Grayscale to Color Map Transformation for Efficient Image Analysis on Low Processing Devices

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Abstract. This paper presents a novel method to convert a grayscale image to a colored image for quality image analysis. The grayscale IP operations are very challenging and limited. The information extracted from such images is inaccurate. Therefore, the input image is transformed using a reference color image by reverse engineering. The gray levels of grayscale image are mapped with the color image in all the three layers (red, green, blue). These mapped pixels are used to reconstruct the grayscale image such that it is represented in a 3 dimensional color matrix. The algorithm is very simple and accurate that it can be used in any domain such as medical imaging, satellite imaging and agriculture/environment real-scene. The algorithm is implemented and tested on low cost mobile devices too and the results are found appreciable.

Keywords: Digital Image Processing, Grayscale to Color Transformation, Image Analysis, Low Processing Devices.

1 Introduction

The technological advancements are contributing a major role in human society and colored cameras and scanners are becoming ubiquitous. There is a demand for better image analysis, in general. The growth of image processing from grayscale

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uni-variant data analysis to a colored multi-variant data analysis is still challenging the researchers. The areas like biomedical imaging are still working with grayscale image and phase problems like segmentation, edge detection, and blob detection, in case of tumor detection. Enhanced medical imaging techniques have attracted attention after the advanced medical equipments used in medical field. Colored images are much easier to distinguish the various shades by human eye.

Computer vision technologies are applied in various domains for image enhancements and automatic image summarization. The traditional process of identification involves lot of technical expert knowledge, lack of which misleads the results, particularly in medical cases. Therefore, the image is enhancement before the data is applied for any decision making analysis which increases the difference between the objects in image [1]. The aim of this paper is to present an algorithm to automatically transform a grayscale image to a colored image, which adds extra information in it making analysis easier.

Barghout and Sheynin [2] used *k*-mean clustering algorithm to segment different objects in real-scene based on the pixel color intensity. The algorithm guaranteed to converge but highly depends on *k*-value. Since the real-scenes include irregular shapes the *k*-value selection may fail to return an optimal solution. Chang et al. [3] agreed with this and thus proposed a novel environment scene image analysis approach based on the perceptual organization which incorporates *Gestalt* law. This algorithm can handle objects which are unseen before and so used for quality image segmentation. Few authors have used object-shape based models to overcome the segmentation problem with fixed objects [4], but it's not the real case. The major problems with such algorithms are that, they results in over segmentation and under segmentation.

A solution to over segmentation, in 2011, Prasad et al. [5], proposed a block-based unsupervised disease segmentation algorithm which segment the sub-images into small classes that is later on combined to form a bigger class. While in 2013, Prasad et al. [6], used a cluster based unsupervised segmentation approach to identify the diseased and non-diseased portion from a colored natural plant leaf image, considering only a single disease attack at a time. This algorithm granted the best result in disease detection in $L^*a^*b^*$ color space. On the other side, Grundland and Dodgson [7] introduced a new contrast enhanced color to grayscale conversion algorithm for real-scenes in real-time. They used image sampling and dimension reduction for the conversion. They transformed a colored image to a high contrast grayscale for better understanding. But again losing information in this dimension reduction which creates problem of under segmentation.

Sharma and Aggarwal [8] discuses the limitations of segmenting CT and MR scanned images due to its image type (i.e. grayscale images) [9]. The problem faced in segmentation may be due to its grayscale nature and so if it was in color space their might not be such case. Therefore, the aim of this paper is to transform grayscale image into colored (pseudo colored) image for better analysis and segment. This pseudo colored images may also be used in controlling various computer operations like operating power point presentation without using any statist input devices, as proposed and used by Prasad et al. [10-11]. Here, different color markers are used to identify the objects; as a pointer and tracking the movements of these pointers they are mapped with the static mouse operations.

Hence, color image processing bit complex but resolves many problems faced with grayscale processing and give users new dimensions to think and analysis the input image. This pseudo color transforms helps to gain color images from devices that are limited with intensity values only such as CT scanner and X-ray machines.

