Introduction to Machine Vision : Color Enhancement of RGB Images (Histogram Equalization and Gamma Correction)

Amir M. Mousavi

Department of Computer Engineering
Shahid Rajee University

Tehran, Iran

AmirMahmood.Mousavi@yahoo.com

Nowadays, machine vision systems have numerous other applications. Systems that depend on visual stock control and management, such as barcode reading, counting, and store interfaces, often use machine vision systems. Large-scale industrial product runs also employ machine vision systems to assess the products at various stages in the process and also work with automated robotic arms. Even the food and beverage industry uses machine vision systems to monitor quality. In the medical field, machine vision systems are applied in medical imaging as well as in examination procedures.

Machine Vision plays an important role in computer technology and artificial intelligence. With the use of machine Vision , human effort can be reduced in recognizing, learning, predictions and many more areas. This article presents an introduction to machine vision and we will, discuss some common methods (Histogram Equalization and Gamma Correction) used to enhance color(rgb) images or color in the images. We also talk about their advantages and disadvantages and general comparison.

Keywords— Machine Vision , Computer Vision, , Bayesian , Gamma Correction , Histogram Equalization , RGB , HSV ,HSI , Color Enhancement.

.

I. INTRODUCTION

Computers have been used for nearly 30 years for numerous applications involving the automatic or semiautomatic recognition of patterns in image or signal data. Major areas of application include character recognition (document reading), speech recognition, medical applications such as blood counting and x-ray analyses, interpretation of remote sensor imagery, target recognition inreconnaissance data, and many others. A particular application area with growing interest is machine vision for robotics and industrial quality control. This paper reviews the basic steps involved in such computer-based recognition processes. with emphasis on visual recognition. For concreteness, our examples will be drawn from the domain of industrial machine vision. including such tasks as flaw detection and parts inspection. The basic components of a machine vision system are shown schematically in Fig. 1.

The sensor, most commonly a television camera, acquires an image of the object that is to be recognized or inspected. The digitizer converts this image into an array of numbers, representing the brightness values of the image at a gid of points; the numbers in the array are called pixels. The pixel array is input to the processor, a general-purpose or custom-built computer that analyzes the data and makes the necessary decisions (object detection) [1].

.

In this paper we have proposed to provide a comprehensive tutorial and survey about review of the Computer vision (machine vision), which is discussed in section II . Then a brief explanation of Histogram Equalization and Gamma Correction methods are in sections III and IV . Finally. The results of the implementation are presented V and the conclusions are discussed in section VI .

II. COMPUTER VISION

Computer vision is an interdisciplinary scientific field that deals with how computers can be made to gain high-level understanding from digital images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do.[2][3]

Computer vision tasks include methods for acquiring, processing, analyzing and understanding digital images, and extraction of high-dimensional data from the real world in order to produce numerical or symbolic information, e.g., in the forms of decisions.[4][Understanding in this context means the transformation of visual images (the input of the retina) into descriptions of the world that can interface with other thought processes and elicit appropriate action. This image understanding can be seen as the disentangling of symbolic information from image data using models constructed with the aid of geometry, physics, statistics, and learning theory.[5]

As a scientific discipline, computer vision is concerned with the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences, views from multiple cameras, or multi-dimensional data from a medical scanner. As a technological discipline, computer vision seeks to apply its theories and models for the construction of computer vision systems.

Sub-domains of computer vision include scene reconstruction, event detection, video tracking, object recognition, 3D pose estimation, learning, indexing, motion estimation, and image restoration.

III. MACHINE VISION

Machine vision is the incorporation of computer vision into industrial manufacturing processes, although it does differ substantially from computer vision. In general, computer vision revolves around image processing. Machine vision, on the other hand, uses digital input and output to manipulate mechanical components. Devices that depend on machine vision are often found at work in product inspection, where they often use digital cameras or other forms of automated vision to perform tasks traditionally performed by a human operator. However, the way machine vision systems 'see' is quite different from human vision.

