Color Traits Transfer to Grayscale Images

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Abstract

Here we are presenting some novel techniques for squirting colors in grayscale images. The problem of coloring grayscale images has no exact solution. Here we are attempting to minimize the human efforts needed in manually coloring the grayscale images. We need human interaction only to find a reference color image, then the job of transferring color traits from reference color image to grayscale image is done by proposed techniques. In these techniques, the color palette is prepared using pixel windows of some degrees taken from reference color image. Then the grayscale image is divided into pixel windows with same degrees. For every window of grayscale image the palette is searched for equivalent color values, which could be used to color grayscale window. In the whole process the luminance values of reference color image and target grayscale image are only matched and based on best possible match the respective chromaticity values of color image are transferred to grayscale image. For palette preparation first we used RGB color space and then Kekre's LUV color space[9]. Results with Kekre's LUV color space were comparatively better. To improve the searching time through color palette the exhaustive and Kekre's fast search are used.

1. Introduction

The colorization of grayscale images using semi-automated techniques, where users provide clues in order to facilitate the image re-coloring, has been investigated by several research groups. Grayscale image colorization can find its applications in black and white photo editing [1,12], classic movies colorization [5,13,14] and scientific illustrations [1,2]. In medicine [1,8] , the greyscale images such MRI, X-ray and CT images can be enhanced with color for presentations. The task of ''colorizing'' a grayscale image involves assigning 3-D (RGB) pixel values to an image which varies along only one dimension (luminance or intensity) [1]. Since different colors may have the same luminance value but vary in hue or saturation, the problem of colorizing greyscale images has no inherently ''correct'' solution and hence human interaction is needed in the colorization process. Even in the case of pseudocoloring, [5,8] where the mapping of luminance values to color values is automatic, the choice of color map is determined by human decision. Welsh et al. [1] proposed a grayscale image colorization method that works very impressively for natural image (scenes), where the image is divided into distinct luminance clusters or textural regions. However, their technique does not work very well with human faces. Levin et al [12] produced grayscale re-colorizations of *video* by having users pick colors from a source image and draw freehand curves to cue where and how color transfer should occur for selected destination *frames*. Also an image re-coloring scheme for *gamut* replacement is described in [15, 16] that uses grayscale re-colorization methods. Recently, The non-interactive (fully-automated) techniques are given in [2] and [3]. Ruderman et al. [3] developed a color space, called $L\alpha\beta$ color space, which minimizes correlation between channels. Reinhard et al. [2] used this color space to transfer color from color image to another The basic idea of that paper is to combine the color transferring technique with texture synthesis techniques. This works really well on scenes (distinct luminance clusters). However, the technique does not work well with faces. It fails to differentiate the skin and lips. In [12,13,14] grayscale image matting algorithms are used with color transferring techniques to achieve object-based colorization, where objects in the same image are colorized independently. In [17], the authors have demonstrated the possibility to color grayscale image completely automatically. Here the source image is found from database of color images based on their feature matching with gray target.

All these techniques are very complex and fail at one or other category of images., also computationally

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they are very heavy. Here we have proposed comparatively simpler method for color trait transfer to grayscale images. Our method works well on all type of images. To improve the quality of colored images we have used Kekre's LUV color space which is computationally better than L$\alpha\beta$ space [3]. Further for speed improvement we have used KFS.

1.3. Kekre's LUV Color Space [9]

Here we have even used Kekre's LUV color Space. Where L gives luminance and U and V gives chromaticity values of color image. Positive value of U indicates prominence of red component in color image and negative value of V indicates prominence of green component. The RGB-to-LUV and LUV-to-RGB conversion matrices are given in equation 1 and 2

$$\begin{vmatrix} L \\ U \\ V \end{vmatrix} = \begin{vmatrix} 1 & 1 & 1 \\ -2 & 1 & 1 \\ 0 & -1 & 1 \end{vmatrix} \begin{vmatrix} R \\ G \\ B \end{vmatrix} \quad (1) \qquad \begin{vmatrix} R \\ G \\ B \end{vmatrix} = \begin{vmatrix} 1 & -2 & 0 \\ 1 & 1 & -1 \\ 1 & 1 & 1 \end{vmatrix} \begin{vmatrix} L/3 \\ U/6 \\ V/2 \end{vmatrix} \quad (2)$$

2. Color trait transfer algorithm using RGB space of Source Image

To transfer the color traits to grayscale image initially user needs to find the reference source color image. Then one can follow the steps given below.

