.γhave performed the first gamma correction 2 to adjust the contrast in very dark regions.γThen, we conduct the second gamma correction The proposed method adaptively enhances both contrast and luminance in local regions, and thus is very effective in enhancing dark images and daylight ones with strong dark shadows. Also, its computational complexity is very low due to the independent block processing for contrast 682 images. Experimental results×enhancement, i.e. more than 35 frames/sec at 1024 demonstrate that the proposed method outperforms state-ofthe-arts in terms of visual quality and quantitative measurements.

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