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Visual Improvement of Breast Histopathology Images using Color Transfer Techniques

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***Abstract*— Breast cancer is a very common type of cancer in women around the world. Digital Histopathology is one of the emerging trends in modern medicine. Histopathological studies are getting more prominence in detection of various types of cancers especially breast cancer. Different structures of the tissue are colored with different stains for the sake of conceptualizing under the microscope. Problem of color variation in histopathology images, jointly caused by inconsistent biopsy staining and nonstandard imaging condition. In, order to remove this inconsistent color this paper proposes to build a color normalization technique. This technique is based on color transfer between a standard image and color varied image using the mean and variance of the both images. The algorithm tested on different histopathology images and compared with conventional color transfer technique. Performance of proposed method is evaluated using entropy, and similarity measure. Proposed method gives better results compared to histogram matching**

***Index Terms*— Color Transfer, Histopathology Images, Breast cancer**

I. INTRODUCTION

One of the common tasks in image processing techniques is altering the image color for better visual improvement. The goal of this work is to provide a method to transfer the color from one image (source image) to another image (Target image).Histopathology is a branch which deals with microscopic examination of tissues to observe the detailed appearance of diseased cells and tissues. It allows studying the structure and function of cells, tissues, organs and organ systems. Main use of histopathology tissue sections to gain maximum clinical information. Importance of histopathology image is providing better diagnosis of cancer and other diseases usually need histopathological investigation of samples. Generally, these kinds of images are called microscopic images. Histopathology image inspection under the light microscope will analyze a sample manifestation of diseases. Microscope offers even more benefits on studying pathogens that cause tissue changes or damage, as it allows them to see the level of tissue degradation present and therefore, verify the progression of the particular diseases etc. Different structures of the tissue are colored with different stains for the sake of conceptualizing under the microscope. Problem of color Variation in histopathology images, jointly caused by inconsistent biopsy staining and nonstandard imaging condition. Color transferring technique becomes necessary process to alter the color appearance of medical image granting to the color information from standard image. The construction of proposed work is based on color transferring techniques.

Identifying the early breast cancer through architectural distortion in mammogram images very difficult [1]- [2].But recognize any diseases especially cancer present in the breast is easy through histopathological images. The category of color transfer techniques contains two great classifications of colorization and re-coloring techniques [3]-[5].Several operations can be done in histopathological images such as segmentation, classification, detection and enhancement process. Although color constancy algorithms have been originally developed to estimate the color from the scene, they also improve the chromatic content [6].To reduce effects of color variation among histopathology images, some works have been initiated [7]. (i.e.) using a look-up table to transfer colors to other images. In [8] non-negative matrix factorization (NMF) is proposed to solve the general color unmixing problem. The majority of stains only absorb light, and the stained slides are therefore viewed using a microscope with a light illuminating the sample and also no stain is present, all of the light will pass through, appearing bright white [9]. To transfer one image's aspect to another, it's possible to select source and target images that don't work well together. The result's quality depends on the images' similarity in composition [10].

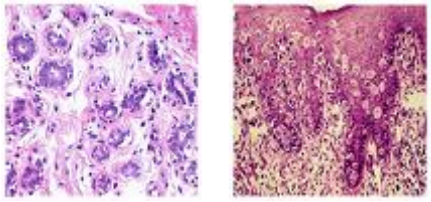

Fig. 1. Shows that Example of Standard H&E and Stained variation Images

II. Staining of Histopathology Slides

Histopathological images are processed by several ways such as fixation, dehydration, cleaning, embedding, cutting and staining. Staining is used to highlight important features of the tissue as well as to enhance the tissue contrast. The tissues are stained with one or more stains for better visualization under the microscope. Histopathological images are mostly use H&E and IHC (Immune histo chemistry) staining. Eosin dye is a negatively charged acidic color with pink, orange and red color. H&E used for demonstration of nucleus (blue, purple) and cytoplasm (pink, orange) inclusions in clinical specimens. Haemotoxylin is a dark blue or violet that is positive dye. This staining method is used to gives a general overview structure of the tissue and it can be used to better diagnosis tool. This type of staining is used to diagnose the abnormal cells such as those found in cancerous tumors. Figure 2 shows that examples of H&E and IHC stained image. H&E staining image is accommodating from UCSB dataset of a benign stage. The histopathological images are acquired through digital camera through a light microscopy with a different magnification such as 10×, 20× and 40×.

