Grayscale image coloring by using YCbCr and HSV color spaces

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Abstract—Colorization is a computer aided process of adding color to a grayscale image and video her
in this paper we proposed a coloring algorithm that produce vibrant and realistic color image, generally
olorizing gray image involves greyscale image, color space and source color image. The problem of
coloring grayscale image is clearly under constrained, previous approaches have either relied on
icient user interaction her in our proposed coloring algorithm we trying to reduce the human efforts
eeded in manually coloring of grayscale image, the human interaction is needed only to find a source
color image, then the job of transfer color traits from source color image to grayscale image is done by
the proposed algorithm. Here the proposed algorithm of color traits transfer to grayscale image has been
formed by using two different color spaces together in the coloring process, these color space are
YCbCr and HSV with generation of color palette for color source image and grayscale image, color
transfer depend on the comparison between the color palettes of color source image and target grayscale
image along with different pixel window size start from (2 x 2), (3 x 3) up to (10 x 10).

Key Words: Color space, grayscale image, color palette, color transfer, pixel window

I. INTRODUCTION

The colorization of grayscale images is a valuable tool for many applications such as
“colorizing” black and white films or restoring old photographs. Color can be added to grayscale images
in order to increase the visual appeal of images such as old black and white photos, classic movies or
scientific illustrations\(^1\), Additionally, colorization is shown to be useful in image compression,
where with the luminance information and some samples of the color (much less than the ordinary sub-
sampling in common compression schemes), the color components of the data can be faithfully
recovered\(^2\), in medicine image modalities which only acquire grayscale image such Magnetic
Resonance Imaging (MRI), X-ray and Computerized Tomography (CT) images can be enhanced with
color for presentations and demonstrations\(^3\).

The task of “colorizing” a grayscale image involves assigning three dimensional (RGB) pixel
values to an image which varies along only one dimension (luminance or intensity). Since different
colors may have the same luminance value but vary in hue or saturation, the problem of colorizing
grayscale images has no inherently “correct” solution\(^3\) converting a color image to gray means that
dropping information about color and it is quite easy to convert color image to grayscale but its reverse is not that
easy, it look like that we can reverse the process of converting a color image to gray to get colors back, but it's not
that true. Reason for this is that there can be numerous colors which lead to one gray level but when we go reverse
of it, we cannot decide which color corresponds to this one particular gray level which we try to convert to color
\(^4\).

Our proposed colorization method require selection of source color image whose chromatic
information is transferred to target grayscale image, unfortunately empirical evidence suggests that the
degree of similarity between source and target image has a strong influence on the quality of the result
obtain\(^5\), after that both source and target image transfer form RGB color space to YCbCr and HSV
color space than divided both of them into pixel window size (2 x 2), (3 x 3) up to (10 x 10), then start
compare luminance value of each pixel window form target image with all pixel window of source image, depending on minimum Euclidean distance color component of color source image are transferred to grayscale image pixel window found and used for colorization of respective pixel window from input grayscale image[6].

II. COLOR SPACE

2.1 RGB color space (Standard)

The RGB model is represented by a 3-dimensional cube with red green and blue at the corners on each axis (Figure 1). Black is at the origin. White is at the opposite end of the cube. The gray scale follows the line from black to white. In a 24-bit color graphics system with 8 bits per color channel, red is (255, 0, and 0). On the color cube, it is (1,0,0) [7]. The RGB model simplifies the design of computer graphics systems but it is not ideal for all applications that red, green, and blue color components are highly correlated. This makes it difficult to execute some image processing algorithms. Many processing techniques, such as histogram equalization, work on the intensity component of an image only. These processes are easier implemented using the HIS or YIQ color models [8]

![Figure (1) RGB color cube(9).](image)

2.2 YCbCr COLOR SPACE

YCbCr or sometimes written as Y’CbCr is a family of color spaces 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 [5]. In the YCbCr color space, luminance information is stored as a single component (Y), and chrominance information is stored as two color difference components (Cb and Cr). Cb represents the difference between the blue component and a reference value. Cr represents the difference between the red component and a reference value. [10]

To convert from RGB to YCbCr

\[ Y = 0.299*R + 0.587*G + 0.114*B \]  \hspace{1cm} (1)
\[ Cb = 128 - 0.169*R - 0.331*G + 0.500*B \] \hspace{1cm} (2)
\[ Cr = 128 + 0.500*R - 0.419*G - 0.081*B \] \hspace{1cm} (3)
Where:
R, G, B: Red, Green and blue Channels
Y, Cb, Cr: Channels of YCbCr color space
The inverse transform equations are
\[
R= Y + (Cb-128) + (Cr-128) \quad (4)
\]
\[
G= Y-0.343*(Cb-128) - 0.711*(Cr-128) \quad (5)
\]
\[
B= Y + 1.765*(Cr-128) \quad (6)
\]

2.3 HSV COLOR SPACE
HSV is stands for (Hue, Saturation Value/Brightness). This color space is three dimensions put together gives a volume shaped like a cone, Figure (2) illustrate the cone shape of the HSV color space, this color space has the following characteristic [7]
- The hue (H) of a color refers to which pure color it resembles. All tints, tones and shades of red have the same hue [11].
- The saturation (S) of a color describes how white the color is. A pure red is fully saturated, with a saturation of 1; tints of red have saturations less than 1; and white has a saturation of 0 [11].
- The value (V) of a color, also called its lightness, describes how dark the color is. A value of 0 is black, with increasing lightness moving away from black [11].