The components of a machine vision system can vary, but there are several common factors found in most. These elements include:

a) Digital or analog cameras for acquiring images
b) A means of digitizing images, such as a camera interface
c) A processor

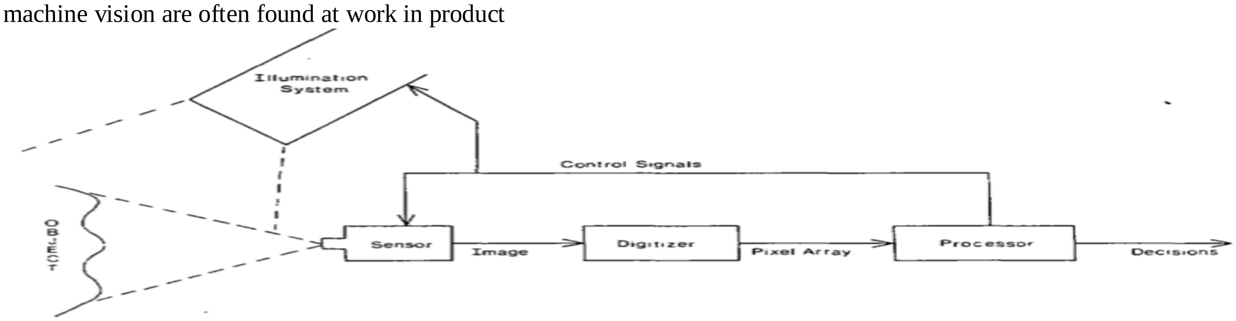

Fig.1.

When these three components are combined into one device, it's known as a smart camera. A machine vision system can consist of a smart camera with the following add-ons:

a) Input and output hardware
b) Lenses
c) Light sources, such as LED illuminators or halogen lamps
d) An image processing program
e) A sensor to detect and trigger image acquisition
f) Actuators to sort defective parts

Although each of these components serves its own individual function and can be found in many other systems, when working together they each have a distinct role in a machine vision system.

To understand how a machine vision system works, it may be helpful to envision it performing a typical function, such as product inspection. First, the sensor detects if a product is present. If there is indeed a product passing by the sensor, the sensor will trigger a camera to capture the image, and a light source to highlight key features. Next, a digitizing device called a frame grabber takes the camera's image and translates it into digital output, which is then stored in computer memory so it can be manipulated and processed by software.

In order to process an image, computer software must perform several tasks. First, the image is reduced in gradation to a simple black and white format. Next, the image is analyzed by system software to identify defects and proper components based on predetermined criteria. After the image has been analyzed, the product will either pass or fail inspection based on the machine vision system's findings .

IV. HISTOGRAM EQUALIZATION

Histogram is a data-structure to store the frequencies of all the pixel levels in the images. By frequency, I simply mean the number of pixels in the image which have that specific pixel intensity value. The number of bins for the histogram in this case are taken to be equal to the number of pixel intensity levels in the image. Usually, it is 0 - 255.

The HE is an image processing technique for contrast enhancement of images. The purposes of the HE are [6]:

1. employ all the intensity levels,
2. distribute the number of intensities in all the pixels of the image, in other words, all the intensity levels have the same occurrences within the image.

The HE is computed with the following equation [6]:

$$\lambda(k) = \frac{L-1}{N}\sum_{i=0}^{k} h(i).$$

Where h ið Þ is the occurrence of intensity level i of the image to process, L is the number of intensity levels, N is the number of pixels of the image, k = (x, y) is the intensity value of the pixel located (x, y) of the image I, and kð Þk is the value of the equalized intensity level k. This technique is developed for grayscale images, so, usually L ¼ 256; for RGB color images, the pixel's intensity is represented by the magnitude of the vector that characterizes the pixel's color. Thus, the number of intensity levels is different.

For equalizing the histogram, we need to compute the histogram and then normalize it into a probability distribution. For normalization, we just need to divide the frequency of each pixel intesity value by the total number of pixels present in the image. This is equal to the resolution of the image. i.e. (rows * cols). The equalization process makes sure that the resulting histogram is flat. Following is the transformation function for the image in order to obtain a flat histogram.

V. GAMMA CORRECTION

. Gamma is an important but seldom understood characteristic of virtually all digital imaging systems. It defines the relationship between a pixel's numerical value and its actual luminance. Without gamma, shades captured by digital cameras wouldn't appear as they did to our eyes (on a standard monitor). It's also referred to as gamma correction, gamma encoding or gamma compression, but these all refer to a similar concept. Understanding how gamma works can improve one's exposure technique, in .addition to helping one make the most of image editing

each pixel in a image has brightness level, called luminance. This value is between ٠ to ١' where ٠ means complete darkness (black), and ١ is brightest (white). [see CSS: HSL [Color

Different camera or video recorder devices do not correctly capture luminance. (they are not linear) Different display devices (monitor, phone screen, TV) do not display luminance correctly neither. So, one needs to correct them, . therefore we use the gamma correction function

