Converting Gray-Scale Image to Color Image

Govind Haldankar, Atul Tikare and Jayprabha Patil

Abstract--**We introduce a general technique for "colorizing" grayscale images by transferring color between a source, color image and a destination, grayscale image. Rather than choosing RGB colors from a palette to color individual components, we transfer the entire color "mood" of the source to the target image by matching luminance and texture information between the images. We choose to transfer only chromatic information and retain the original luminance values of the target.**

I. INTRODUCTION

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. In addition, the information content of some scientific images can be perceptually enhanced with color by exploiting variations in chromaticity as well as luminance. 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. Due to these ambiguities, human interaction usually plays a large role in the colorization process. Where the mapping of luminance values to color values is automatic, the choice of the color map is commonly determined by human decision. Since most colorization software used in the movie industry is proprietary, detailed technical documents describing the process are generally not publicly available.

However a few web articles describe software in which humans must meticulously hand-color each of the individual image regions. For example, one software package is described in which the image is first polygonal zed so the user can color individual components much like a coloring book. Then the system tracks polygons between frames and transfers colors in order to reduce the number of frames that the user must color manually [Silberg 1998]. Alternatively, photographs can be colorized using photo-editing software to manually or automatically select components of a scene. The area is then painted over with a color selected from a palette using a low opacity level. There also exist a number of applications for the use of color in information visualization. For example, Gonzalez and Wintz[1987] describe a simple approach for pseudo coloring grayscale images of luggage acquired by X-ray equipment at an airport. The method separate transformations for each color channel which results in coloring objects with the density of explosives in bright range and other objects with a blue tone. Our concept of transferring color from one image to another is inspired by work by Reinhardt et al. [2001] in which color is transferred between two color images. In their work, colors from a source image are transferred to a second colored image using a simple but surprisingly successful procedure. The basic method matches the three-dimensional distribution of color values between the images and then transforms the color distribution of the target image to match the distribution of the source image. The grey scale image is represented by a one-dimensional distribution, hence only the luminance channels can be matched between the two images. Because a single luminance value could represent entirely different parts of an image, the statistics within the pixel's neighborhood are used to guide the match-in process. Once a pixel is matched, the color information is transferred but the original luminance value is retained. After color is transferred between the source and the target swatches, the final colors are assigned to each pixel in the grayscale image by matching ach gray image pixel to a pixel in the target swatches using the *L2* distance metric. Thus, each pixel match is determined by matching it only to other pixels within the same image

II. COLOR TRANSFER

In this section, we describe the general algorithm for transferring color; the basic idea is then extended to use swatches. The general procedure for color transfer requires a few simple steps. First each image is converted into the l color space. We use jittered samplings select a small subset of

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pixels in the color image as samples. Next, we go through each pixel in the grayscale image in scan-line order and select the best matching sample in the color image using neighborhood statistics. The best match is determined by using a weighted average of pixel luminance and the neighbor-hood statistics. The chromaticity values (channels) of Thebes's matching pixel are then transferred to the grayscale image to form the final image.

A .Color Transfer Algorithm:

Both color (source) and grayscale (target) RGB images are converted to the decor related . space [Ruder man et al. 1998] for subsequent analysis. . space was developed to minimize correlation between the three coordinate axes of the color space. The color space provides three decors related, principal channels corresponding an achromatic luminance channel (l) and two chromatic channels □and □which roughly correspond to yellow-blue and red-green opponent channels. Thus, changes made in one color channel should minimally affect values in the other channels. The reason the . color space is selected in the current procedure is because it provides a decor related achromatic channel for color images. This allows us to selectively transfer the chromatic a. and b channels from the color image to the grayscale image without cross-channel artifacts. The transformation procedure follows directly from Rein hard et al. [2001].In order to transfer chromaticity values from the source to the target, each pixel in the grayscale image must be matched to a pixel in the color image. The comparison is based on the luminance value and neighborhood statistics of that pixel. The l channel in . space determines the luminance value. In order to account for global differences in luminance between the two images we perform luminance remapping [Hertz Mann et al. 2001]to linearly shift and scale the luminance histogram of the source image to fit the histogram of the target image. This helps create a better correspondence in the luminance range between the two images but does not alter the luminance values of the target image. The neighborhood statistics are recomputed over the image and consist of the standard deviation of the luminance values of the pixel neighborhood. We have found that a neighborhood size of5x5 pixels works well for most images. For some problematic images we use a larger neighborhood size. Since most of the visually significant variation between pixel values is attributed to luminance differences, we can limit the number of samples we use as source color pixels and still obtain a significant range of color variation in the image. This allows us to reduce the number of comparisons made for each pixel in the grayscale image and decrease computation time. We have found that approximately 200 samples taken on a randomly jittered grid is sufficient. Then for each pixel in the grayscale image in scan-line order the best matching color sample is selected based on the weighted average of luminance (50%) and standard deviation (50%). We have also included the neighborhood mean and varied the ratio of these weights but have not found significant differ-encasings the results. Once the best matching pixel is found, the a and b. chromaticity values are transferred to the target pixel while the original luminance value is retained. This automatic, global matching procedure works reasonably well on images when corresponding color regions between the two images also correspond in luminance values. However, regions in the target image that do not have a close luminance value to an appropriate structure in the source image will not appear correct.

B .Video:

Colorization of video can be automated using the colorization procedure described above. To colorize all of the frames in a scene, we first transfer color from a source color image to a single target frame. Then every frame in the video sequence can be colorized using the same colorized target swatches used in the single frame. If a single frame is successfully colorized using these procedures, then frames which consist of the same objects as that single frame will be colorized similarly.