![Figure (2) HSC color space [7]](image)

III. PROPOSED METHOD

The following steps describe the proposed coloring methods:
- A. Select color source image that has similar features to target grayscale image.
- B. Convert both color source image and target grayscale image from RGB color space to both YCbCr and HSV color space.
- C. Divide both the channels of YCbCr and HSV color space for both source and target image in to pixels windows size (M x N).
- D. Calculate the Euclidian distance from V-channel between the first pixel window form target grayscale image with all pixel windows from V-channel of source color image separately.
- E. The best matching pixel window from source color image to the first pixel window of target grayscale image that how has the smallest Euclidian distance.
F. Transfer the (Cb) and (Cr) channels from the best matching pixels window (source color image) to the first pixel window of target grayscale image and keep the (Y) channel of target grayscale image unchanged.

G. Repeat steps D, E, F above for all pixels windows of target grayscale image.

H. Transfer the result image from YCbcr color space to RGB color space.

IV. QUALITY OF RESULT COLOR IMAGE

Quality of grayscale image colorization technique is subjective to the source color image selected for coloring and also to the grayscale image to be colored. There are no objective criteria to check the performance of colorization method. At most one may take a source greyscale of source color image and try to recolor it using the colors from source color image. Then calculate the Mean Squared Error (MSE) and peak signal to noise ratio (PSNR) between the result image and original image could be considered serve as performance measure to see the quality of colorization method.

V. RESULT AND DISCUSSION

The grayscale coloring algorithm design using Visual Basic.net 2013 as programming language. Our program building in personal computer has 64-bit operation system (Microsoft Window 8.1) with 8 GB RAM and processor type Intel core ™ i7-5500 2.4Ghz and VGA card type NVIDIA GeForce 920M.

The quality of output of colorization algorithm is subjective to the type of source color image used to generate color palette and the target (to be colored) grayscale image. For test the performance of the coloring proposed algorithm we used four grayscale test images as shown in Figure (3,4,5,6) are recolored by using our coloring algorithm through (9 pixel window size) start from (2 x 2) up to (10 x 10) with calculation of mean square error (MSE) and peak signal to noise ratio (PSNR).
Below table (1) contain the values of the mean square error (MSE) and peak signal to noise ratio (PSNR) for the above test image for pixels window size from (2 x 2) to (10 x 10).

Table (1) MSE and PSNR values for the test images

| M x N | Test image #1 MSE | Test image #1 PSNR | Test image #2 MSE | Test image #2 PSNR | Test image #3 MSE | Test image #3 PSNR | Test image #4 MSE | Test image #4 PSNR |
|-------|-------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 2 x 2 | 306.83            | 23.261             | 174.933           | 25.702            | 49.764            | 31.161            | 43.121            | 31.783            |
| 3 x 3 | 267.203           | 23.862             | 168.034           | 25.876            | 47.378            | 31.374            | 36.887            | 32.462            |
| 4 x 4 | 279.973           | 23.659             | 154.052           | 26.254            | 46.525            | 31.543            | 33.967            | 32.82             |
| 5 x 5 | 283.152           | 23.61              | 156.803           | 26.177            | 44.635            | 31.633            | 31.745            | 33.114            |
| 6 x 6 | 275.333           | 23.732             | 153.945           | 26.257            | 46.02             | 31.501            | 32.763            | 32.976            |
| 7 x 7 | 338.32            | 22.837             | 155.523           | 26.212            | 46.9              | 31.419            | 29.777            | 33.391            |
| 8 x 8 | 342.939           | 22.778             | 149.753           | 26.377            | 45.12             | 31.587            | 32.053            | 33.072            |
| 9 x 9 | 238.414           | 23.606             | 153.083           | 26.253            | 44.936            | 31.604            | 32.992            | 32.946            |
| 10 x 10| 266.399           | 23.875             | 160.379           | 26.079            | 43.16             | 31.779            | 33.179            | 32.922            |

below Figure (7) show the Mean Squared Error (MSE) difference between the original image and respective re-colored image by our proposed coloring algorithm for the all test images using various pixel window sizes. It observed that the pixel window give less MSE reflecting better coloring result compared to the other pixel window size, as for Peak Signal to noise Ratio (PSNR) greater value reflecting better coloring result compared with the other pixel window size see (Figure 8).
VI. CONCLUSIONS

In this paper we have transfer color traits form color source image to target grayscale image by using two different color spaces (HSV and YCbCr) with different pixels window size (2 x 2), (3 x 3) up to (10 x 10), we conclude that the choice of source images who has similar feature to target image lead to get better coloring result, and obtain bad coloring result in case of select unsuitable source color image, the pixels window size give the best coloring result depend on the feature of both source color image and target grayscale image.

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