Steps….a. Generate color palette using source image

b. Search the respective matches for grayscale pixels in the color palette.

c. Transfer the colors from best found palette match to grayscale pixels.

2.1 Color palette generation using source

The colored source image is converted into grayscale source image. These images are then divided into the pixel windows of size MxN. Every window is represented as array of grayscale intensity values and respective R, G, B component values of inclusive pixels. This array is referred as the color palette which is used to squirt colors in target grayscale image.

2.2 Search

The target grayscale image is also divided into the pixel windows of size MxN. Every window is represented as array of grayscale intensity values of inclusive pixels. For every row of grayscale intensity values the best match is searched from the color palette using Mean Squared Error (MSE). For searching either ES or KFS are used.

2.3 color Transfer to Grayscale image

The R, G, B component values from best match palette entry are copied to the target image array as respective pixels R, G, B component values.

All these R, G, B intensity values are then transferred back R, G and B planes of target image at respective pixel window positions. Thus the target image is constructed using these pixel windows as a color image with R, G and B planes.

3. Color trait transfer algorithm using Kekre's LUV Color Space of Source Image

Here the very first step is to transfer RGB components of source color image into respective Kekre's LUV color components. Then these LUV color components are considered for color palette generation. As component L is addition of R,G and B, instead of converting the image into grayscale L component is divided by 3. The source images are then divided into the pixel windows of size MxN and the same procedure is followed as given in color transfer algorithm using RGB space. Finally LUV components of colored target image are obtained and using LUV to RGB transformation matrix the R, G and B planes of colored target image are obtained and thus the target image is constructed using these pixel windows as a color image with R, G and B planes.

4. Search in Color Palette

For searching the best possible source color palette match of grayscale windows, here we have used Exhaustive Search (ES) and Kekre's Fast Search (KFS). KFS is computationally faster but gives poor quality of colored target images.

4.1 Exhaustive Search (ES)

Here for every target gray pixel window, the MSE is computed with all records in color palette from first to last. Wherever the MSE value is lowest that is considered to be best match. So is Exhaustive Search.

4.2 Kekre's Fast Search (KFS)

Color palette is sorted with respective to every grayscale value column of source image. Thus the columns of MxN window size color palette are sorted first with respect to grayscale intensity value of pixel (1,1) of every window, then the color palette is divided into two parts upper and lower. The upper part is sorted w.r.t pixel (1,2) and divided into two subparts. Even the lower part is sorted w.r.t pixel (1,2) and divided into two subparts. This process is repeated till pixel (M,N). While searching the grayscale target window match in color palette, the first grayscale target window pixel i.e pixel (1,1) is compared with the source grayscale pixel (1,1) at the center of palette. If source pixel value is greater the search should be done in first half else in later half. Then the search limits are minimized by repeating these steps for gray target pixel (1,2), pixel(1,3),…till pixel(M,N).

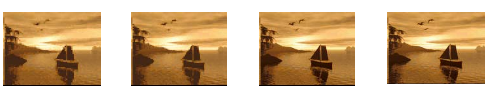
5. Quality of colored target image

As the process of coloring grayscale image is very subjective to the target image and source color image, the objective criteria to measure the quality of colored target image can not be considered. At the most we can convert some color image into grayscale image and then recolor it using same original color image. Then the Mean Squared Error (MSE) difference of re-colored image with original one could be considered to compare the proposed algorithms with each other.

