Contrast Image Enhancement Using Luminance Component Based on Wavelet Transform

[1] Sachin Luthra,[2] Mr.Ajay Singh Dhabariya
[1]M.Tech,CSE Department,Mewar University Chittorgarh,Rajasthan,INDIA
[2]Asst. Professor in Mewar University Chittorgarh,Rajasthan,INDIA

Abstract

The goal of Contrast image enhancement is to improve the image quality so that the resultant image is better than the original image for a specific application or set of objectives. Image enhancement refers to accentuation or sharpening of image features such as edges, boundaries or contrast to make a graphic display more useful for display and analysis. The enhancement process does not increase the inherent information content in the data. But it does increase the dynamic range of the chosen features so that they can be detected easily. There are many image enhancement techniques to obtain satisfactory result, but here I use color image enhancement and I got good results.

1. Introduction

The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques.

2. Image enhancement techniques can be divided into two broad categories:

1. Spatial domain methods, which operate directly on pixels, and
2. Frequency domain methods, which operate on the Fourier transform of an image.

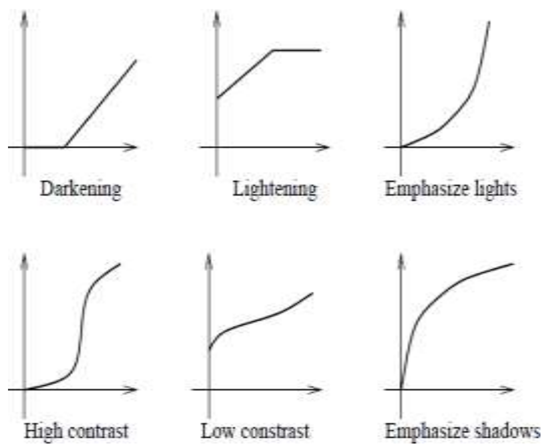
Unfortunately, there is no general theory for determining what is `good' image enhancement when it comes to human perception. If it looks good, it is good! However, when image enhancement techniques are used as pre-processing tools for other image processing techniques, then quantitative measures can determine which techniques are most appropriate.

3. Spatial domain methods

The value of a pixel with coordinates (x; y) in the enhanced image ^ F is the result of performing some operation on the pixels in the neighborhood of (x; y) in the input image, F.[2]
Neighborhoods can be any shape, but usually they are rectangular.

4. Grey scale manipulation

The simplest form of operation is when the operator T acts only on a 1 x 1 pixel neighborhood in the input image, that is ^ F(x; y) depends on the value of F only at (x; y). This is a grey scale transformation or mapping. The simplest case is thresholding where the intensity profile is replaced by a step function, active at a chosen threshold value. In this case any pixel with a grey level below the threshold in the input image gets mapped to 0 in the output image. Other pixels are mapped to 255.[1]



5. Histogram Equalization

Histogram equalization is a common technique for enhancing the appearance of images. Suppose we have an image which is pre dominantly dark. Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed in to the dark end of the histogram. If we could `stretch out' the grey levels at the dark end to produce a more uniformly distributed histogram then the image (see Figure would become much clearer.[4]

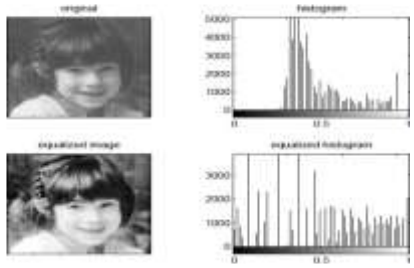


Figure:The original image and its histogram

6. Contrast Enhancement

7. When presented with an image, the task is to understand what is depicted. Through visual processing we recognize objects, interpret their reflectance properties, and resolve the scene's spatial organization. The task is made more difficult if the image is blurry or appears to have low contrast, either on account of poor eyesight or poor image quality. In the scientific and medical imaging fields, low-quality images like those arising from X-ray technology, require enhancement to increase the visibility of important areas. There are thus several methods for enhancing all types of images; here however, focus is placed primarily on the enhancement of photographic or complex images. Contrast enhancement improves image efficacy by easing the separation of objects in a scene, simplifying the understanding of complex and self-occluding objects, by placing emphasis on salient regions and improving the impression of depth. [34

