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Hue Preserving Improvement in Quality of Colour Image

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ABSTRACT: *Image enhancement is used to improve the quality of an image for visual perception of human beings. In many colour image enhancing techniques for processing intensity and saturation in colour images keeping hue unaffected is the transformation of the image data from RGB space to other colour spaces such as HSL (hue-saturation-lightness), HIS (hue-saturation-intensity), YIQ, HSV (hue-saturation-value), etc. Transforming from one space to another and processing in these spaces usually generate gamut problem, i.e., the values of the variables may not be in their respective intervals. A principle is suggested to make the transformations gamut problem free, using the same principle as class of hue preserving contrast enhancement transformations are proposed, which generalize the existing gray scale contrast intensification techniques to colour images. These transformations are also seen to bypass the above mentioned colour coordinate transformations for image enhancement. In this work, an efficient technique is proposed which can be applied to generalize any linear or non-linear gray-scale contrast enhancement function to the colour domain. The technique provides hue preserved, gamut problem free color contrast enhancement in accordance with the gray-scale contrast enhancing function it generalizes. Results for the proposed color image enhancement technique are better than the currently available techniques such as DCT.*

Keywords*: image enhancement, gamut problem, RGB image enhancement, Discrete Cosine Transform, hue preservation, contrast enhancement.*

1. Introduction

IMAGE enhancement is used to improve the quality of an image for visual perception of human beings. It is also used for low level vision applications. It is a task in which the set of pixel values of one image is transformed to a new set of pixel values so that the new image formed is visually pleasing and is also more suitable for analysis [1]. The main techniques for image enhancement such as contrast stretching, slicing, histogram equalization, for gray scale images are discussed in many books. The generalization of these techniques to colour images is not straight forward. Unlike gray scale images, there are some factors in colour images like hue which need to be properly taken care of for enhancement. Image enhancement plays a fundamentally important role in nearly all of the vision and image processing systems. Image enhancement aims at producing images with improved brightness/contrast and detail, so as to better represent the visual information. It is widely used in many areas, such as vision, remote sensing, dynamic scene analysis, autonomous navigation and biomedical image analysis. Images provide visual representation of the content that is to be examined and allow the users to reflect on them later. They are a powerful data collection medium [1], [2] that is stored easily and used indefinitely. With the advent of digital imaging, a whole new set of possibilities have opened up for professional and amateur users. The amateur users can now easily snap, store, edit and share images [3], while researchers and professional users rely on them to identify areas of interest, scrutinize details and present their findings effectively. Image Enhancement (IE) transforms images to provide better representation of the subtle details. It is an indispensable tool for researchers in a wide variety of fields including (but not limited to) medical imaging, art studies, forensics and atmospheric sciences. It is application specific: an IE technique suitable for one problem might be inadequate for another. For example forensic images/videos employ techniques that resolve the problem of low resolution and motion blur while medical imaging benefits more from increased contrast and sharpness. To cater for such an ever increasing demand of digital imaging, software companies have released commercial softwares [4], [5] for users who want to edit and visually enhance the images. Image processing is the system of mathematically transforming an image, generally to change some characteristics [1]. This includes many applications such as image enhancement, edge detection, object recognition, and noise reduction. Providing digital images with good contrast and detail is required for many important areas such as vision, remote sensing, dynamic scene analysis, autonomous navigation, and biomedical image analysis [2]. Producing visually natural images or modifying an image to better show the visual information contained within the image is a requirement for nearly all vision and image processing methods [3]. Methods for obtaining such images from lower quality images are called image enhancement techniques. Much effort has been spent extracting information from properly enhanced images [4]–[8]. The enhancement task, however, is complicated by the lack of any general unifying theory of image enhancement as well as the lack of an effective quantitative standard of image quality to aid in the design of an image enhancement system. Conventionally, image processing methods such as image enhancement utilize linear operations to manipulate images. Current research in image enhancement employs traditional linear arithmetic to implement algorithms based on the human visual system [9]; deconvolution methods [10] or neural models [11] attempting to undo image degradations; histogram modification with hue preservation [12] and other histogram modification techniques. Hue, saturation and intensity are the attributes of color. Hue is that attribute of a color which decides what kind of color it is, i.e., a red or an orange. In the spectrum each color is at the maximum purity (or strength or richness) that the eye can appreciate, and the spectrum of colors is described as fully saturated. If a saturated color is diluted by being mixed with other colors or with white light, its richness or saturation is decreased. For the purpose of enhancing a color image, it is to be seen that hue should not change for any pixel. If hue is changed then the color gets changed, thereby distorting the image. Consider the case where the pixel values go out of bounds after processing, due to the nonlinear nature of the uniform color spaces, conversion from these spaces with modified intensity and saturation values to RGB space generates gamut problem. In general this problem is tackled either by clipping the out of boundary values to the bounds or by normalization. Clipping the values to the bounds creates undesired shift of hue and normalization reduces some of the achieved intensity in the process of enhancement which is against its objective.

