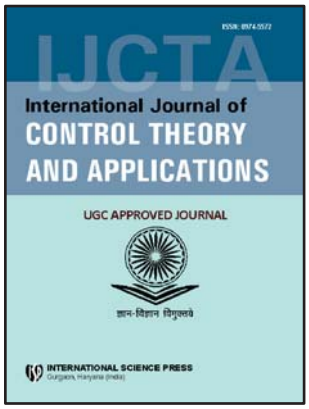

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GCS Decolour Based Binarization of Historical Manuscripts

Jayanthi Natarajan[a] and InduSreedevi[b]

[a]*M.Tech, B.Tech.Assistant Professor, Electronics and Communication Department, Delhi Technological University (Formerly Delhi College of Engineering) New Delhi-110042, India*

E-mail: njayanthi@dce.ac.in

BPh.D, M.tech, B.Tech, Associate Professor, Electronics and Communication Department, Delhi Technological University (Formerly Delhi College of Engineering) New Delhi-110042, India

Abstract: Pre-processing is an essential step in the binarization of historical manuscripts in order to preserve the information, especially in the case of low contrast images. This paper addresses the problem of contrast preservation of the historical manuscripts using GCS decolorization based binarization process. The paper also involves a comparison with various other algorithms which is the nick, Sauvola, Otsu, with respect to standard color to gray conversion and GCS decolorization helping us understand the advantages that this algorithm presents. Promising experimental results obtained on the DIBCO-2010 dataset, and this shows the validness of the proposed framework against conventional color to gray conversion based contemporary binarization methods.

Keywords: *Gradient Correlation Similarity, Binarization, Decolorization.*

1. INTRODUCTION

In recent past numerousapproach, has been put forward to binarize the document images basedon global and local thresholding methods. [1]- [3]and [15] to [16]. Several researchers also worked on the restoration of ancient degraded documents for better readability of the text which in turn increases the OCR performance [4] – [9]. Color to gray transformation is a necessary pre-processing aid for binarization. Because of the dimensionality reduction from three dimensional colour space value to one dimensional gray values,definitely it suffers from the information loss. However, since many decolorizing methods have been employed in computer vision [10]-[13], we found that Gcs based decolorization preserves the appearance of the original colour image in comparison with conventional luminance method [9] as a pre-processing technique for the process of digitization.

The most important theories of optimization of color to grayscale conversion involved global contrast among colors [13] or local contrasts among pixels [12]. Both methods are slow processes prone to local minima because of a large number of variables and thus prove impractical. The calculation of gradient correlation for Gcs measure is done in a scalar manner where individual consideration of each channel is adaptively estimated and the three are added for the end result, which reduces the information losses during color to gray scale conversion [10].A novel approach for the binarization of document images using Gcs based color to gray transformation

as a pre-processing tool to preserve and enhance the color contrast, which helps in better binarization is put forward in this paper.The proposed method is tested on DIBCO 2010dataset [19]. Experiments on the dataset show the improvement in the binarised output achieved by ourproposed framework based on the measured PSNR value.

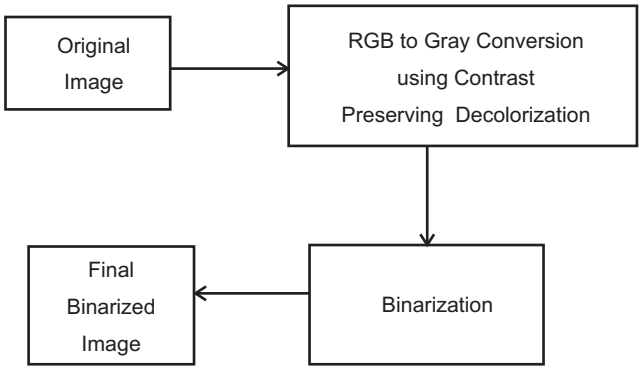
The remaining paper is organized as follows. In section 2, problem statement is presented. In section 3,methodology of the proposed framework is discussed. Section 4provides outcome of the proposed strategy. Lastly, section 5proceeds with the conclusions and future prospects.