Local Contrast

In natural images, contrast varies spatially over the depicted scene. There may be both large flat areas free of contrast (i.e. a clear sky) and areas with high contrast (i.e. a field of sunflowers). The contrast measures given in the previous section are suitable for simple stimuli, but may not capture the appearance of contrast in a complex image. A Single measure applied over the whole image is susceptible to highlights and shadows and outlier luminance values. Due to two greatly differing regions, a high contrast measure may occur even when overall perceived contrast seems very low. A simple measure could be made local by applying it to each pixel and its surrounding neighborhood. A more perception related metric incorporates findings in vision theory that show local contrast is related to an image's local gradient. Local contrast is modeled as an abrupt change in intensity (i.e. luminance), and the maximum of that change is said to be an edge. Thus edges represent locations of local contrast, and are found by edge detection. So, the magnitude and orientation of edges in an image are a measure of its local contrast. Sharp contrasts (those that produce obvious edges) are measured by calculating the rate of change of intensity, otherwise known as the intensity gradient. These first-derivative methods measure the amount of difference between pixels, and the direction of greatest change. For a host of reasons, including image understanding, computer vision and robotics, edge detection is a fundamental task in image processing, and there are various different algorithms to perform the task. For instance, given the intensity profile of an edge in Figure 2.8(a), the peak in the first-order gradient, shown in Figure 2.8(b), detects edges in the image and thus identifies intensity difference. Approximate gradient calculation can be done efficiently with convolution kernels. [28]

8. Lightness constancy

There are several terms to describe different aspects of seeing light. To begin, light is reflected off a surface to an eye. The amount of physical light is termed luminance. Luminance the physical amount of light reflected off a surface or emitted from a light source in a particular direction, measured in cd/m2 and denoted as Y. Through various levels of physiological and neurological processing, luminance is perceived by a viewer as lightness: Lightness The perceptual response of a human viewer to luminance and is defined by Hunt as "the brightness of objects relative to that of a similarly illuminated white". Denoted L* ("L-star"),

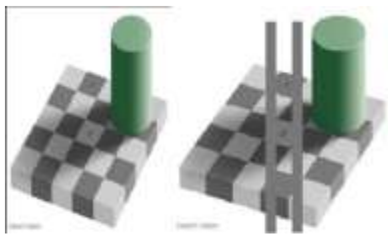


Figure:Lightness constancy illustrated by Edward Adelson's

9. Methodology

Image enhancement is a technology to improve the quality of an image in terms of visual perception of human beings. With the growing quality in image acquisition, image enhancement technologies are more and more needed for many applications. Images are categorized into grey-level images and color images. Each pixel of the grey-level image has only one grey-level value as opposed to color images' pixels; therefore, there have been many algorithms for contrast enhancement for grey-level images. The main techniques for image enhancement such as contrast stretching, slicing, histogram equalization,[10] for grey-level images are discussed in many articles and books. On the other hand, since each pixel of color images consists of color information as well as grey-level information, these typical techniques for grey-level images cannot be applied to color images. Thus, compared with grey- level images, the enhancement of color images is more difficult, and there are much more points to be researched. Some color enhancement methods were proposed. Based on histogram equalization, as the well-known contrast enhancement methods, Buzuloiu proposed an adaptive neighborhood histogram equalization method, and Trahanias proposed a 3D histogram equalization method in RGB cube. Thomas proposed an enhancement method by considering the correlation between the luminance and saturation components of the image locally. A method for enhancing the color contrast in xy-chromaticity diagram was proposed by Lucchese. Shyu suggested a genetic algorithm approach in which the enhancement problem is formulated as an optimization problem. In recent years, multi-scale technologies have been widely used in image processing[11]