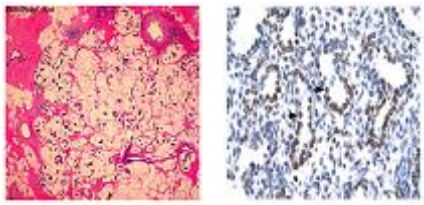

Fig. 2. Shows that Example of H&E and IHC Stained Images.

III. Proposed Work

This proposed algorithm presented a histopathological image color normalization technique used for better visual quality without any information loss. In that technique need to alter a source into target image. Figure 3 shows that the color transferring technique is proposed. Generally, histopathological images are obtained from light microscope. The information estimating the techniques are relating in the following sections.

The Reinhardcolor normalization equation can be described as,

$$I_{CN}= ((I_s-\mu_s)*(\frac{\sigma TR}{\sigma SR}) +\mu_{T;}$$

This technique represents for suit with color distribution of an image to that of a target image by use of linear transform in perceptual color space. So, as to match the means and standard deviations of each color channel in the two images in that color space. There is no scaling factor include in the existing algorithm. It gives insufficient results compared proposed Reinhard color normalization technique.

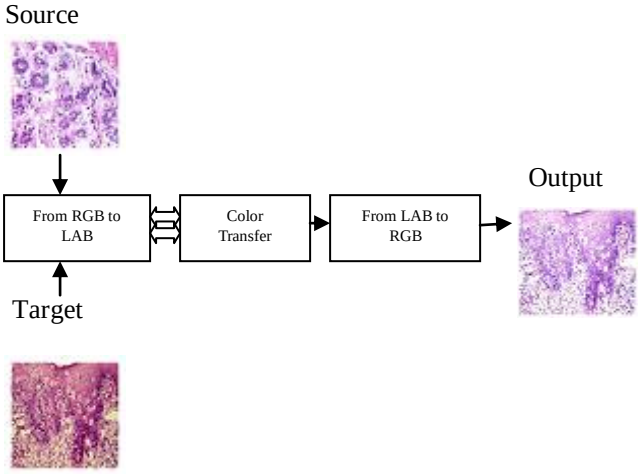

Fig. 3. Shows that Proposed Color Normalization Technique.

This technique represents for suit with color distribution of an image to that of a target image by use of linear transform in perceptual color space. So, as to match the means and standard deviations of each color channel in the two images in that color space. There is no scaling factor include in the existing algorithm. It gives insufficient results compared proposed Reinhard color normalization technique.

The proposed Reinhardcolor normalization equation can be described as,

$$I_{CN}= ((I_s-K\mu_s)*(\frac{\sigma TR}{\sigma SR}) +\mu_{T;}$$

I_s denotes Source Image, K denotes scaling factor, μ_d denotes mean of source image, σ_{TR} denotes standard deviation of target image, σ_{SR} denotes standard deviation of source image, μ_T denotes mean of target image.

