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Multicolor Transformation Using Locally Linear Embedding Algorithm

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Abstract: - **In this paper, an effective Locally Linear Embedding (LLE) algorithm is used for still images and image sequence to transfer the colors. The performance of this new algorithm is demonstrated through simulation and comparisons to another state of the art method. This algorithm is mainly based on color transfer between images based on the simple statistics and locally linear embedding. LLE algorithm is not restricted to one-to-one image color transfer and can make use of more than one source images to transfer the color in different regions in the target image. The new measure is highly consistent with human perception, even compared to other current color transfer quality measures such as PSNR and MSE.**

***Keywords*: Color Transfer, K-means, Image Quality Measure.**

I. INTRODUCTION

Color transfer is widely used in the field of image processing. Color transfer changes the color contents from the source image to the target image. For complete color transfer, color space and color transfer algorithm should be needed. Color transfers are used in many applications such as animation, color correction, including scanners and commercial photo editing software. LLE is an unsupervised learning algorithm in which it preserves neighborhood embeddings of a high dimensional data. Hwang et al [1] designed a color transfer using probabilistic moving least squares which is a process of transferring color of an image to match the color of another image of the same scene. The color of a scene may vary from image to image because the photographs are taken at different times, with different cameras, and under different camera settings. To solve for a fully nonlinear and nonparametric color mapping in the 3D RGB color space, a scattered point interpolation scheme using moving least squares is proposed and has been strengthened with a probabilistic modeling of the color transfer in the 3D color space to deal with misalignments and noise. The effectiveness of the method over previous color transfer methods both quantitatively and qualitatively is analyzed. Nguyen et al [2] developed an illuminant aware gamut based method which is unique in its consideration of the scene illumination and the constraint that the mapped image must be within the color gamut of the target image. Specifically, this illuminant aware gamut based approach first performs a white-balance step on both images to remove color casts caused by different illuminations. Then each image is aligned to share the same 'white axis' and gradient preserving histogram matching technique is performed along this axis to match the tone distribution between the two images. This illuminant-aware strategy gives a better result than directly working with the original source and target image's luminance channel as done by many previous methods.

Okura et al [3] designed a unifying color and texture transfer for predictive appearance manipulation. The existing color transfer methods use local information to learn the transformation from a source to an exemplary image and then transfer this appearance change to a target image. These solutions achieve very successful results for general mood changes, e.g., changing the appearance of an image from "sunny" to "overcast". Rabin et al [4] developed an adaptive color transfer with relaxed optimal transport. The proposed adaptive color transfer with relaxed optimal transport focuses on the problem of color transfer between images using optimal transport technique. Since being a generic framework to handle statistics properly, it is also known to be sensitive to noise and outliers and is not suitable for direct application to images without additional post-processing regularization to remove artifacts. This approach is based on the relaxed and regularized discrete optimal transport method. Real images demonstrate the capacity of the model to adapt itself to the considered data. The problem of adaptive color transfer is to transfer color between images using optimal transport techniques. Pang et al [5] suggested a color transfer and image enhancement by using sorting pixels comparison. The fast color transfer is valuable in digital images. Firstly, based on color information sorting of