10. Color Space

If the visible portion of the light spectrum is divided into three components, the predominant colors are red, green and blue. These three colors are considered the primary colors of the visible light spectrum. The RGB color space, in which color is specified by the amount of Red, Green and Blue present in the color, is known as the most popular color space. RGB is an additive and subtractive model, respectively, defining color in terms of the combination of primaries, whereas HSV color space encapsulates information about a color in terms that are more familiar to humans. In HSV color space,[12] the color is decomposed into hue; saturation and luminance value similar to the way humans tend to perceive color. Ledley's research shows that the performance of HSV color space is good in color improving. Among the three components of HSV color space, hue is the attribute of a color, which decides which color it is. 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. Compared with other perceptually uniform such as CIE LUV color space and CIE Lab color space, it is easier to control the Hue component of color and avoid color shifting in the HSV color space. In our method, we keep hue preserved and apply the enhancement only to luminance and saturation. In Yang's research, they have paid attention to the effect of luminance and saturation to color image enhancement. Therefore, we chose HSV color space for our enhancement method.[13]

11. Luminance Enhancement

We apply wavelet transform and Reverse-S-Shape transform obtained from human visual system to enhance the luminance component. The wavelet transform, or wavelet expansion is to express a signal or function as a linear decomposition based on a group of certain functions. Wavelet analysis, a new mathematics branch developed in recent years, is a perfect combination of harmonic analysis, function analysis, Fourier analysis and numerical analysis. Wavelet analysis has been applied to various research areas. Xu developed a noise filtration method based on the spatial correlation between wavelet coefficients over adjacent scales. Pan proposed an improved schema. In our approach, we exploit the characteristic that wavelet transform can decompose the signals into approximate components and detail components, and the approximate component is enhanced by increasing the contrast. According to the human visual theory, receptive fields on the retina receive light stimuli. Rod cells and cone cells process them. Receptive fields are very common in the retina of many species, and the same arrangement is found in second and higher order neurons. Kobayashi analyzed the feature of human visual system and proposed a Reverse-S- Shape transform to enhance the grey-level image. To obtain the result, we generalize the method to color image processing and applied the transform to the luminance component of the color image.[15]

12. Algorithm

Color Space Conversion

As mentioned before, we apply our enhancement method in HSVcolor space. In general, color images are represented by RGB color space. Therefore the firststepistoconvert RGBcolorspacetoHSVcolor space[16]

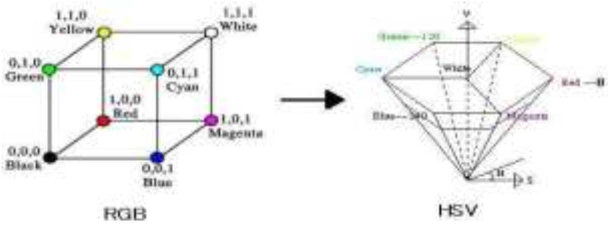


Fig.RGB Color Space and HSV Color Space

$$S = \begin{cases} 0, & if\ MAX = 0 \\ 1 - \frac{MIN}{MAX}, & otherwise \end{cases}$$

13. Luminance Contrast Enhancement

The luminance value, V component in the HSV color space, is enhanced. The wavelet transform can decompose the luminance into approximate component and detail component. We apply a contrast enhancement method for grey-level images to the approximate component and then reconstruct the brightness information by applying inverse Wavelet transform. Thus, the above mentioned process consists of three steps: Wavelet Transform, contrast enhancement and Inverse Wavelet Transform[17]

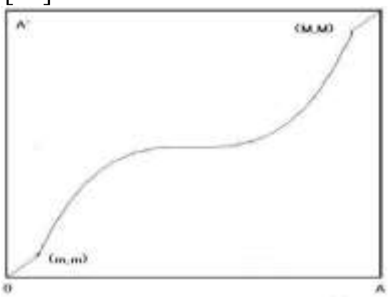


Fig. Coefficient Conversion Mapping Diagram

To assign the threshold mand M,we tried two ways. One is "Manual Assignment", the other is "Automatic Adaptation". The manual assignment is to simply assign the parameters as certain constants. The manual assignment is simple but there is a problem. From the wavelet decomposition equation, we get a set of approximate coefficients. If most of the coefficients are near the maximal value, we need to set a larger threshold otherwise most coefficients are not changed which leads to an ineffective enhancement. The situation is similar when most of the coefficients are near the minimal value. To solve the problem, we use Automatic Adaptation. Automatic Adaptation is to compute the parameters according to the information of the input image. So we compute the threshold m and M to assure: [18]