In this paper, we represent a gray pixel with a color pixel value and map it with the color map to form color image with extra information. To be very specific and to the point, the paper is transformed into 4 phase: the section 2 discusses about the proposed grayscale to color transform and in section 3 results are highlighted in different domains. The last phase is the conclusion and future scopes.

2 Proposed Grayscale to Color Transform

As we know that a grayscale digital image, say $\boldsymbol{I_{gray}^2(x,y)}$, is a single dimension pixel intensity matrix whereas a colored image, $\boldsymbol{I_{color}^3(x,y)}$ is a three dimension matrix. The first layer of matrix is red, second is green and third is blue layer because of these layers a gray image $\boldsymbol{I_{gray}^2}$ is transformed to a color image $\boldsymbol{I_{color}^3}$. Figure 1 explains the concept of gray and color image.

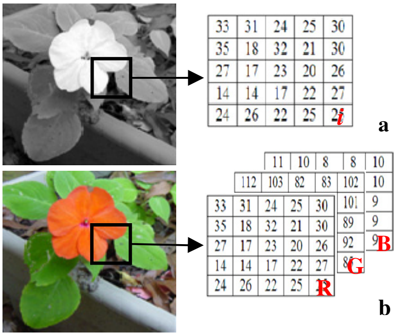

Fig. 1 Image, I: (a) grayscale intensity image matrix, I_{gray}^2, where i=intensity; and (b) colored three dimension (red, green , blue) image matrix, I_{color}^3

There are various devices that capture gray and colored images with different formats in different domain, such as CT scanner and mobile camera respectively. It is very simple and easy to convert a colored image to a single dimension grayscale image by losing any two layers information called single layer grayscale but the visa-versa is bit difficult and challenging. Few the RGB to grayscale image conversion formulas are shown in equations 1-5, they are the most commonly used.

$$gray = (\text{red} + \text{green} + \text{blue})/3 \tag{1}$$

$$gray = red * .3 + g * .59 + b * .11 \tag{2}$$

$$gray = red * .2126 + green * .7152 + blue * .0722 \tag{3}$$

$$gray = (max(red, green, blue) + min(red, green, blue))/2 \tag{4}$$

$$gray = (max\ /\ min)(red, green, blue) \tag{5}$$

Here, equation 1 is the average grayscale image formed from RGB. It is quick but results an inaccurate dirty image. Whereas by grayscale image formed by using equation 2-3, the result is good and it treats each color same as human eye perceive. Thus they are also called as *Luma* or luminance gray image. The 4^{th} and 5^{th} formula results in a de-saturation and decomposition gray image respectively. There are many other methods and approaches to get a grayscaled image but it's very difficult to convert a gray image to a colored one. These grayscale images from grayscale capturing devices are very challenging and involve many hurdles for image processing operations. This paper aims the same. A pseudo color image transformation is proposed for better IP operations. Below is the complete flow graph of the proposed system, see figure 2.