III.RESULTS ANALYSIS

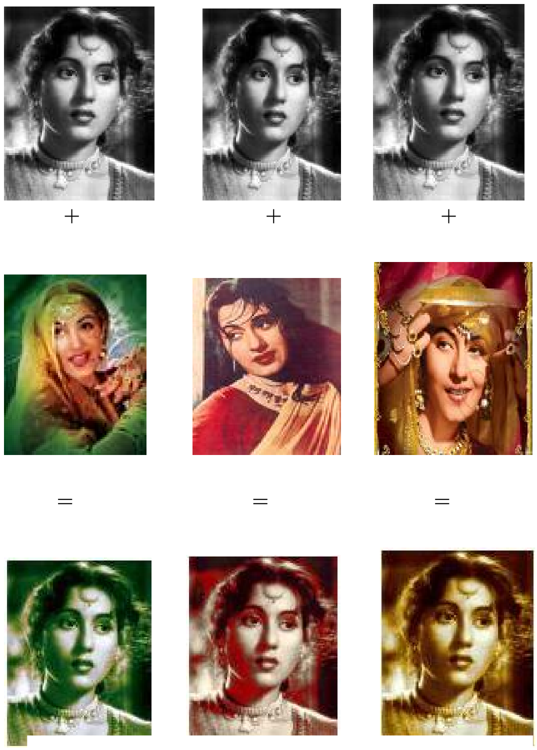
Figure2a-c showcases the final results of the algorithm applied to a Variety of image domains. Figures 1a-c shows the results of colorizing foliage, face and landscape photographs. The technique Works well on scenes where the image is divided into distinct luminance clusters or where each of the regions has distinct textures. In general, however, the current technique does not work very well with faces.

Although colors are transferred well into the swatches, the L2 distance is not always a sufficient measure in classifying the difference between skin and lips and sometimes clothes and hair. Figures2a,c demonstrate the use of the algorithm with different types of scientific data

Although this technique is not intended for clinical diagnosis with medical image data, it might be used in anatomical illustrations or to enhance scientific presentations. Although we show that the algorithm works well in a number of image domains, we do not claim that the technique will work on most images.

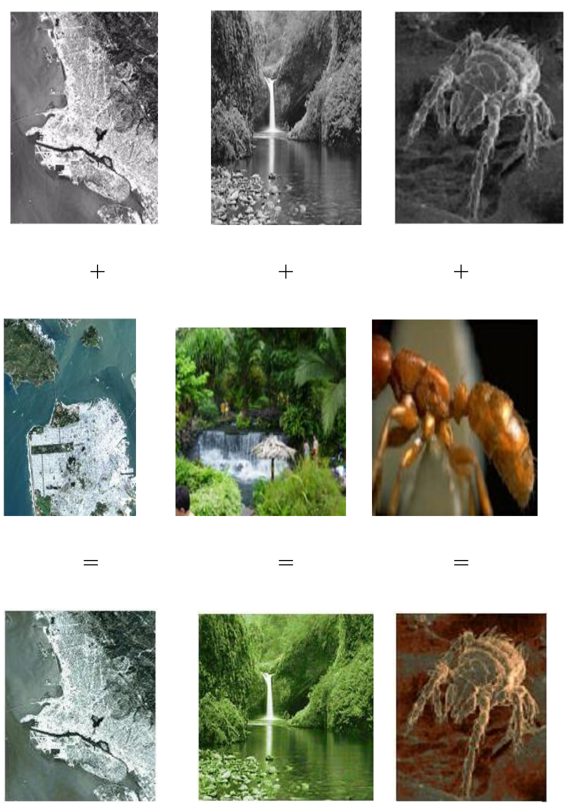
It should be clear that when one considers only a Small neighborhood size around a pixel it is often impossible to determine whether that neighborhood belongs to one texture or another. However, by using high resolution images and larger neighborhoods we can obtain improved results.

Further, we believe that more images can be colorized using



1.a *1.b* *1.c*

Fig 1. results of colorizing foliage



2.a *2.b* *2.c*

Fig 2.final results of the algorithm applied to a Variety of image domains

the basic method provided but with better texture classification methods at the expense of simplicity and computation time. The running time of the algorithm for one image can range From 15 seconds to 4 minutes on a Pentium III 900 MHz CPU using Optimized MATLAB code running time will vary depending on the number of samples used for comparison, the number of swatches, neighborhood size and the size of the images. Most images can be colorized reasonably well in under a minute.

IV.CONCLUSION

In this paper we have formulated a new, general, fast, and user-Friendly approach to the problem of colorizing grayscale images. While standard methods accomplish this task by assigning pixel Colors via a global color palette, our technique empowers the user to first select a suitable color image and then transfer the color Mood of this image to the grey level image at hand. We have intentionally kept the basic technique simple and general by not requiring registration between the images or in corpora ting spatial information. Our technique can be made applicable to a larger class of images by adding a small amount of user guidance .Currently, the L2Isused to measure texture similarity within the image. In the future we believe the technique can be substantially improved by using more sophisticated measure of texture similarity. Our technique of employing an example color image to colorize a grey level image is particularly attractive in light of the Growing sophistication of internet images ear changing and he Emergence of centralized and index able image collections which can be used to easily locate suitable color images. Finally, one could also utilize a database of basis texture swatches for the initial Color transfer in the user-guided stage of the colorization process.

V. REFERENCES

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