1. Most of the coefficients are between m and M. The coefficients out of the range [m, M] are not converted.
2. The range [m, M] should not be too small. Otherwise, even if most coefficients are in the range and converted ,the effect of the contrast enhancement is not significant, because the results are also in [m, M]. The computing algorithm includes the following three steps:

1. Assign two constants m0 and M0, which satisfy 0<=m0<M0<=255,andM0-m0>150.For instance,m0=30,M0=200.

$$H = \begin{cases} undefined, & if\ MAX = MIN \\ 60 \times \frac{G-B}{MAX-MIN} + 0, & if\ MAX = R\ and\ G \geq B \\ 60 \times \frac{G-B}{MAX-MIN} + 360, & if\ MAX = R\ and\ G < B \\ 60 \times \frac{B-R}{MAX-MIN} + 120, & if\ MAX = G \\ 60 \times \frac{R-G}{MAX-MIN} + 240, & if\ MAX = B \end{cases}$$

2. Compute m1 and M1 satisfy that there are just 5% of approximate coefficients(A_j)arelessthanm1 and5%of A_j largerthan M1.
3. Set m = min (m0, m1), M = max (M0, M1). The algorithm assures that at least 90% coefficients are converted and the conversion range is large enough.[19] It maybe considered that it is simpler to manually assign m= 0 andM = 255 to meet with the two requirements. However, if most coefficients are near 128, and few are near maximal or minimal value, the contrast efficiency is low. In this situation, Automatic Adaptation algorithm shows its advantage.[20]

14. Processing Flow

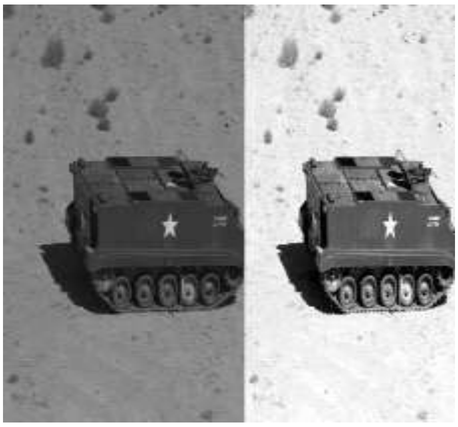
Our method is represented by the following steps:

1. Load a color image
2. Read(r,g,b)values for each pixel
3. Convert RGB color space to HSV color space
4. Apply the wavelet transform toV component
5. Apply the Reverse-S-Shape transform to the approximate coefficient of Eq. (1)
6. Reconstruct Vby inverse wavelet transform
7. Apply the saturation enhancement
8. Convert HSV color space to RGB color space
9. Store the color image

15. RESULT

To test the performance of our method, we apply our method to a low contrast color image and a dark color image and compare the results, the experimental result of the low contrast image. (a) is the original image, (b) is the result obtained by our proposed method. The experimental result of different images shown blow, respectively.

OriginalImage



(a)Original image(b)Enhanced image

16. Conclusion and applications

The motivation is to enhance local contrast so that the resulting imagery Communicates the utmost of the represented scene. This thesis has proposed a color contrast enhancement method that uses a luminance component enhancement based on wavelet transform: more specifically, Reverse- S-Shape enhancement based on human visual system for the approximate component coefficients obtained by the Wavelet transform. It turns out that the proposed wavelet based color contrast enhancement method can achieve a successful enhancement of color images which are dark or with low contrast. However, there are still some remaining issues. The transformation algorithm for the approximate coefficients is to be improved and the enhancement of detail coefficients may also be effective. The relationship between luminance value and saturation is not considered in the method. The method is a global transformation of a certain image but the performance might be better if we divide the image into some certain areas according to some certain rules and apply a different algorithm or different parameters to different areas. Another topic is that sometimes the color contrast enhancement requires changing color; that is; the hue component should also be adjusted.The over all performance of this method is good.

Applications

Image enhancement is a process of improving the quality of a digitally stored image, image enhancement technique shave been widely applied to geological images and use to make it easier for visual interpretation and geological understanding. Image enhancement techniques widely using medical science and microscopy image processing and many image analysis applications

References

[1] V. Buzuloiu, M. Ciuc, R. M. Rangayyan, & C. Vertan,Adaptiveneighborhoodhistogramequalization of color images, *International Journal of Electron Image, 10*(2), 445-459, 2001.

