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Colorization of Grayscale Image Using Quaternion Algebra in MATLAB

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Abstract - Colorization of grayscale images is a long standing and ill-posed problem. There are many possible applications for colorization. The most obvious application is the colorization of monochrome images from archives. Studies have also gone into using colorization to highlight biomedical images in order to allow potential areas of interest to be easily visible. This seems to be a really good use of the technique in the medical industry and shows that there are many potential uses for colorization in other fields. Colorization can also be used to highlight potentially dangerous substances shown in grayscale x-rays at airport security. This paper deals with different methods of colorization, explore quaternion algebra and its application in image processing. The main aim of proposed work is to investigate the various application of quaternion algebra in image processing and color grayscale images using quaternion algebra. Our proposed method is based on approach using seed color to initiate colorization process. We present a colorization method which uses operation of quaternion algebra to produce color image for a given input grayscale image. It is important to remember that the results of colorization are purely perceptual, even if the colors are wrong they may still be acceptable.

Keywords - Colorization, Image Processing, Edge Detection, Quaternion Algebra.

I. INTRODUCTION

Computerized colorization began in the 1970s with a process developed by Wilson Markle for adding color to black and white movies and TV programs. The term is now used generically to describe any technique for adding color to monochrome image or video. Colorization finds wide area applications, for example in the field of medical science where technology still is not much advanced and require much more accurate presentation of the X-ray report. Also, for efficient use of the data storage of large amount of security footage, it is a pre requisite to save it in monochrome version of the acquired data and later use colorization techniques.

In our daily life, there are many valuable photos retaining the memory that we cannot write in words. Many of them are recorded in black-and-white, especially for those old photos. Traditionally, to colorize them is a very time-consuming handmade work. Fortunately, the digital image processing technology results in significant progress on image colorization, and allows us to color the black-and-white world with little interaction.

1.1 GENERALIZATION OF COLORIZATION

The image colorization can be generalized into two ways:

1) Based on requirement of user interaction during colorization process.
2) Based on additional image(s) used for colorization process.

1) On The Basis of User Interaction During Colorization Process:

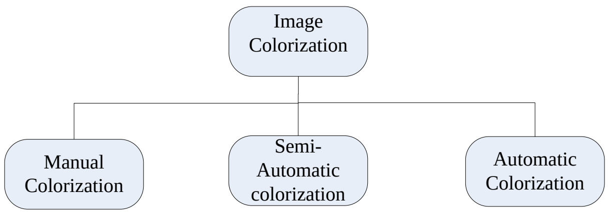

Fig. 1.1 Generalization of Image Coloring on the Basis of User Interaction

Image colorization can be generalized on the basis of user supervision or user guidance during colorization process.

2) On The Basis of Additional Image(S) Used For Colorization Process:

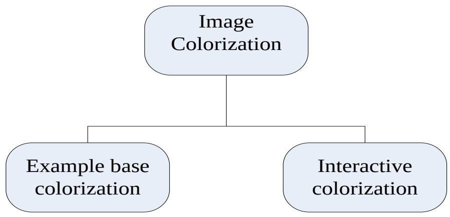

Fig. 1.2 Generalization of Colorization on Based on Additional Images Require For Colorization Process

Colorization method can be Generalization based on addition image require to transfer color, this additional image also known as source image

II. SYSTEM MODEL

2.1 OBJECTIVE

Exploration and use of quaternion for achieve colorful image from grayscale image and scribbled image. Implementation of canny edge detection algorithm in colorization process to find object boundary.

2.2 PROBLEMS STATEMENT

There are several problems associated with colorizing both natural and unnatural images. Firstly, color blending and edge detection are common issues that must be taken into consideration. It is necessary to create an algorithm which will allow blending over a smooth intensity gradient, such as an image of a sunset, but will give distinct edges when necessary and will not allow blending over images with distinct shapes of very different intensities. There is generally no way to solve the colorization problem for both of these image types and all of the literature in this field has concentrated on just one of them.

2.2.1 AMBIGUITY IN COLORIZATION

Unfortunately, it is not always possible to differentiate between colors when only provided with luminance information. This is due to the fact that the number of channels available has been cut from three to one, so where there may have been over 16 million different possible values for a pixel there are now only 256. This means that, although we can try our best, it is unlikely that we will select the right one from all 65000+ possible combinations for each intensity value without at least some sort of reference. When you add to this the notion that humans can only distinguish around two dozen shades of gray (Gonzalez and Woods, 2007) it is clear that there is a large margin for error when colorizing.