The proposed color normalization gives better results compared to Reinhardcolor normalization technique. Multiply mean of source image into different scaling factor the image will be better to normalized with a target image. This approach maps the color distribution of an over/under stained image to that of a well stained target image. This technique has two different tasks,

(i) Transfer color in RGB Space
(ii) Transfer color in LAB Space

A. Color Transfer in RGB Space

A color transfer technique directs to alter the color pleasant of a source image by conveying the statistics from a target image. In this method, only the global mean and the standard deviation in the image are calculated. The aim of our work is to transform an input image (dark) into another with a look similar to that of the reference image (target). Especially, changing the color content of the source image using the statistics from the target image. This technique improves the quality of an image. The mean and standard deviations are

calculated on both target and source images using equations [1]-[4].

$$\mu_{S,t}^{R} = \frac{\sum Ri}{n}, \mu_{s,t}^{G} = \frac{\sum Gi}{n}, \mu_{s,t}^{B} = \frac{\sum Bi}{n} \quad (1)$$

Where R_i, G_i, B_i are the Red, green and blue color each pixel of picture.

Standard deviations of source and target image as,

$$\sigma_{s,t}^{R} = \frac{\sqrt{\sum (Ri - R')2}}{n-1} \quad (2)$$

$$\sigma_{s,t}^{G} = \frac{\sqrt{\sum (Gi - G')2}}{n-1} \quad (3)$$

$$\sigma_{s,t}^{B} = \frac{\sqrt{\sum (Bi - B')2}}{n-1} \quad (4)$$

Where, where $\mu_{s,t}$ and $\sigma_{s,t}$ are the mean and standard deviation, s and t is the source and target image. The RGB image must be transformed into another color space. RGB color space has limitation of in representation shading property or fast illumination varying. So, as to resolve, there is a necessity to convert an image from RGB space to LAB space to achieve a better results compared to RGB.

B. Color Transfer in LAB Space

This work investigates the utilization of color transfer for entirely stained varied images. Color variation is affected by different staining and illumination variation in RGB Space. So, solve this problem there is a necessity to process an image in color transfer technique. Color corrections are achieved by using an appropriate source image and apply its characteristic to another image. Convert RGB space color to lαβ space and use mean and standard deviations to adjust the color distributions in lαβ space. In this work, we compare the method between transferring in RGB space and in lαβ space. In, lαβ color space, which minimizes correlation between channels. The resulting color will have less correlation between channels and produce more appealing image. The mean and standard deviations are calculated on both target and source images using equations [5]-[8].

$$\mu_{s,t}^{L} = \frac{\sum li}{n}, \mu_{s,t}^{A} = \frac{\sum ai}{n}, \mu_{s,t}^{B} = \frac{\sum \beta i}{n} \quad (5)$$

Where L_i, A_i and Bi are the Red, green and blue color each pixel of picture.

Standard deviations of source and target image as,

$$\sigma_{s,t}^{L} = \frac{\sqrt{\sum (li - l')2}}{n-1} \quad (6)$$

$$\sigma_{s,t}^{A} = \frac{\sqrt{\sum (ai - a')2}}{n-1} \quad (7)$$

$$\sigma_{s,t}^{ß} = \frac{\sqrt{\sum (\beta i - \beta')2}}{n-1} \quad (8)$$

Using above equations finally got the enhanced image.

IV. Experimental Results and Discussions

The proposed method is tested on all histopathological images from UCSB database [11]-[12]. In order to prove its qualitative efficiency, three of the results are presented in Fig. 3. First column of Fig. 3 refers the source, second column refers to the target image and third column refers to the output Histogram matching method and fourth column refers to the proposed color normalization technique. From the presented results it is easily observed that our method enhances the contrast of the histopathology image in better way than histogram matching method.

A. Performance Measures

The enhancement results are evaluated using entropy, structural similarity index (SSIM).

1. Entropy

The image enhancement is based on information content of an Image. Larger entropy value the image has, the higher information contained in the output image. The entropy for the whole image can be defined by,

$$H(K) = \sum_{i=0}^{255} p_i \log_2 p_i$$

Where, p_i is the probability of intensity I at pixel in enhanced Image.

2. Structural Similarity Index (SSIM)

Structural similarity (SSIM) index is a method for measuring similarity between the images. The SSIM index can be viewed as a quality measure of one of the images being compared provided the other image is regarded as of perfect quality.

$$SSIM(x, y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)}$$

Where,

μ_x , μ_y is the mean values of x and y

σ_x, σ_y is the standard deviation of x and y.