6. Results and Discussion

Selection of source color image plays important role in coloring grayscale images. Here figure 1 shows the technique is applied to gray image given as 1.a. The two color source images are shown as 1.b and 1.c. Here 1.d. to 1.g are colored target (1.a) using 1.b. Here in 1.d & 1.e, RGB color space is used and for 1.f & 1.g, Kekre's LUV color space is used. Fig. 1.d & 1.f are showing results using KFS while 1.e & 1.g are obtained using ES. Fig.1.h to 1.k are showing results of coloring grayscale image using source image i.e.1.c

1.a Target 1.b Source-1 1.c Source-2



1.d KFS 1.e ES 1. f KFS 1.g ES

1.d -1.g Colored grayscale images using Source-1

1.h KFS 1.i ES 1.j KFS 1.k ES

1.h -1.k Colored grayscale images using Source-2

1.a Gray Target, 1.b Color source-1 1.c color source-2
1.d-1.h using RGB & KFS 1.e-1.i using RGB & ES
1.f-1.j using LUV & KFS 1.g-1.k using LUV & ES

Fig. 1 Coloring of grayscale scene image

The color trait transfer techniques are also applied to other image classes like faces, flowers, animals. Fig 2 shows results on face images, fig.3 on flower image. From results we can conclude that the color distortion in case of RGB color space is minimized to great extent in Kekre's LUV color space. Further we can state that exhaustive search works better over KFS.

2.a 2.b 2.c 2.d 2.e 2.f

2.a Target Imagef 2.b Color Source
2.c using RGB & KFS 2.d using RGB & ES
2.e using LUV & KFS 2.f using LUV & ES

Fig.2 Color traits transfer to Face Image

3.a 3.b 3.c 3.d 3.e 3.f

3.a Target Imagef 3.b Color Source
3.c using RGB & KFS 3.d using RGB & ES
3.e using LUV & KFS 3.f using LUV & ES

Fig 3. Coloring of grayscale flower image

In Fig. 4 we have taken the butterfly as source color image. The target image is grayscale conversion of same image, which is colored using source image.

4.a 4.b 4.c 4.d 4.e 4.f

4.a Target Imagef 4.b Color Source
4.c using RGB & KFS 4.d using RGB & ES
4.e using LUV & KFS 4.f using LUV & ES

Fig 4. Coloring of butterfly grayscale image using same butterfly color source

Table 1 gives the speed comparisons of proposed techniques. From the data we can conclude that the KFS is really faster than ES. Table 2 shows the MSE and PSNR comparisons of colored result images of fig. 4(c,d,e,f) with original color image(4.a) for the proposed techniques. From table 2 one can conclude that the quality of coloring is slightly better for the Exhaustive Search using Kekre's LUV space (LUV_ES).

Table 1. Speed comparison of techniques

Image	Elapsed exec. time in secs.			
	RGB		Kekre's LUV	
	KFS	ES	KFS	ES
Scene Fig.1 from 1.b	0.78	2.03	4.02	5.47
Scene Fig.1 from 1.c	0.72	2.28	3.81	5.20
Face fig.2	0.22	0.58	0.42	0.78
Flower Fig.3	13.3	36.5	75.2	99.4
Butterfly Fig.4	0.19	0.42	0.58	0.78

Table 2. Quality of techniques

Comparison Parameter	RGB		Kekre's LUV	
	KFS	ES	KFS	ES
MSE	4446.8	4351.1	4327.7	4301.0
PSNR	11.650	11.745	11.768	11.795

7. Conclusion

In this paper we have presented simple, computationally light and easier techniques for color traits transfer to grayscale images. The Kekre's LUV color space is used for better results and for improvement in searching time Kekre's fast search is used. From the results we can conclude that the quality of colored image using Kekre's LUV coloe space and exhaustive search is best. The solutions are generic and so can be used to all type of images like scenery, face, flowers, animals etc.

Global color transfer does not have adequate spatial consideration, so becomes difficult if the source or target image contains different color regions, the global transfer cannot distinguish the different statistics and will mix regions up. As the color traits transfer technique is highly subjective, the quality of colored image can not be expressed by any objective criteria. Just to compare the proposed techniques same color source image is re-colored and it is found that LUV with exhaustive search produces better results. Further work would involve segmentation based coloring and relating the pixel window size (used to prepare color palette) to the probabilistic distribution of colors in the source image.

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