Fig. 2.1 The same image in full color and monochrome - notice how the sun almost disappears when the color information is removed. (Monet, 1872)

If the image itself has very clear areas of different luminance that correspond to different chrominance, then the process of colorization is fairly trivial. If, however, the image contains spatially near areas that should be of differing chrominance values but have very similar luminance values then the process becomes somewhat more difficult. One very famous example of this problem is Monet's painting `Impression, Sunrise' (Figures) in which the sun and the sky have almost exactly the same intensity.

2.2.2 FINDING THE COLOR OF EACH PIXEL

The colorization problem itself can be seen as a maximum a posteriori problem [3]. That is to say that the probability of a pixel being colorized with a certain chrominance is in relation to the pixels viewed after it. For example, after looking at the first image in a pixel the nearest color clue may not appear for another 50 pixels. This means that the first pixel will be affected by those viewed after it and so will be colorized as such.

When trying to solve the problem of which pixels are influenced by which scribbles it is necessary to use a method of finding the nearest neighbors. This does not just mean the spatial location of one pixel in relation to another but also the similarity in their luminance. Dijkstra's algorithm [2] allows for the shortest path from one point to another to be calculated simply. This can easily be adapted to the field of colorization and would allow for the best possible colorization of pixels by nearby scribbles.

III. PREVIOUS WORK

Colorization exists since the birth of photography and dates back to 18th century. In the beginning of the 19th century, T.V. system was developed which only showed black and white images and videos. In 1930 color television was commercialized and all the videos and images were colorized by hand by a French company. In 1970 first computer assisted colorization process was developed and used to colorize image received from NASA Apollo mission. Invention of digital colorization reduces human work very significantly and produced good quality result. With development in technology coloration became more advanced and realistic.

Colorization method in which a look-up table is used for assign RGB value to each monochrome pixel. When applying various colors at similar intensity, user must intervene and define region manually, which make it very laborious proposed by Gonzalez and woods [1987] . Irony et al. [4] presented a method which require segmentation of example image and then match region between grayscale image and segmented region to transfer color. Transfer color only to pixels whose match is associated with a high level of confidence, and feed the colored pixels as “micro-scribbles” to the optimization algorithm of Levin et al. [7]. A Scribbled based colorization method which first perform sub sampling on input grayscale image and extract boundary information presented by Nie et al. [12]. Abadpour and Kasaei [1] introduced a method for grayscale image colorization by taking advantages of the principal component analysis. Luan et al. [10] presented an interactive system for colorizing the natural images. The colorization procedure is separated into two stages: color labeling and color mapping. By separating the color labeling from the color mapping, the interaction of colorization becomes more intuitive for users. Liu et al. [9] proposed method first register target image into internet to search source color image. After loading lots of source color image form internet, all color information is remove from these images then gray intensity of target image and color image process to find similar region in source and target image. Then color information of source image is used to draw scribble and Morimoto et al. [11] present an automatic colorization method which require internet to gather source images from web using a gist scene descriptor. It will produce unnatural results due to the source images that are structurally similar but semantically different. colorization by using 1 million image used as reference image to achieve higher accuracy and more option for user.CBIR to retrieve color image which is symmetrical similar to grayscale image from the database which is created by author[13] containing a large set of color image. The limitation of this method is that if database doesn't have a similar image like input grayscale image then this method fails to produce desire result.Liu & Zhang [8] had presented a colorization method which is based on histogram regression. A source image is used which is similar to grayscale image to transfer color to grayscale image. An image colorization process which require an artificial neural network (ANN) to train before producing output colorize image [6]. Kazunori et al. [5] presented an image colorization proposes with a new image colorization algorithm which is based on the sparse optimization and approximated by series. Ling et al. [14] presented a novel colorization method based on color propagation and rank minimization. In this method firstly propagate the known color values to other pixels to be colorized, As the colorized image after color propagation is not accurate, then define a confidence matrix to measure the propagation fidelity. Numerical and visual comparisons show that proposed method leads to colorization results of high-quality.

IV. PROPOSED METHODOLOGY

The proposed method presents image colorization technique in which two input images are required. Firstly, a grayscale image which needs to be colorized and the second which is the scribbled image (i.e., which is color marked on grayscale image). MATLAB 2016 tool is used to implement the proposed work. MATLAB provides the inbuilt features for processing of the image. The key idea behind the proposed work is to develop a robust technique for grayscale image colorizing process that will ensure that there is no leakage of color in boundary region and each grayscale pixel will be colorized.