2. DCT Image Enhancement Technique

Every image is on the bases of color, contrast and brightness, these three primary elements are altered in order to obtain enhanced image. Thus direct observation and recorded color images of the same scenes are often strikingly different because human visual perception computes the conscious representation with vivid color and detail in shadows, and with resistance to spectral shifts in the scene illuminant [2, 4].

1. Read the Image.
2. Resize that image for applying DCT Compression.
3. Convert into ycbcr color space
4. Convert luminance part of the input image into vector.
5. Calculate the scaling coefficient from this image.
6. Apply DCT for all three color spaces.
7. Convert image into vector for this compressed images.
8. Apply the scaling coefficient into compressed image in all three color spaces.

I. For brightness→Scale Only DC Coefficients.
II. For contrast→Scale DC and AC Coefficients.
III. For color→Scale DC and AC Coefficients using function (use all three colors Information)

9. Convert vector into image.
10. Apply inverse DCT.
11. Convert into RGB color space.

YCbCr or Y'CbCr is a family of color space used as a part of the color image pipeline in video and digital photography systems. Y′ is the luma component and CB and CR are the blue-difference and red-difference chroma components. Y' (with prime) is distinguished from Y which is luminance; meaning that light intensity is non-linearly encoded using gamma .Y image is essentially a greyscale copy of the main image. Y'CbCr is not an absolute color space; it is a way of encoding RGB information. The actual color displayed depends on the actual RGB colorants used to display the signal. Therefore a value expressed as Y'CbCr is only predictable if standard RGB colorants. YCbCr and Y'CbCr are a practical approximation to color processing and perceptual uniformity, where the primary colours corresponding roughly to Red, Green and Blue are processed into perceptually meaningful information [4,9]. By doing this, subsequent image/video processing, transmission and storage can do operations and introduce errors in perceptually meaningful ways. Y'CbCr is used to separate out a luma signal (Y') that can be stored with high resolution or transmitted at high bandwidth, and two chroma components (CB and CR) that can be bandwidth reduced, subsampled, compressed, or otherwise treated separately for improved system efficiency. Discrete cosine transforms (DCT) DCT and DST is the fastest transform in the existing transforms. But DCT is more commonly used in image compression algorithms compared to DST because it reduces the number of computational complexity. The 2-D image of the DCT equation is given by $\{x(m,n),0\leq m\geq N-1,0\leq n\leq N-1\}$ The coefficient C(0,0) is the DC coefficient and the remaining are the AC coefficients for the block.