Table -1: Performance Comparison Proposed and Other Color Normalization Methods

Parameters	Histogram Matching	Proposed
Entropy	7.0609	7.1570
SSIM	0.6991	0.7089

These parameters are evaluated for 10 images in pathpedia and UCSB database and the average is tabulated in table 1. Proposed techniques gives better results compared to other methods and analyze the performance qualitatively. The proposed technique low contrast enhancement scheme gives high quality and also retains the entropy values from the existing methods.

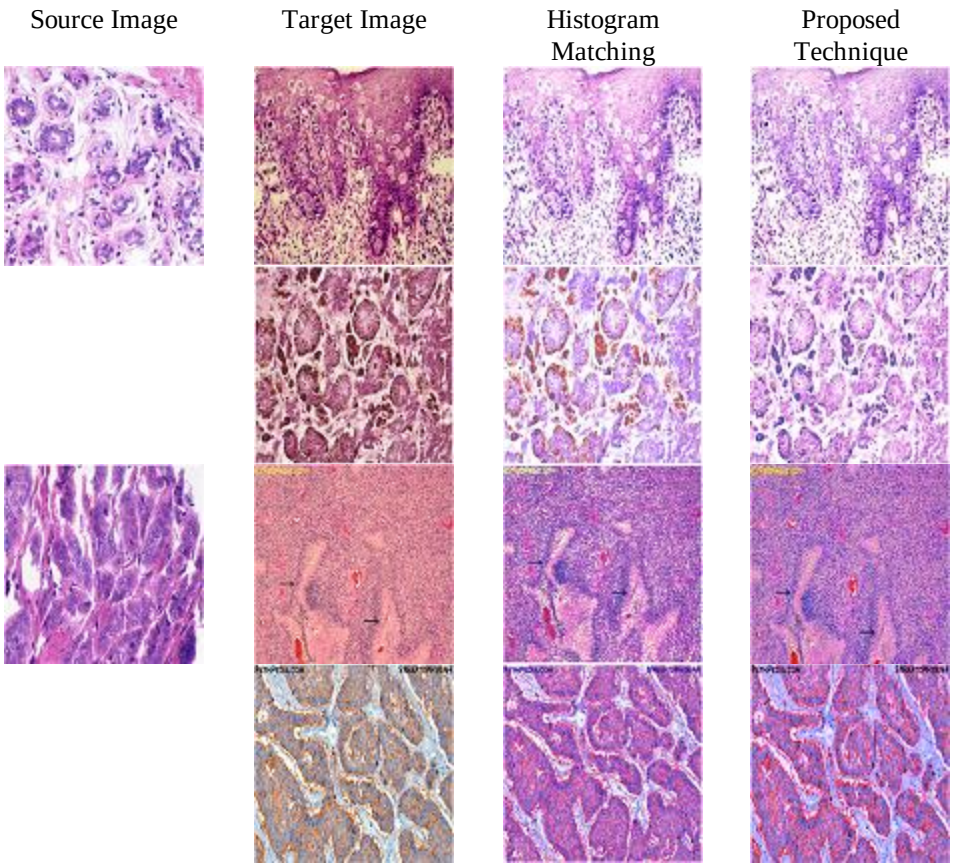

Fig. 4. Enhancement results comparison: column 1: Source, column 2: Target, column 3: Color normalization by histogram matching, Column 4: Proposed method color normalization.

CONCLUSION

The novelty of the proposed method is that color image transferring technique is based on color normalization technique which is a new way to integrate color and brightness details extracted from color image transferring technique. The proposed technique offers better performance in terms of better contrast verified by perfect quality (SSIM) and the information content in the image is verified by comparing entropy values of original image and enhanced output image. The experimental results were illustrating the superiority of the proposed scheme over the other methods.

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