Automated colorization of grayscale images

Kaleem Ahmed Qureshi
B.Tech. I.T. Student
School of Information Technology and Engineering
Vellore Institute of Technology
Vellore, India

Prof. C. Vanmathi
Assistant Professor (senior)
School of Information Technology and Engineering
Vellore Institute of Technology
Vellore, India

***Abstract*—Current image colorization methods and systems attempt to colorize the pictures by capturing their information needs with the help of users using automated or semi automated approaches. There are many pseudo coloring techniques that have been adopted to color images. In this paper we proposed a method which uses true color image colorization with 256x256x256 image which contains all the colors. Colorization process has three main steps. The first is find out the reference image from the image database using content based image retrieval system. Second step is to find the pixel that matches the source color image to the target gray scale image. The third step uses 256x256x256 true color image to search and find the best matching pixel value and this step is used only when there is no pixel value found from the reference image.**

Keywords- pseudo color ; true color ; reference image; colorization.

I. INTRODUCTION

Colorization is the process of converting a gray scale image into RGB color image. Colorization of an image is a topic that was prevailing for a very long time but only recently people have started working in it. The basic meaning of colorization is to turn a gray scale image 256 shades to a color image 256x256x256 which contains all the colors. Now since there are many more shades in color image for a particular gray and minimum of two colors are mapped to single gray shade. Because of the above reasons coloring of an image becomes a very tedious task since every image has unique color characteristics.

The general problem associated with colorization is that many colors have mapped to the same gray shades. So it is difficult to differentiate whether the given gray shade is of which color. Through colorization it is possible to clearly identify different colors having same gray scale and it is easy for analyzing the image.

There have been many assisted and semi assisted methods that have been developed to color an image. The assisted methods include colorizing an image manually using Photoshop, Corel draw, Microsoft paint etc. There is also a semi assisted methods advised in which it accepts similar image and using it to color a gray scale image. But these methods require assistance suffer with the deficiencies of human and also require an enormous time. So an un assisted method proposed in this paper.

II. RELATED WORK

A. *Gabor texture method*

According to the method proposed in [2] CBIR rotation normalization is presented by doing circular shift of the feature elements so that the resultant image has same dominant direction. The method has many disadvantages as follows

i. It requires a large storage space. Since the representation of Gabor functions are very voluminous.

ii. There is no efficient algorithm available for finding forward and inverse transformations.

iii. The time required for computation is very high. For real time systems it should be low.

B. *Content based image retrieval (CBIR)*

Many methods have been introduced for content based image retrieval which is based on texture, color, similarity, shape etc. The best method found out for CBIR is 8 tap methods [3] of Daubebchies for texture analysis.

Pyramidal wavelet transform contains all the basic functions called wavelets. The input signal is passed through high and low pass filters. The results of the filters are decimated by 2. The information is extracted from the image at different level of hierarchy. The reconstructed coefficients are up sampled and passed through the filters. The image is divided into sub images based on the levels needed. The mean, standard deviation, energy and all the possible combinations of all the sub images and the feature vector is calculated.

The feature vector is used to calculate the Euclidian distance and Manhattan metric is used to find the similarity between the source image and target image.

III. PROPOSED METHOD

The colorization process is divided into three steps.

1. Retrieve an reference image similar to that input image from the image database using content based image retrieval (CBIR) system.[3]

2. Coloring the input gray scale image using the image retrieved from the CBIR system. Find the pixel that matches the source color image to the target gray scale image.

3. If the pixel chromaticity value of the reference image and the input image doesn't exactly match then there will be a great difference in the color of the reference image and the natural appearance of the image. So find the matching Chromaticity value of the reference image retrieved from the database is compared with input image then the RGB value of the pixel is identified. Now this RGB value is searched in true color image and hence the true color image is converted into Lαβ color space.

Compare the chromaticity of the color image with that of the grayscale image and the pixel values that matches the most, its RGB values are transferred from the color to the gray scale image. The Lαβ color space is chosen because it has minimum correlation between its individual components. The comparison of chromaticity values can easily be done between gray scale and color image.

Next a method in which 7x7 tuples of pixels are taken and their mean and standard deviation is used to chose their color. The 50 % of the mean value is used and 50 % of standard deviation is used for the comparison.

