A Novel Approach for Colorization of a Grayscale Image using Soft Computing Techniques

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ABSTRACT

Colorization of grayscale image is a process to convert a grayscale image into a color one. Few research works reported in literature on this but there is hardly any generalized method that successfully colorizes all types of grayscale image. This study proposes a novel grayscale image colorization method using a reference color image. It takes the grayscale image and the type of the query image as input. First, it selects reference image from color image database using histogram index of the query image and histogram index of luminance channel of color images of respective type. Once the reference image is selected, four features are extracted for each pixel of the luminance channel of the reference image. These extracted features as input and chrominance blue(Cb) value as target value forms the training dataset for Cb channel. Similarly training dataset for chrominance red(Cr) channel is also formed. These extracted features of the reference image and associated chrominance values are used to train two artificial neural network(ANN)- one for Cb and one for Cr channel. Then, for each pixel of the query image, same four features are extracted and used as input to the trained ANN to predict the chrominance values of the query image. Thus predicted chrominance values along with the original luminance values of the query image are used to construct the colorized image. The experiment has been conducted on images collected from different standard image database i.e. FRAV2D, UCID, v2 and images captured using standard digital camera etc. These images are initially converted into grayscale images and then the colorization method was applied. For performance evaluation, PSNR between the original color image and newly colorized image is calculated. PSNR shows that the proposed method better colorizes than the recently reported methods in the literature. Beside this, “Colorization Turing test” was conducted asking human subject to choose the image (closer to the original color image) among the colorized images using proposed algorithm and recently reported methods. In 80% of cases colorized images using the proposed method got selected.

KEYWORDS

Adjacency Ratio, Artificial Neural Network, Clustering, Color Quantization, Colorization, Neighborhood Statistic, Particle Swarm Optimization, PSNR, YCbCr

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**INTRODUCTION**

Color is a key attribute of an image due to its extensive use in various important fields like medical image processing, face image processing, video processing, entertainment etc. (Gonzalez et al., 2010; Umbaugh, 1998; Gonzalez & Woods, 2010). Colorization is a process that converts a grayscale image to a color one. It is an active and challenging area of research with a lot of interest in the image editing and compression community (Zhang et al., 2016; Larsson et al., 2016; Haldankar et al., 2007; Reinhard et al., 2001; Welsh et al., 2002; Blasi et al., 2003; Levin et al., 2004; Yatziv & Sapiro, 2006; Kang & March, 2007; Sathik & Parveen, 2010; Bugeau et al., 2014; Hasnat et al., 2017). A few grayscale image colorization methods work successfully on different types of images. Mainly, two types of colorization methods are found in the literature. In the first category, the user manually colorizes some sample area in the grayscale image which is later used as source of color for colorization of the entire grayscale image. But this process is time consuming and tedious. Also, it requires very careful sample color selection from the user. The second category of algorithms uses a reference color image which presumably contains semantically similar color for the grayscale query image. This process is semi-automatic and sometimes requires user intervention in the process and has produced some impressive colorization using user input. But sufficiently complex images still may require many user interactions.

Colorization process has no unique solution because for a same luminance value in two different positions in the grayscale image, there may be different chrominance value in the color image. Although some works found in the literature, colorization still remains a challenging area. Haldankar et al. (2007) proposed a system in 2007 which modifies a gray scale image into a color one by the luminance effect of the reference image but the time required for colorization is huge for a large size image and hence the method is less effective in real time system. In 2001, Reinhard et al. (2001) proposed a method for a general color correction that takes one image’s color characteristics from another using statistical analysis to make a synthetic image which takes on another image’s look. But this method is not actually a method of grayscale image colorization. A semi-automatic neighborhood statistics based colorization approach was proposed by Welsh et al. (2002). Their method, effectively colorizes a grayscale image where they choose to transfer only chromatic information and retain the original luminance values of the query image. Further rectangular swatch based colorization is done for enhancing the colorized areas where the user is not satisfied with the color information. In this method, colors are transferred between the corresponding swatches. But Welsh et. al (2002) finally concluded that their method won’t work on images where color change is gradual such as face image. Moreover, all these existing methods take reasonable amount of time for colorization.

In 2003, Blasi et al. (2003) proposed a fast colorization method for homogeneous images based on a new data structure, called anti-pole tree. But it is not a method which is applicable for all types of images. In 2005, Levin et al. (2004) presented a method based on the neighboring pixels in space-time that have similar intensities and similar colors. This method is formalized by using a quadratic cost function and generalized to an optimization problem which could be solved using a standard optimization technique. In 2006, Liron Yatziv and Guillermo Sapiro proposed a method where a graph is formed considering each pixel as node and intrinsic distance is used to measure the similarity of colors where users manually colorizes some regions (called scribble) of the grayscale image which are used as sample color to colorize the whole image. Sung Ha Kang and Riccardo March proposed (Kang & March, 2007) different variational models using chromaticity color components and colorizes the gray scale image by minimizing the total variation where sample colors should be given manually by the user. In 2010, M. S. Sathik and N. R. S. Parveen proposed a method to convert a gray scale X-ray image into a RGB space to diagnose the fracture properly which works for only certain types of images (Sathik & Parveen, 2010). In 2014, Aurélie Bugeau et al. proposed an automatic colorization process where color source pixel is selected based on the best color for each pixel from a set of candidate pixel using pixel energy minimization method (Bugeau et al., 2014).
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