As we can observe in fig.٢/ Gamma correction. x-axis is voltage. y-axis is brightness. The solid red curve is typical CRT monitor's voltage and brightness ratio. The dashed red curve is its inverse function, the gamma correction function Gamma correction is, in the simplest cases, defined by the :following power-law expression

$$V_{\text{out}} = AV_{\text{in}}^{\gamma}$$
.

where the non-negative real input value V in is raised to the and multiplied by the constant A, to get the output γ power value Vout. In the common case of A = ١' inputs and outputs .are typically in the range ٠–١

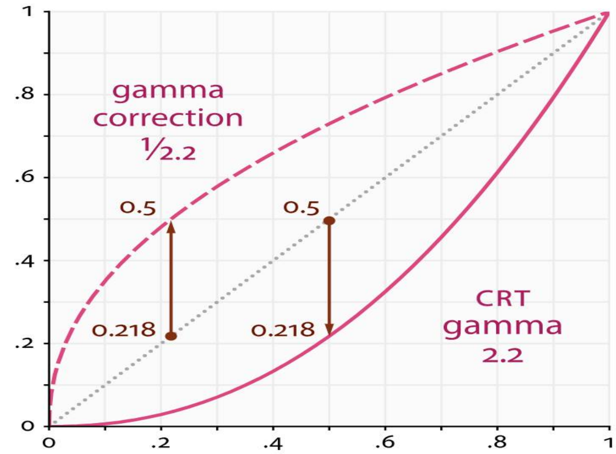

Fig.2.

VI. IMPLEMENTATION RESULTS

In this part we are going to discuss the implementation results . it is in 2 part , first part is histogram equalization and the second part is gamma correction .

i. Histogram Equalization :

✓ **RGB :**

In this method we follow the following steps:

١(.Separate out r,g,b components of the image

٢(Apply histogram equalization to all the three .components

٣(Merge the histogram equalized components to get the .final equalized image

.The results are shown in fig.٣

✓ The fig٣/a. is show every channel effects on image and the HE of every channel seperately

✓ The fig٣/b. is show the combination of three channel

Fig.3.a. every channel effects on image and the HE of every channel seperately

Fig.3.b. combination of three channel

✓ : Conclusion

Here we see that the image has the contrast at some points, but its thoroughly jumbled up at other points.What happens is separate histogram equalization for the three color .channels will result in artificial color shift

main disadvantage of the RGB space involving natural images is the high correlation between its components. The RGB space also suffers from nonuniformity, since it is impossible to evaluate thenperceived differences between colors on the basis of distances, and psychological intuitiveness, since the visualization of a color based on R, G,B components is rather hard. Using this method may yield dramatic changes in the image's color balance since the relative distributions of the color channels change as a result of applying this algorithm. To reduce the effects of such .abrupt changes, we can use smoothing after equalizing

Fig /٤/ HE on HVS space

✓ **: HVS (Hue , Saturation ,Value)**

The problems faced in first method could be resolved using this method. can be applied to the luminance or value channel without resulting in changes to the hue and saturation of the image. It separates the color information from its intensity information. Intensity is achromatic and describes the brightness of the scene, while hue and saturation are the chromatic components. More precisely, hue is an attribute associated with the dominant wavelength, and thus represents the dominant color perceived by an observer. Saturation corresponds to relative color purity, that is the amount of white light mixed with a hue. By converting a RGB image to HSV, we can equalize the Value channel without altering the Hue or Saturation. After converting the .result back to RGB, a properly equalized image is produced .The result is shown in fig.٤

ii. Gamma correction :

In this part , to try another space , we tried YCbCr space and worked on Y to apply the gamma correction .
We have tested several Bright and dark images and the results are shown in fig.5.