A. Conversion of RGB to Lαβ

First step is to convert RGB into device independent XYZ values (1)

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.5141 & 0.3239 & 0.1604 \\ 0.2651 & 0.6702 & 0.0641 \\ 0.0241 & 0.1228 & 0.8444 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

The values of XYZ which are device independent is therefore mapped to LMS space by (2)

$$\begin{bmatrix} L \\ M \\ S \end{bmatrix} = \begin{bmatrix} 0.3897 & 0.6890 & -0.0787 \\ -0.2298 & 1.1834 & 0.0464 \\ 0.0000 & 0.0000 & 1.0000 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

(1) and (2) combines to give (3)

$$\begin{bmatrix} L \\ M \\ S \end{bmatrix} = \begin{bmatrix} 0.3811 & 0.5783 & 0.0402 \\ 0.1967 & 0.7244 & 0.0782 \\ 0.0241 & 0.1288 & 0.8444 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

The data found by this conversion shows a great deal of skew in the following color model, which is primarily eliminated by taking a logarithmic transform:

L=log L
M=log M (4)
S=log S

To take an inverse transform from *LMS* space to RGB color space is shown. Firstly, the *LMS* pixel values exponent ten and then these are transferred to simple LMS space. Finally, the data can be mapped from LMS back to RGB using the inverse transform of Equation (5):

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 4.4679 & -3.5873 & 0.1193 \\ -1.2186 & 2.3809 & -0.1624 \\ 0.0497 & -0.2439 & 1.2045 \end{bmatrix} \begin{bmatrix} L \\ M \\ S \end{bmatrix}$$

The following simple transformation was given by Ruderman *e.a.* [5] to decorrelate the individual components in the *LMS* space: (6)

$$\begin{bmatrix} l \\ \alpha \\ \beta \end{bmatrix} = \begin{bmatrix} \frac{1}{\sqrt{3}} & 0 & 0 \\ 0 & \frac{1}{\sqrt{6}} & 0 \\ 0 & 0 & \frac{1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & -2 \\ 1 & -1 & 0 \end{bmatrix} \begin{bmatrix} L \\ M \\ S \end{bmatrix}$$

On assuming that L axes is red, M channel is green, and the S channel is blue, an obvious variant of a color opponent model which is given below:

Achromatic α r + g + b
Blue-yellow α r + g - b (7)
Green-red α r - g

After the color signals are processed in the *l*αβ model the inverse of the Equation (6) is used to change back to the *LMS* space:

$$\begin{bmatrix} L \\ M \\ S \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & -1 \\ 1 & -2 & 0 \end{bmatrix} \begin{bmatrix} \frac{\sqrt{3}}{3} & 0 & 0 \\ 0 & \frac{\sqrt{6}}{6} & 0 \\ 0 & 0 & \frac{\sqrt{2}}{2} \end{bmatrix} \begin{bmatrix} l \\ \alpha \\ \beta \end{bmatrix}$$

B. True color image processing

The pixel that does not have the exact matching chromatic value is sent to this method to be processed. The chromatic value of the pixel as well as the corresponding RGB values found in the above method is sent to this method. The true color image is searched for the given RGB pixel value and the index of the given value is found out. The true color image is converted to Lαβ color space. The true color image is searched for matching chromatic value of pixel using greedy search technique. When the pixel is found out the value of pixel is set by the function as the new color of the pixel. The following are the steps for calculating exact matching chromatic value for the input image.

- Calculate the Manhattan distance between chromaticity of the input pixel value and the pixels around the current pixel (C_{jl}).
- Find the pixel having minimum Manhattan distance from the input pixel

D_M = Min (mod($L_i - C_{j-k+2,\, l-k+2}$))

Where K = 1 , 2 , 3

D_M - Minimum Manhattam distance of the current pixel relative to the input pixel

L_i – Chromatic value of the current pixel

C_{ij} – Chromatic value of the pixel ij. Where i and j are row and column respectively.

- The pixel having least Manhattan distance is selected as a current pixel.
- If the chromatic value is found add the αβ value to the Lαβ color space and then transformed back to the RGB color space and the image is colored using the current pixel value.
- If the chromatic value is not found repeat the above steps till it finds the matching in the color space.