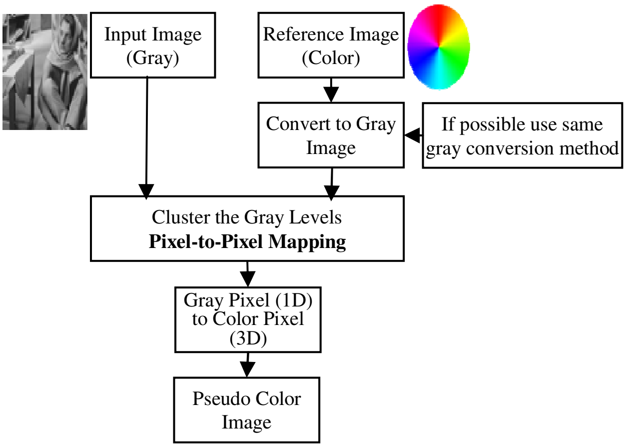

Fig. 2 System flow graph – grayscale to color image conversion

As in figure 2, a grayscale image, I^2_{gray} is taken as an input image to be converted to a color image from a reference colored image, I^3_{refe}. The reference image I^3_{refe} is again transformed into a grayscale image, $I^3_{refe\_gray}$ such that the method of grayscale conversion for both I^2_{gray} and $I^3_{refe\_gray}$ images are same, but is not necessary. The next step is to cluster the gray levels of both the images and map it to the reference image, I^3_{refe}. That is, a single intensity pixel of 8-bits is represented by a three layer pixel of 24-bits, reversed engineered from $I^2_{refe\_gray}$ to I^3_{refe}. In such a way, the single dimension (1D) I^2_{gray} is transformed to a three dimension (3D) colored image, I^3_{pseudo}. This colored image can be used in-for segmentation or any other IP operations.

The mapping of a single pixel for 8-bit grayscale image to 24-bit color image. That is, if a pixel from $\boldsymbol{I_{gray}^2}$ with i^{th} gray level then the pixel with same i^{th} gray level from $\boldsymbol{I_{refe\_gray}^2}$ act as a reference pixel. Referring to $\boldsymbol{I_{refe}^3}$ with the same coordinate value, say $(\boldsymbol{x}, \boldsymbol{y})$, as the i^{th} gray level pixel in $\boldsymbol{I_{refe\_gray}^2}$ the i^{th} gray pixel is mapped to this 24-bit pixel from $\boldsymbol{I_{refe}^3}$. The mapping of pixels from 8-bit to 24-bit is shown in figure 3 for better explanation. The complete pseudo algorithm is presented in algorithm 1 below.

***Algorithm 1.* Grayscale Image to Color Image Transformation.**

Assumptions: Input: 1D grayscale image, I_{gray}^2 and 3D reference color image, I_{refe}^3 of any size.
Output: Pseudo colored image, I_{pseudo}^3

1. Transform the referenced image I_{refe}^3 to grayscale using any of the methods from equations (1-5) or simply single layer gray image $I_{refe\_gray}^2$
2. Cluster the gray levels into 256 clusters for $0 - 255$ levels for both $I_{refe\_gray}^2$ and I_{gray}^2. K-Mean clustering algorithm is used here.
3. For every i^{th} gray level in I_{gray}^2 we map with the same i^{th} level in $I_{refe\_gray}^2$ such that the coordinate (x, y) of i^{th} of $I_{refe\_gray}^2$ refer to the coordinate (x, y) of I_{refe}^3 for the intensity values of different layers (red, green, blue), say (r, g, b)
4. For every layer of I_{pseudo}^3 assign values (r, g, b)
5. Repeat till gray level reaches 255

In mapping, there may be a case where many pixels are of i^{th} gray level in $\boldsymbol{I_{refe\_gray}^2}$, as in figure 3, so pixel p(x, y) in $\boldsymbol{I_{gray}^2}$ is mapped with the first pixel p(x', y') in $\boldsymbol{I_{refe\_gray}^2}$.

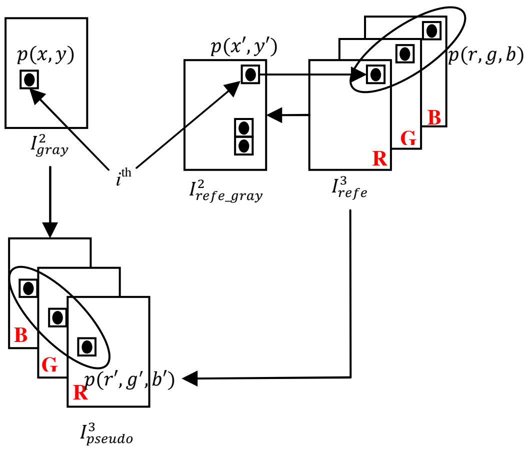

Fig. 3 Pixel mapping from 8-bit to 24-bit, using reverse engineering

The I_{pseudo}^{3} is the output pseudo color image with various extra details which a colored image has, without losing any other information. I_{pseudo}^{3} now can be used in digital color image processing operation which was not possible in earlier case for I_{gray}^{2}. Note that the pseudo color image depends upon the reference color image inputted in the system, i.e. as the reference color image changes the resultant output pseudo color image changes. Therefore, a standard reference color image is chosen where all color shades are present, as in figure 2.