pixel distribution is implemented separately on color images and grayscale images. Finally, using the color transferring algorithm, the grayscale images are colored perceiving the rearranged pixel comparison information. After the process on large numbers of grayscale images, it shows that this method is concise and clear, efficient for dyeing process and the results can be further used for the automatic coloring of multiple targets color enhancement. Jolly et al [6] surveyed about the method and an arrangement for color transfer between images for compensating color differences between at least two images as a first and a second image represented by pixel data. In the technique, corresponding feature points of the images, a color map and a geometric map are calculated for compensating the first image by applying said a geometric map and said color map to the first image resulting in a compensated first image. The method can be performed on the fly and is applicable for equalizing color differences between images different in geometry and color.
Zhang et al [7] developed a method of illumination effect transfer between images using color transfer and gradient fusion. Illumination plays a crucial role in determining the quality of an image, especially in photography. An unsupervised illumination-transfer approach for altering the illumination effects of an image by transferring illumination effects from another. Chen et al [8] designed a no reference image quality measure using a distance doubling variance. Image quality is most essential for autonomous systems, where processing occurs on an acquired image and it is used for detection and recognition of objects. The Distance Doubling Variance measure differs from color image quality methods, which typically attempts to extend traditional grayscale image approaches for color images. It utilizes the color properties in the color space, where the difference between two color pixels is evaluated by computing the distance in the color space using different weights for each color components.
Liao et al [9] developed a neural color transfer between images. Color transfer is a long-standing problem that seeks to transfer the color of a reference photograph onto another image. These new algorithms of neural color transfer between images have perceptually similar semantic structures. The study aims to achieve more accurate color transfer that leverages semantically-meaningful dense correspondence between images. This algorithm uses neural representations for matching. Additionally, the color transfer should be spatially-variant and globally coherent. Therefore, color transfer algorithm optimizes a local linear model for color transfer satisfying both local and global constraints. This approach has jointly optimized matching and color transfer, adopting a coarse-to-fine strategy.

II. PROPOSED METHOD

This section presents the detailed description of the proposed multicolor transfer. At first, the given source image and the target image is k-means to group the similar pixel values. After that, the color matching using LLE to calculate the probability weights of each component. Finally, color transfer to transfer the colors from all the planes in the CIELαβ color space for each segmentation. The overall flow of the proposed system is shown in Fig 1 and Fig 2, which includes the following stages:

- K-means Clustering
- Color Matching using LLE
- Color Transfer

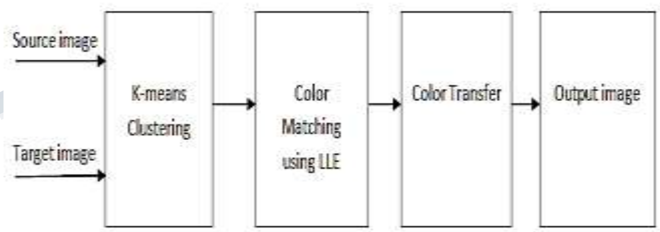

Fig. 1 Block diagram of the proposed system for Still images

Fig.1 represents block diagram for the single source image and single target image for color transfer using LLE algorithm.

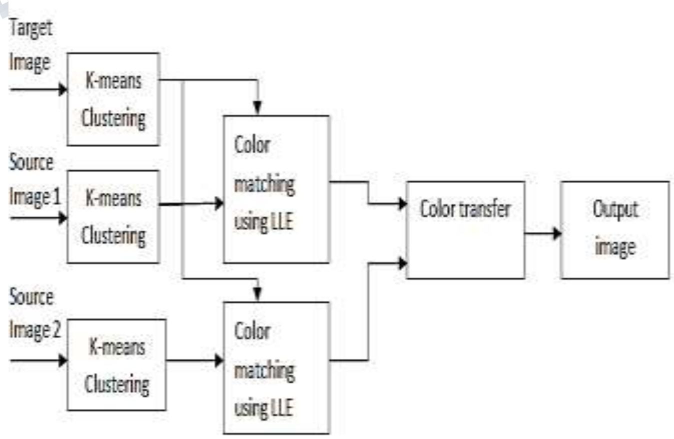

Fig. 2 Block diagram of the proposed system for image sequences

Fig.2 represents block diagram for the multiple source image and single target image is used for color transfer using LLE algorithm.

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A. K-means Clustering

The k-means is a simple and easy way to classify a given data set into a certain number of clusters. Its mathematical model can be shown in (1).

$$\arg\min_{I(i,j)} \sum_{i=1}^{m}\sum_{j=1}^{n} \| X^{ij} - Y(I(i,j),:) \|^2 \qquad (1)$$

Where, I(i,j) is the index number of the cluster for each sample data X^{ij} which is a p-dimensional vector as shown in (2). Y with the size of k*p and $Y(I(i,j),:)$ is the mean value vector of each cluster. For k=3

$$X^{ij} = [x_a^{i-1j}, x_a^{ij-1}, x_a^{ij+1}, x_a^{i+1j}, x_\beta^{i-1j}, x_\beta^{ij-1}, x_\beta^{ij}, x_\beta^{ij+1}, x_\beta^{i+1j}] \qquad (2)$$

Where x_a^{ij} and x_β^{ij} are the color pixel values in the α and β planes. Classification can be processed by using K-means depending on the different colors to get the segmentation map I and Y.