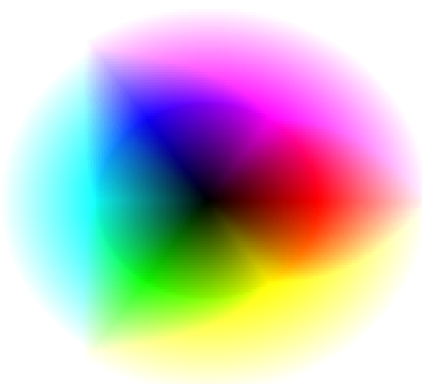
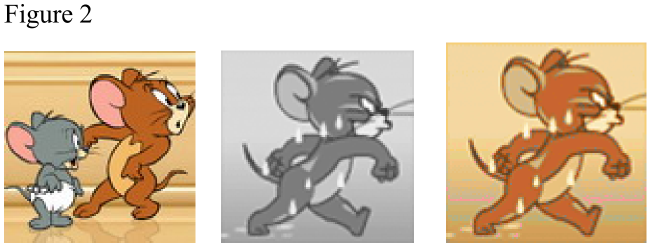


Fig 1 : True Color 256*256*256 image for choosing the real pixel values Used for real color pixel matching.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

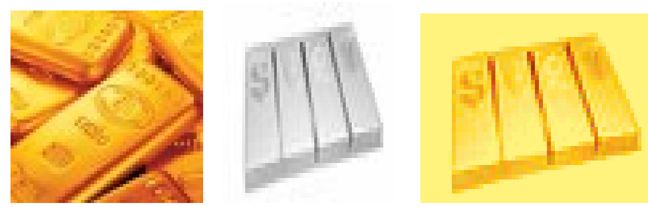
To evaluate the proposed system some sample images were taken and the outputs are shown below. The images processed using the above technique is found to be closer in appearance to the original image than by the methods which were used earlier.

Figure 2



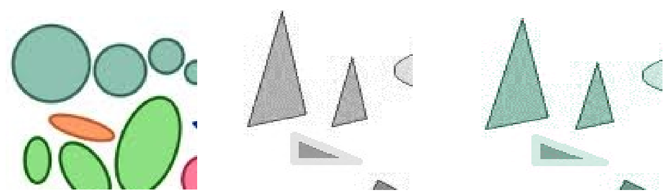
(a) (b) (c)

Figure 3



(a) (b) (c)

Figure 4



(a) (b) (c)

In figure 2 , 3 , 4 a – reference color image fetched from the image database , b – gray scale input image c – output color image achieved by the proposed system.

V. CONCLUSIONS AND REMARKS

In this paper an effective technique to color a gray scale image has been introduced. The method involves fetching of reference image using content based image retrieval system from a image database. The image is then converted to decorrelate to Lαβ color space. The chromatic values of the reference image are compared with the input image. If an exact chromatic value is found from the referred image then the RGB values are transferred into gray scale image otherwise the true color image is referred. The RGB value of the closely related chromatic value in reference image is searched in the true color image and the search for exactly matching chromatic value is done in the true color image. The searching is done using greedy search techniques on the basis of Manhattan distance.

Even though the fore mention techniques brings us to closer to finding the original image yet the original image is not perceived. Hence a lot of work can still be done in this domain to improve the quality of the colored output image.

REFERENCES

[1] G. Eason, B. Noble, and I. N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

[2] Content –based Image Retrieval Using Gabor Texture Features, Dengsheng Zhang, Aylwin Wong, Maria Indrawan, Guojun Lu,

Gippsland School of Computing and Technology, Monash University Churchill, Victoria, 3842, Australia.

[3] Wavelet Transform Based Texture Features for Content Based Image Retrieval Manesh Kokare, B.N. Chatterji and P.K.Biswas Electronics and Electrical Communication Engineering Department, Indian Institute of Technology, Kharagpur, India.

[4] T.Welsh, M. Ashikhmin and K. Mueller Transferring colot to grayscale images, Proceedings of ACMSIGGRAPH, ACM2002.

[5] D.L. Ruderman, T.W.Cronin and C.-C. Chiao,Statistics of cone responses to natural images: implications for visual coding. Journal of the Optical Society of America.

[6] Colorizing Grayscale Intensified Nightvision Images Alexander Toet,TNO Human Factors, Oesterberg,Netherlands.

[7] K.R. Castleman. Digital Image processing, Prentice-Hall,Englewood Cliffs, NJ , USA.