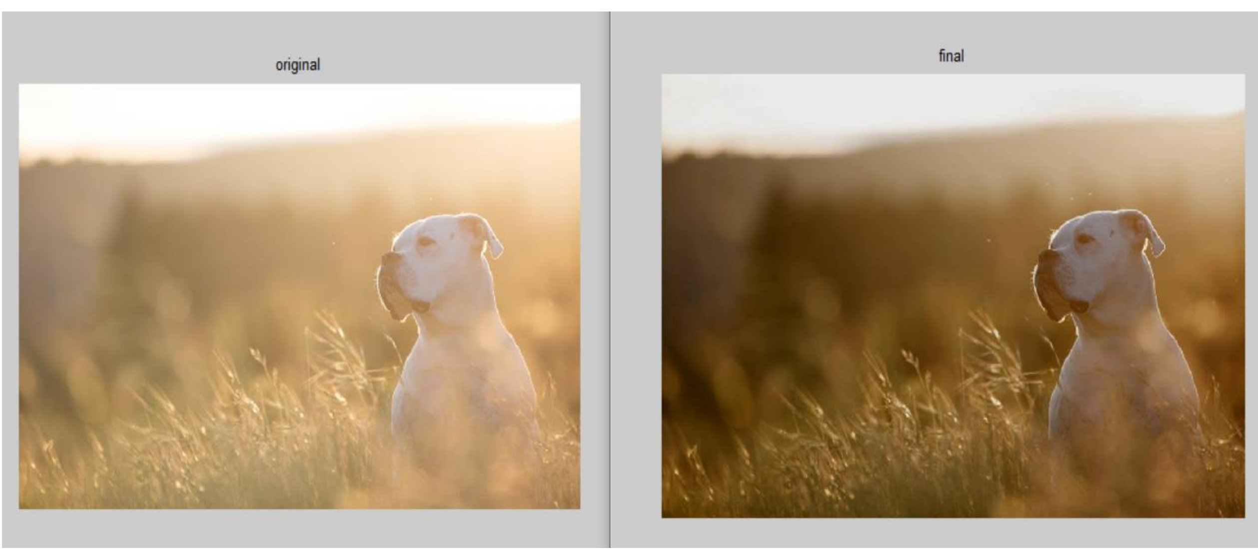

Fig /٥/a. Gamma correction on bright images (gamma = ٠/٥)

Fig ۰/۵/b. Gamma correction on bright images (gamma = ۰/۷)

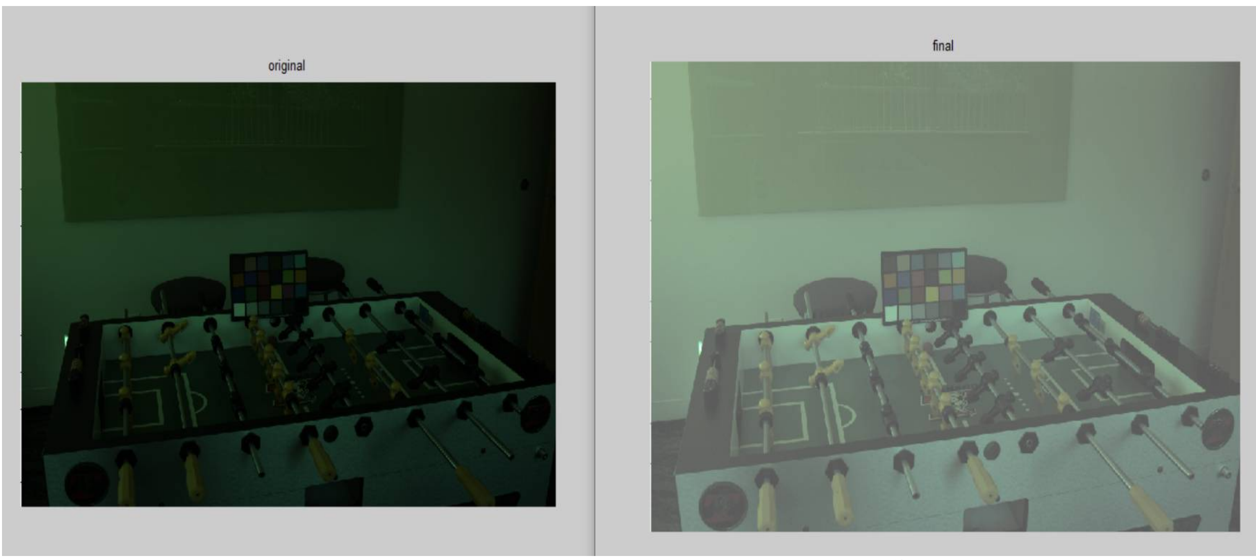

Fig ۰/۵/c. Gamma correction on dark images (gamma = ۲/۸)