B. Color Matching Using LLE

After applying k-means clustering algorithm, resultant image is processed by using LLE algorithm from which probability weight can be calculated. The probability weights of w_{ij} that can best rebuild x_i from these k neighbors. Locally Linear Embedding more accurately transfers the source color to the target image while preserving the boundaries and exhibits more natural output. Its mathematical model can be shown in (3)

$$\sum_{i=1}^{N} \| x_i - \sum_{j\varepsilon N_i} W_{ij} x_{ij} \|^2 \qquad (3)$$

Subject to constraint $\sum_{j\varepsilon N_i} W_{ij} x_{ij} = 1.$

C. Color Transfer

Color transfer is done by using CIELαβ color space for each segmentation. Color transfer is applied only α and β planes except for luminance plane because it converts dark color into other dark colors, similarly for light colors also. Its mathematical model is shown in (4)

$$R_j^i = \frac{\sigma_{Sj}^{M(i)}}{\sigma_{Tj}^i}(T_j^i - \mu_{Tj}^i) + \mu_{Sj}^{M(i)}, i = 1,.,K, j = L,\alpha,\beta \qquad (4)$$

Where $\mu_{Tj}^i, \sigma_{Tj}^i$ are the mean value and standard deviation of the target image and $\mu_S^{M(i)}, \sigma_{Sj}^{M(i)}$ are the mean and standard deviation of the source image.

III RESULTS AND DISCUSSION

The Locally Linear Embedding algorithm has been implemented for the still images and image sequences. Fig. 3 shows the source and target images used for implementation of the still image. Based on Lαβ components and LLE algorithm, a multicolor transfer has been implemented. Both the source and target image are of size 512*512 in png format. The output obtained in the color transfer process with the dominant color in the source image being transferred to the object in the target image.

(a)

(b)

(c)

Fig. 3 Single source target image (a) Source image (b) Target image (c) Recolored image

Fig. 4 shows the implementation of image sequences. Dominant colors present in the source image1 is transferred to the target image and that image is represented the first level image. Similarly, this process takes place for source image2 also and it is denoted as the second level image. After combining both outputs, result is obtained.

(a)

(b)

(c)

(d) ***(e)*** ***(f)***

Fig. 4 Multiple source target image (a) Source image1 (b) Source image2 (c) Target image (d) First level (e) Second level (f) Recolored image

TABLE I

Images	PSNR using LLE	PSNR using k-means	MSE using LLE	MSE using k-means
SSTI	18.5836	14.2949	300.3285	806.2413
MSTI	15.5805	12.0300	599.6675	1.3582e+03

Table I presents the PSNR values obtained for both the cases namely SSTI (Single Source Target Image) and MSTI (Multiple Source Target Image). Similarly, MSE using both LLE and K-means are presented for comparison. The PSNR obtained using LLE of SSTI is greater than PSNR obtained by K-means. A similar change is also observed for image sequences. The shows that multicolor transfer using LLE results in an efficient color transfer.

IV. CONCLUSION

In this work, Locally Linear Embedding algorithm has been presented for color transfer in still images and image sequences. Multicolor transformation using still images based on three process K-means Clustering, Color Matching using LLE and Color Transfer. First, the K-means algorithm has been used to extract the representative colors in the source and target images and also to do the segmentation according to the representative colors. In the second stage, color matching using LLE can construct the mapping relationship between the source image and target image. In the final stage, the color transfer was applied only in two planes in the CIELαβ color space. Thus the recolored image is obtained by using Locally Linear Embedding algorithm.

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