[2] P. E. Trahanias, & A. N. Venetsanopoulos, Color image enhancement through 3-D histogram equalization, *Proc. 11th IAPR Conf. on Pattern Recognition*, The Hague, Netherlands, 545-548, 1992.

[3] B. A. Thomas, R. N. Strickland, & J. J. Rodriguez, Color image enhancement using spatially adaptive saturation feedback, *Proc. 4th IEEE Conf. on ImageProcessing*, Santa Barbara, CA, USA, 30-33, 1997.

[4] A. Gupta, & B. Chanda, A hue preserving enhancement scheme for a class of color images, *Pattern Recognition Letters, 17*(2), 109-114, 1996.

[5] L. Lucchese, S. K. Mitra, & J. Mukherjee, A new algorithm based on saturation and desaturation in the xychromaticity diagram for enhancement and re-rendition of color images, *Proc. 8th IEEE Conf. on Image Processing*, Thessaloniki, Greece, 1077-1080,2001.

[6] M. S. Shyu, & J. J. Leou, A genetic algorithm approach to color image enhancement, *International Journal of Pattern Recognition, 31*(7), 871-880, 1998.

[7] A.Toet,Multiscalecolorimageenhancement, *PatternRecognitionLetters,13*(3),167–174,1992.

[8] J. Lu, & D. M. Hearly, Contrast enhancement via multi-scale gradient transformation, *Proc. SPIE Conf. onWaveletApplication* , Orlando , FL , USA , 345-365, 1994.

[9] T. J. Brown, An adaptive strategy for wavelet based image enhancement, *Proc. IMVIP Conf. on Irish Machine Vision and Image Processing*, Belfast, Northern Ireland, 67-81, 2000.

[10] R. S. Ledley, M. Buas, & T. J. Colab, Fundamentals of true-color image processing, *Proc. 10th IEEE Conf. on Pattern Recognition*, Los Alamos, CA, USA, 791- 795, 1990.
[11] S.K.Naik,&C.A.Murthy,Hue-preservingcolor image enhancement without gamut problem, *IEEE Trans.on Image Processing, 12*(12), 1591-1598, 2003.
[12] C.C.Yang, &J.J.Rodrguez,Efficientluminance and saturation processing techniques for bypassing color coordinate transformations, *Proc. IEEE Conf. OnSystems, Man and Cybernetics*, Bogota, Columbia, 56-67, 1995.
[13] Y. Xu, J. B. Weaver, D. M. Healy, & J. Lu, Wavelet transform domain filters: A spatially selective noise filtration technique, *IEEE Trans. on Image Processing, 3*(6), 747-758, 1994.
[14] Q. Pan, L. Zhang, G. Dai, & H. Zhang, Two denoising methods by wavelet transform, *IEEE Trans. On Signal Processing, 47*(12), 3401-3406, 1999.
[15] Y. Kobayashi, & T. Kato, A high fidelity contrast improving model based on human vision mechanism, *Proc. IEEE International Conf. on Multimedia Computing and Systems*, Florence, Italy, 578-584, 1999.
[16] R. N. Strickland, C. S. Kim, & W. F. McDonnell, Digital color image enhancement based on the saturationcomponent, *InternationalJournalofOptical Engineering, 26*(7), 609-616, 1987.
[17] Jobson D. J., Rahman Z., & Woodell G. A., Statistics of visual representation, *Proc. SPIE Conf. on Visual Information Processing XI*, Orlando, FL, USA, 25-35, 2002.
[18] AndersonC.H.BergenJ.R.BurtP.J.Adelson,
E. H. and J. M. Ogden. Pyramid methods in image processing. RCA Enginee, 29(6):33–41, 1984.
[19] Josef Albers. Interaction of Color. Yale University Press, New Haven, 1975.
[20] L. Arend. Lightness, Brightness, and Transparency, chapter Intrinsic image models ofhuman color perception,pages 159–213.Hillsdale,NJ: Lawrence Erlbaum Associates, 1994.