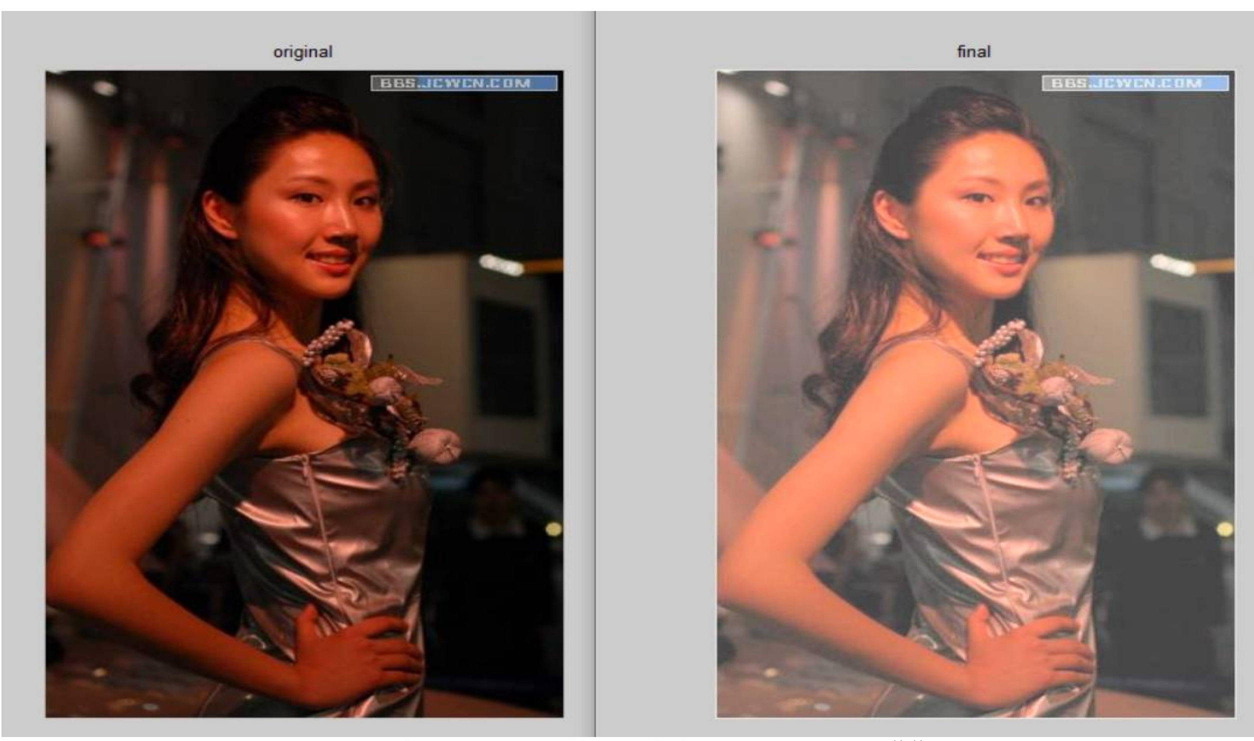

Fig ۰/۵/d. Gamma correction on dark images (gamma = ۲/۲)

VII. CONCLUSION

In this paper,we have introduced the machine vision and observed how HE and Gamma correction works on color images , we also saw the different spaces of color images including RGB , HSV , YCbCr . as shown , image processing is a nessecary tool for computer vision and we need to learn the techniques to work on machine vision . problems in real world

REFERENCES

[1] Rosenfeld, A. (1985). Introduction to machine vision. IEEE Control Systems Magazine, 5(3), 14–17. doi:10.1109/mcs.1985.1104954

[2] Huang, T. (1996-11-19). Vandoni, Carlo, E, ed. Computer Vision : Evolution And Promise (PDF). 19th CERN School of Computing. Geneva: CERN. pp. 21–25. doi:10.5170/CERN-1996-008.21. ISBN 978-9290830955.

[3] Milan Sonka; Vaclav Hlavac; Roger Boyle (2008). Image Processing, Analysis, and Machine Vision. Thomson. ISBN 978-0-495-08252-1

[4] Linda G. Shapiro; George C. Stockman (2001). Computer Vision. Prentice Hall. ISBN 978-0-13-030796-5.

[5] Tim Morris (2004). Computer Vision and Image Processing. Palgrave Macmillan. ISBN 978-0-333-99451-1.

[6] Zhang, H., Friits, J.E., Goldman, S.A.: Image segmentation evaluation: a survey of unsupervised methods. Comput. Vis. Image Underst. 110(2), 260–280 (2008)

[7] Belongie, S., Malik, J., Puzicha, J.: Shape matching and object recognition using shape contexts. PAMI, vol. 24, no. 24, 2002

THE END