In next section experimental results with different domains are presented and analyzed.

3 Experimental Results and Analysis

Since there are many datasets available in grayscale but are untested with digital color image processing operations and thus fails in proposing a general algorithm for grayscale and colored image, this paper points on this limitation. The algorithm proposed is very simple and thus implemented and tested on low cost computing devices such as mobile phones, $\mathcal{M}_d$. An application is designed for Android operating system version 2.3.x. The algorithm is resolution tolerant, that is, for any resolution of reference color image the output pseudo image has no effect or has very marginal change.

The grayscale to color image transformation in a standard 512x512 grayscale test images [12] is applied and shown in figure 4, below. Here, figure 4(c) and 4(d) are the pseudo images formed by reference image 4(b). Figure 4(c) is formed by using red portion of 4(b) reference image and so output image is red-oriented.

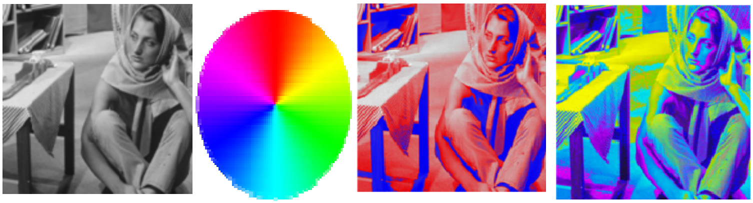

Fig. 4 Grayscale to color transformation: (a) original grayscale image; (b) original reference color image; and (c-d) pseudo color images (transformed)

Using same reference image, figure 4(b), few more grayscaled images are transformed to pseudo color. In figure 5, the first row is the original grayscale images downloaded from [12] and the second row, figure 5(b) is the output colored image mapped to gray values of figure 4(b).

Fig. 5 Color image transformation of standard 512x512 grayscale images [12]: (a) original gray images; and (b) pseudo color images

3.1 k-Means Clustering Algorithm

The gray level of image is clustered using simple *k*-means clustering algorithm. *k*-means is a vector quantization iterative technique to partition an image into k-selected clusters. The pixel intensity is used for computing mean cluster and distance is the squared difference between the intensity and the cluster center. The algorithm may not return optimal result but guaranties to converge and so is used in this paper.

Since *k*-means is very common we must not discuss in details and move to test results of various other datasets and images.

Figure 6(a), is a set of images recorded from satellite which is very difficult to analyze as which is what. The same is then transformed through our proposed system and tried for its pseudo images using same reference images, figure 4(b), we get the second row of figure 6 which is much more clear than the earlier one. Now, images from figure 6(b) can be easily clustered using unsupervised segmentation algorithm [6].

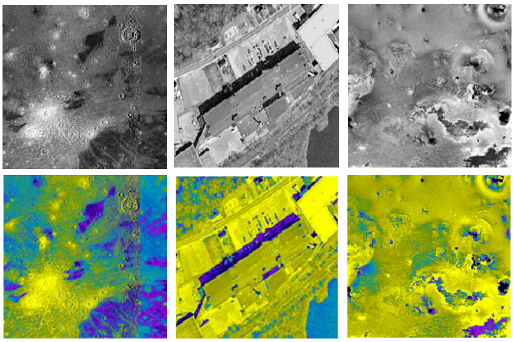

Fig. 6 Satellite sample images: (a) original grayscale image; and (b) pseudo color image (segmented)

Over this, the proposed algorithm plays a better role in biomedical images such as CT scanned images and MRI images. Such images are very complicated and if a colored or pseudo colored images are provided by the physicians, it will be easy and fast way to diagnose the cases. In figure 7, few of the brain MRI images are captured in grayscale and the proposed color transform method is applied over it. The resulted output pseudo color image is much easier to understand and derive and decision. It clearly shows the portion where brain tumors are occurred by just seeing the color changes. It can be visualized by and layman too.

