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Vector Field Based Conversion of Color Image to Gray Scale

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Abstract: The following paper proposes a vector based technique of image processing for converting color images to grayscale images. The three base color channels of red, green and blue are assumed to form the three vector axes of a 3-dimensional vector space with every color having an equal influence at the resultant vector of the three axes. The results of the proposed algorithm are compared with those from the averaging technique or the same.

Keywords: Grayscale, Image Processing, Color channels, vector space

I. INTRODUCTION

Image processing is a fast expanding field in the technological industry and is finding more and more applications for itself in almost all the industrial and other applications. The ever increasing number of techniques for accomplishing various tasks has made computer vision a competitive field not just for the developers, but also for the users. Most of these techniques and algorithms are most efficient when applied to monochrome images.

It is therefore a major field of work wherein monochrome images can be obtained from the color images without changing the imaging sensors. Various algorithms have been developed in recent times to accomplish this task. These methods include averaging method, weighted averaging method, De-saturation and others. Of all the algorithms, averaging and weighted averaging techniques have found most of the takers among the developers.

The following paper describes an algorithm for the same purpose based on vector mathematics. A color image can be described by the values of the red, green and blue colors forming the actual image appearance. The algorithm discussed here assumes the three basic colors to form the three axis of the vector space.

II. LITERATURE REVIEW

Various algorithms have been proposed to convert a color image to a gray scale image. Lightness method, average method, luminosity method, ISOMAP, etc. are a few of the most commonly used algorithms for this purpose.

Lightness method assumes that it is only the minimum and maximum intensities of the three channels that influence the color perception. It, thus, determines the average of the minimum and maximum of the three color channels.[1][2]
Averaging method gives equal weights to each channel of the color image and averages the three channels to obtain the grayscale pixel intensity.[1][2].

In [2], the author discusses seven different techniques for converting color images to grayscale and compares their results.
In [4], Lim and Isa propose a conversion algorithm wherein the weight of each color channel depends on the pixel intensities of the neighborhood pixels.

III. ALGORITHM

The pixel value of any pixel in a color image can be described by the weights of the red, green and blue components of the color. Assume that the three color components form the three component axes of a 3-dimensional vector space. As shown in the figure below, let us assume that the diagonal of the cube formed by the three components, represents the gray scale value. In other words, the magnitude of the position vector of the rectangular projection of the resultant of the three components represents the gray scale value.
If r, b, g represent the magnitudes of the three component vectors along their respective direction, then the position vector representing the resultant of the three components can be written as

$$R = r\hat{\imath} + b\hat{\jmath} + g\hat{k}$$

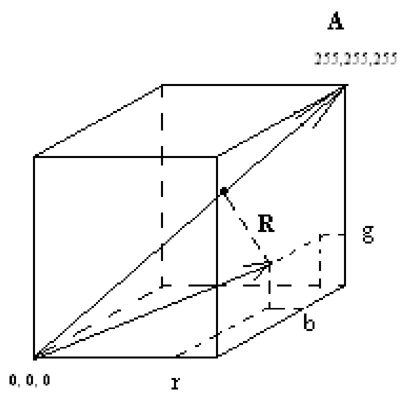

Fig.1. Vector representation of the color components

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Position vector of bright white color can be given as

$$W = 255\hat{\imath} + 255\hat{\jmath} + 255\hat{k}$$

Consider a plane passing through the point A and having the normal vector coinciding with the vector W. Then, the intersection point of this plane with this normal vector represents the gray scale value.

As we move the plane closer to the origin, all the points on the plane and within the vector field can be projected to the normal vector (passing through the origin) to coincide with the intersection point of the plane and the normal vector.

In other words, all the values of three components whose position vector terminates on the plane will have their grayscale value corresponding to the point of intersection of the plane and its normal vector passing through the origin.

Projection of the vector R over vector W can be given as RcosØ, where Ø is the angle between the two vectors.
By the property of the dot product of two vectors, we have

$$R.W = RW\cos Ø$$

Thus,

$$R\cos Ø = \frac{R.W}{W}$$

i.e.

$$R\cos Ø = \frac{255r + 255b + 255g}{255\sqrt{3}} = \frac{r+b+g}{\sqrt{3}}$$

But, the gray scale intensity is distributed over the range [0, 255], while, magnitude of W is 255√3.
Thus, interpolating the magnitude of RcosØ considering that the magnitude of W is split into 255 equal parts, we have

$$Gray\ value = \frac{R\cos Ø * 255}{255\sqrt{3}}$$

i.e.

$$Gray\ value = \frac{r+b+g}{3}$$

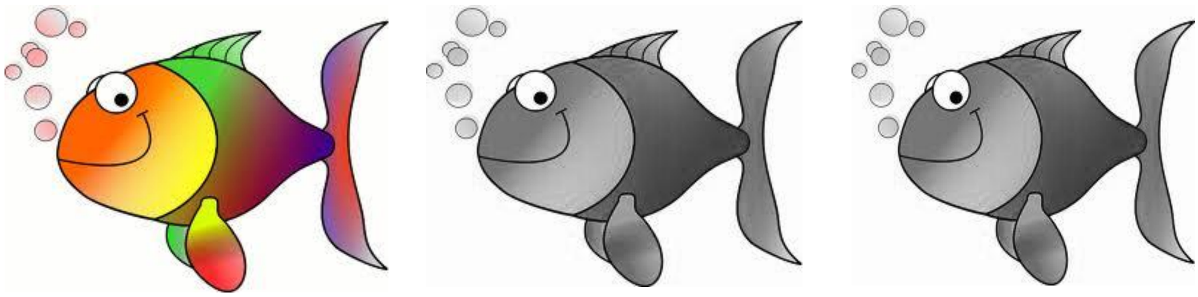
Thus, the result of this technique is the same as the averaging method.

IV. RESULTS

The figure 2 and 3 below compares the results of the proposed algorithm to the averaging method for converting color images to grayscale. The techniques were implemented using C++ language with opencv libraries on Raspbian distribution.

V. CONCLUSION

The results show that the vector based color to gray scale conversion delivers the same result as the one obtained using the averaging algorithm. However, the paper proposes a more sophisticated approach to understand the effect of averaging algorithm in converting a 3-channel color image to gray scale image.



a b c

Fig. 2. a. Original Image[5], b. Result of Averaging Method, c. Result of Vector method (Original Image Courtesy: OpenCV Samples)

a b c

Fig. 3. a. Original Image[5], b. Result of Averaging Method, c. Result of Vector Method (Original Image Courtesy: OpenCV Samples)

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