3. Inverse discrete cosine transforms (IDCT)

The 2-D image of the IDCT equation is given by $\{c(k,l),0\leq k\geq N-1,0\leq l\leq N-1\}$Here also the coefficient X(0,0) is the DC coefficient and the remaining are the AC coefficients for the block. Generation of Many image and video compression schemes perform the discrete cosine transform (DCT) to represent image data in frequency space. An analysis of a broad suite of images confirms previous finding that a Laplacian distribution can be used to model the luminance AC coefficients [7]. This model is expanded and applied to color space (Cr/Cb) coefficients. In MPEG, the DCT is used to code interframe prediction error terms. The distribution of these coefficients is explored. Finally, the distribution model is applied to improve dynamic. Many digital image and video compression schemes use a blockbased Discrete Cosine Transform (DCT) as the transform coding. In particular JPEG and MPEG use the DCT to concentrate image information. Image compression systems often divide each image into multiple planes, one for luminance (brightness) and two for color (for example chrominance-red and chrominanceblue). The images are also spatially divided into blocks, usually 8x8 pixels. The DCT is applied to each block in each plane and the results are quantized and run-length encoded (with additional Huffman or arithmetic coding).

4. Image Enhancement Applications

IE has contributed to research advancement in a variety of fields. Some of the areas in which IE has wide application are noted below.

1. In forensics [7], [8], [9], IE is used for identification, evidence gathering and surveillance. Images obtained from fingerprint detection, security videos analysis and crime scene investigations are enhanced to help in identification of culprits and protection of victims.
2. In atmospheric sciences [10], [11], [12], IE is used to reduce the effects of haze, fog, mist and turbulent weather for meteorological observations. It helps in detecting shape and structure of remote objects in environment sensing. Satellite images undergo image restoration and enhancement to remove noise.
3. Astrophotography faces challenges due to light and noise pollution that can be minimized by IE [4]. For real time

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sharpening and contrast enhancement several cameras have in-built IE functions. Moreover, numerous softwares [5-6], allow editing such images to provide better and vivid results.

4. In oceanography the study of images reveals interesting features of water flow, sediment concentration, geomorphology and bathymetric patterns to name a few. These features are more clearly observable in images that are digitally enhanced to overcome the problem of moving targets, deficiency of light and obscure surroundings.

5. IE techniques when applied to pictures and videos help the visually impaired in reading small print, using computers, and television and face recognition [7]. Several studies have been conducted [8-10] that highlight the need and value of using IE for the visually impaired.

6. Virtual restoration of historic paintings and artifacts [11] often employs the techniques of IE in order to reduce stains and crevices. Color contrast enhancement, sharpening and brightening are just some of the techniques used to make the images vivid. IE is a powerful tool for restorers who can make informed decisions by viewing the results of restoring a painting beforehand. It is equally useful in discerning text from worn-out historic documents [12].

7. In the field of e-learning, IE is used to clarify the contents of chalkboard as viewed on streamed video; it improves the content readability and helps students in focusing on the text [3]. Similarly, collaboration [4] through the whiteboard is facilitated by enhancing the shared data and diminishing artifacts like shadows and blemishes.

8. Medical imaging [5-7], uses IE techniques for reducing noise and sharpening details to improve the visual representation of the image. Since minute details play a critical role in diagnosis and treatment of disease, it is essential to highlight important features while displaying medical images. This makes IE a necessary aiding tool for viewing anatomic areas in MRI, ultrasound and x-rays to name a few.

9. Numerous other fields including law enforcement, microbiology, biomedicine, bacteriology, climatology, meteorology, etc., benefit from various IE techniques. These benefits are not limited to professional studies and businesses but extend to the common users who employ IE to cosmetically enhance and correct their images.

5. Methodology

A novel scheme is proposed to avoid gamut problem arising during the process of enhancement. This scheme is used to enhance the intensity of colour images using a general hue preserving contrast enhancement function.

The proposed hue preserving color image contrast enhancement algorithm that will avoid the gamut problem. Furthermore, by taking care of the simple architectural principles of processors, the proposed algorithm has been made computationally very efficient and fast. The algorithm is given below:

Repeat for every pixel:

(i) Collecting required information

Find the maximum, minimum and intermediate out of the R, G and B values xmin, xmax and xin term respectively.