Another CT scan grayscale image with its pseudo color transform is represented in figure 8. It's clear that the proposed algorithm is very simple and accurate and can be used in any type of domain and also can be used to segment the image.

3.2 *Applications and Scopes*

The algorithm feasibility was tested under various different conditions and found to be positive. The robustness of proposed method is clearly visualized in this paper with the above results. The scope of this paper is mainly in segmentation and image analysis where the texture of an image is not so clear and unique. This method will also be used in biomedical and satellite image processing to classify various patterns and objects in the image. It also enhances the image.

This paper processes grayscale images and represent it in a 3D pseudo color image format. It is not limited to and for any domain and any reference image. Changing the reference image will change the pseudo image but the transformation equation will be the same. Finally, the four concludes this paper with the future scope.

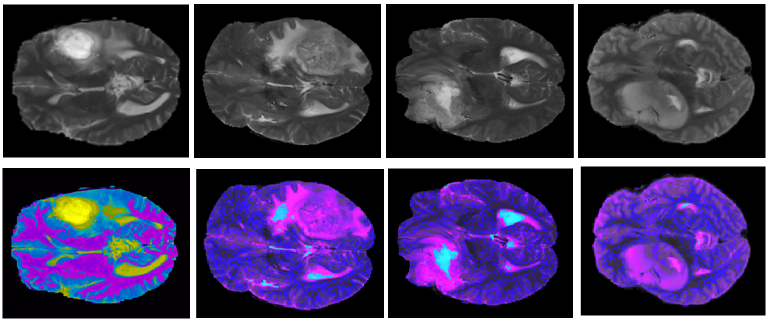

Fig. 7 MRI images: (a) original grayscale image; and (b) pseudo colored transformed images

The interesting point is that, if the reference color image, I^3_{refe} is same, that is, $I^3_{refe} \xrightarrow{gray} I^2_{gray}$ then the I^3_{pseudo} image is approximately the same, that is, $I^3_{pseudo} \approx I^3_{refe}$. Figure 9 shows the same. Where in figure 9(d) is a different I^2_{gray}image is which uses figure 9(a) as I^3_{refe} image giving output to pseudo image shown in figure 9(e).

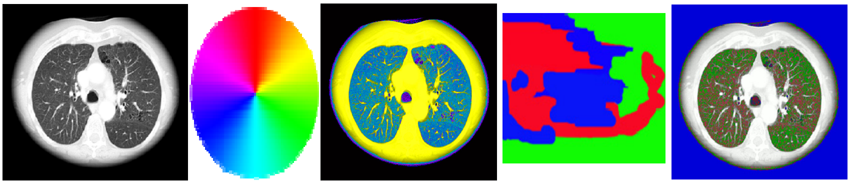

Fig. 8 CT scanned image: (a) original grayscale image; (b) reference color image 1; (c) pseudo color image from reference image 1; (d) reference color image 2; and (e) pseudo color image from reference image 2

Fig. 9 (a) The original I^3_{refe} image, (b) input I^2_{gray} image from I^3_{refe}, (c) the output I^3_{pseudo} image, (d) input I^2_{gray} image and (e) the output I^3_{pseudo} image using I^3_{refe}.

4 Conclusion and Future

This paper aims to transform a grayscale image with 8-bit pixel representation to a pseudo color image with 24-bit pixel representation. The system proposed is robust and flexible with image resolution and reference color image used. Algorithm is so simple and less computationally cost that it can be deployed on and low processing devices such as mobile phones, $\mathcal{M}_d$. The algorithm is unsupervised. Firstly, the input gray image is mapped with the reference gray image formed by the reference color image and then applying k-mean clustering similar gray levels are clustered to 256 clusters. Then using reverse engineering 8-bit pixel is transformed to 24-bit pixel. This method is used to enhance, segment and analyze the image in better way, even though they are of gray in nature. After some many experiments there is still gap between the output pseudo color image and actual color image. Thus, the work may include more realistic color image transformation and robust output.

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