4.1 HARDWARE USED

To propose a system for colorization process, perform many intermediate calculations and neighbor matrix is created and manipulated which require huge memory and high computation.

The system is developed and executed on a PC which has the following hardware specifications:

- Processor: Intel(R) Core™ i7, 2.60 GHz, 7th gen
- Installed memory (RAM): 12 GB
- System Type: 64-bit operating system
- Hard disk: 1 TB
- Operating System: window 10 64 bit.

4.2 SOFTWARE USED

MATLAB is an acronym for MATrix LABoratory, which is developed by MathWorks. It is a high-level computation and simulation tool that allows quick, easy and reliable manipulation of vectors and matrices, scientific calculations. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. It has sophisticated data structures, built-in editing and debugging tools, and supports object-oriented programming. These factors make MATLAB an excellent tool for teaching and research. MATLAB is an essential asset for scientists, researchers and engineers.

In this section, the methodology for the proposed work has been introduced and discussed.

Step 1 Inputs –

- A grayscale image
- Scribble on grayscale image
- Window size

Step 2 Implementation of canny edge detection algorithm in grayscale image, which represents edge as '1' and refers to the white region while the object in black refers to 0.

Step 3 Scribble image is converted into YCbCr color space and is represented in quaternion form in which the grayscale intensity replaces the coefficients of i in quaternion's of the scribble.

Step 4 Weight is calculated for the given window, for each pixel using canny edge detection and normalized difference of intensity.

Step 5 For each pixel process, weight has been generated for a given window and is stored in a new row in the system to form a neighbor weight matrix.

Step 6 With the help of neighbor weight matrix and given color information in quaternion form, we will form a linear system of equations which will be solved using gauss elimination method.

Step 7 Output will be in quaternion form, extract coefficient of imaginary part. Coefficients are converted into M*N*3 to form output color image and stored to file for later view.

V. SIMULATION/EXPERIMENTAL RESULTS

This part presents the results that have been produced by implementing our proposed method. First section contains analysis of results obtained by our proposed method and the comparison with the original color image.

By using edge detection, we put a constraint on color that it cannot cross the boundary region hence color leakage is reduced to produce more sharp image

Original Image	Canny with .8 threshold.	Canny with .4 threshold.	Canny with .1 threshold.

Fig. 5.1 Performance of Canny Edge Detection Algorithm with Different Thresholds.

Output of canny edge detection algorithm is shown above diagram and it is clearly visible that with .1 threshold is better choice to use in our proposed method.

Table 1. Analysis Of Image Colorization

Image Size	239 * 319
Size of NWM	76241 * 76241
No. of Scribbled pixel	12792
No. of pixel to be colorized	63449

Grayscale Image	Scribbled Gray Image	Orignal Color Image

Output From Mask 1	Output From Mask 2	Output From Mask 3

Fig.5.2 Colorization of image by our proposed method

For analysis of result of our proposed colorization first we have taken a set of true color images and converted them into grayscale and marked the scribbles on them to implement our proposed colorization method in MATLAB.

Table 2. Quality Measurement Of Image

Mask Used	Execution Time (in sec.)	Mean Square Error
Mask 1	2.2	2.4823e-04
Mask 2	2.4	1.2254e-04
Mask 3	2.5	1.6899e-04

As shown in above figure, output image of all masks are similar to eyes but little variation in the mean square error conclude that selection or rejection of neighbor pixels has direct impact on our proposed colorization.

VI. CONCLUSION

To produce colorized image our proposed work first calculates weight function for each pixel whose color information is to be calculated. Weight matrix which is a sparse matrix containing only one diagonal is formulated for solving the system of linear equations. Then the scribbled image is converted into YCbCr color space and stored into a quaternion matrix which has the same dimension as that of image. With the help of neighbor weight matrix and quaternion matrix we build a quadratic cost function which solve colorization problem using optimization. Then the coefficient of vector part of the resultant quaternion is extracted to form RGB color space. this section conclusion of the research work should be explained.

VII. FUTURE SCOPES

The robustness of the method can be improved by putting more constraint on the weight calculation. Weight function can be used to capture structural information of image and color only desired region of the image leaving rest of the image in gray, which can be used in x-ray security system to highlight the suspicious object with color. author will explain the future of his/her research.

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