(ii) Contrast Enhancement

para=128 ('=' is for assignment)
If (xmax – xmin) < para
Then:
[xnorm = (float) x intermediate / 255
alpha = grayFunc(xnorm) / xnorm
If (alpha* (float)xmax) > 255
Then:
{xnorm = xmax / 255
alpha = grayFunc(xnorm) / xnorm}
x1 = alpha * x1
x2 = alpha * x2
x3 = alpha * x3

6. Results

Figure 1: Original Image

Figure 2: Enhanced image using DCT adjustment

Figure 3: Enhanced image using proposed technique

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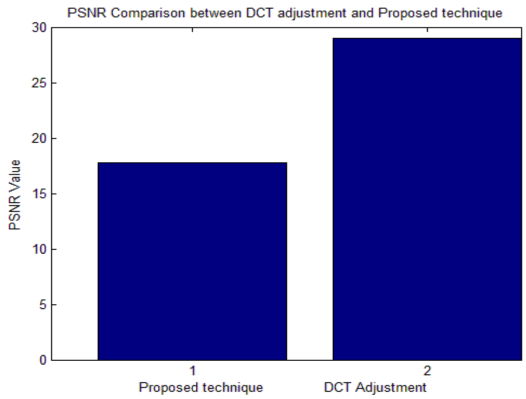

Figure 4: PSNR Comparison between DCT adjustment and proposed technique

Figure 1 shows the original image of a girl. Figure 2 shows the enhanced image using DCT technique. DCT technique enhances the figure but it introduce gamut problem in the image. But our proposed technique avoids the gamut problem, as you can see it figure 3. Figure 4 shows the bar graph between adjustment and proposed technique. It shows that although PSNR value of proposed technique is relatively less as compared to DCT technique, but it enhances the figure without introducing gamut problem.
The proposed algorithm also applied to various figures as shown below.

Figure 5: Original Image

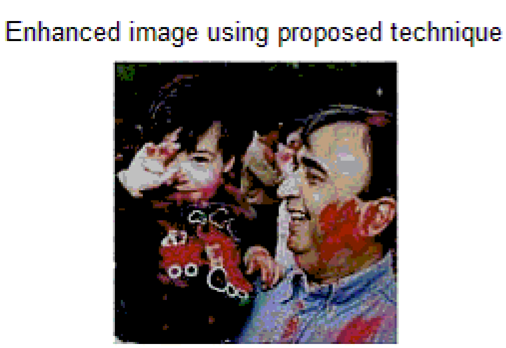

Figure 6: Enhanced image using proposed technique

Figure 5 shows the original image. Figure 6 shows the enhanced image using proposed technique.

Figure 7: Original Image

Figure 8: Enhanced image using proposed technique

Figure 7 shows the original image. Figure 8 shows the enhanced image using proposed technique.

7. Conclusion and Future work

From the above discussion and experimental results, it can be concluded that simple techniques developed using the basic principles related to a problems domain can surpass highly complicated and mathematically elegant techniques with respect to the quality of the output produced. The simple efficient technique proposed in this article produces better results than the best of a number of earlier techniques implied for the solution of the same problem. And these better results are produced in spite of the fact that this proposed algorithm is much faster than the others addressing the same problem. Hence, the proposed algorithm of this article is an efficient and reliable choice for hue preserving, gamut problem free contrast enhancement of colored images. The overall enhancement obtained by the proposed scheme is mainly dependent on the already existing different contrast enhancement functions for grey scale images. These contrast enhancement functions for grey scale images are generalized to enhance the intensity of the color images, keeping the hue intact. A novel scheme is proposed to avoid gamut problem arising during the process of enhancement. This scheme is used to enhance the intensity of color images using a general hue preserving contrast enhancement function.

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But, however image became somewhat darker, this is due to normalization of R, G and B values. In future, we can to eliminate this drawback either using the same method without normalizing R, G and B or using the normalization corrections.

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