2. PROBLEM STATEMENT

Most of the ancient manuscripts suffer from the problem of low contrast due to various Biological and Physical factors. Therefore, binarization of these manuscripts is more challenging. There may be loss of text information during binarization process because of lack of contrast preservation in the pre-processing stage. So we mainly concentrated on pre-processing the image in such an approach where the preservation of contrast is ensured. Color to gray transformation usingGradient Correlation Similarity (GCS) helps in preserving the contrast information in the input color image. Hence, by making use of GCS we try to improve the performance of binarization.

3. METHODOLOGY

A typical configuration of processing modules is shown in fig(1)



Figue 1: Traditional flow of processing in Binarization of historical Manuscripts

3.1. Contrast preserving decolorization(Pre-processing)

For color to gray scale conversion, we used Gcs measure developed in [10], that findsthe gradient similarity in a scalar manner taking into account each channel respectively, and then adding the three components together for the resultant grayscale whereas conventional color to gray conversion is based on linear equation where weighted sum of each component *i.e.* R, G and B is considered. Also Gcs based preprocessing method has ever been used in the application of binarisation. This method is encouraged by the impressive effort made by author in Lu et al[17]. This high resolution decoloring process helps in improving the binarization process.The advantage of using Gcs based color to gray transformation provides structure preservation of the information (text) in the historical documents during binarization process.

We used GCS proposed in [10] for a color to gray transformation as a pre-processing step for binarization of Historical manuscripts. In this process gradient correlation is computed adaptively for individual channel instead of whole color channels together. Also, overall pixel-wise correlation between the gradient magnitude in individual channel of given color image and the grayscale image is calculated to optimize the model given in equation (1) with respect to weights W_C by considering parametric concepts.

$$\min_{W_C} - \sum_{(i,j)\in P} \sum_{c=\{R,G,B\}} \frac{2\left|I_{c,i} - I_{c,j}\right|\left|\nabla g_{i,j}\right|}{\left|I_{c,i} - I_{c,j}\right|^2 + \left|\nabla g_{i,j}\right|^2} \quad (1)$$

Such that $g = \sum_{c=\{R,G,B\}} W_C I_C \; ; \; \sum_{c=\{R,G,B\}} W_C = 1$

where W_C represents weight coefficient, ∇ represents the global gradient operator at pixel pair (i, j) and $\nabla g_{i,j} = g_i - g_j$ and P represents a pixel pairs which consists of the local and global candidates. I_C represents individual channels in the input image. Gcs model helps to partly eliminate the influence of gradient magnitudes which in turn helps to produce better binarized results.

3.2. Binarization

It is a process of separating text (foreground) from the non-text (background) regions. We experimented on Otsu, Savoula and Nick thresholding algorithms to produce the binarized images from the Obtained Gcs based gray scale image. Above said algorithms for calculating the threshold value to decide the pixels belonging to foreground and background is given below in equations (2),(3) and(4).Global threshold T in Otsu's binarization is given below in equation (2).

$$T = \text{threshold in MIN (Within-class variance)} \quad (2)$$

The within class variance is calculated using the equation (3).

$$\sigma_w^M = w_b \sigma_b + w_f \sigma_f^2 \quad (3)$$

Where w_b and w_f are the weights of background and foreground pixels respectively and σ_b and σ_f represents the variance of background and foreground pixels. Value in equation (3)is the 'sum of weighted variances' for the threshold value t. This same calculation needs to be performed iteratively for all the possible threshold values 1 to L gray levels. Finally, we select a threshold T,which has the lowest 'sum of weighted variances' to be the final globally selected threshold. All pixels with a level less than threshold are background, all those with a level greater than or equal tothreshold are foreground

$$T_{Sauvola} = \mu * \left[1 + k\left(\frac{\sigma}{c} - 1\right)\right] \quad (4)$$

$$T_{Nick} = \mu + k\sqrt{\left[\frac{1}{N}(\Sigma p_i^2 - \mu)\right]} = \mu + k\sigma \quad (5)$$

Where μ and σ are the mean and the standard deviation respectively, K and C represents thresholding constants for Sauvola and Nick's method respectively are set according to the image contrast.

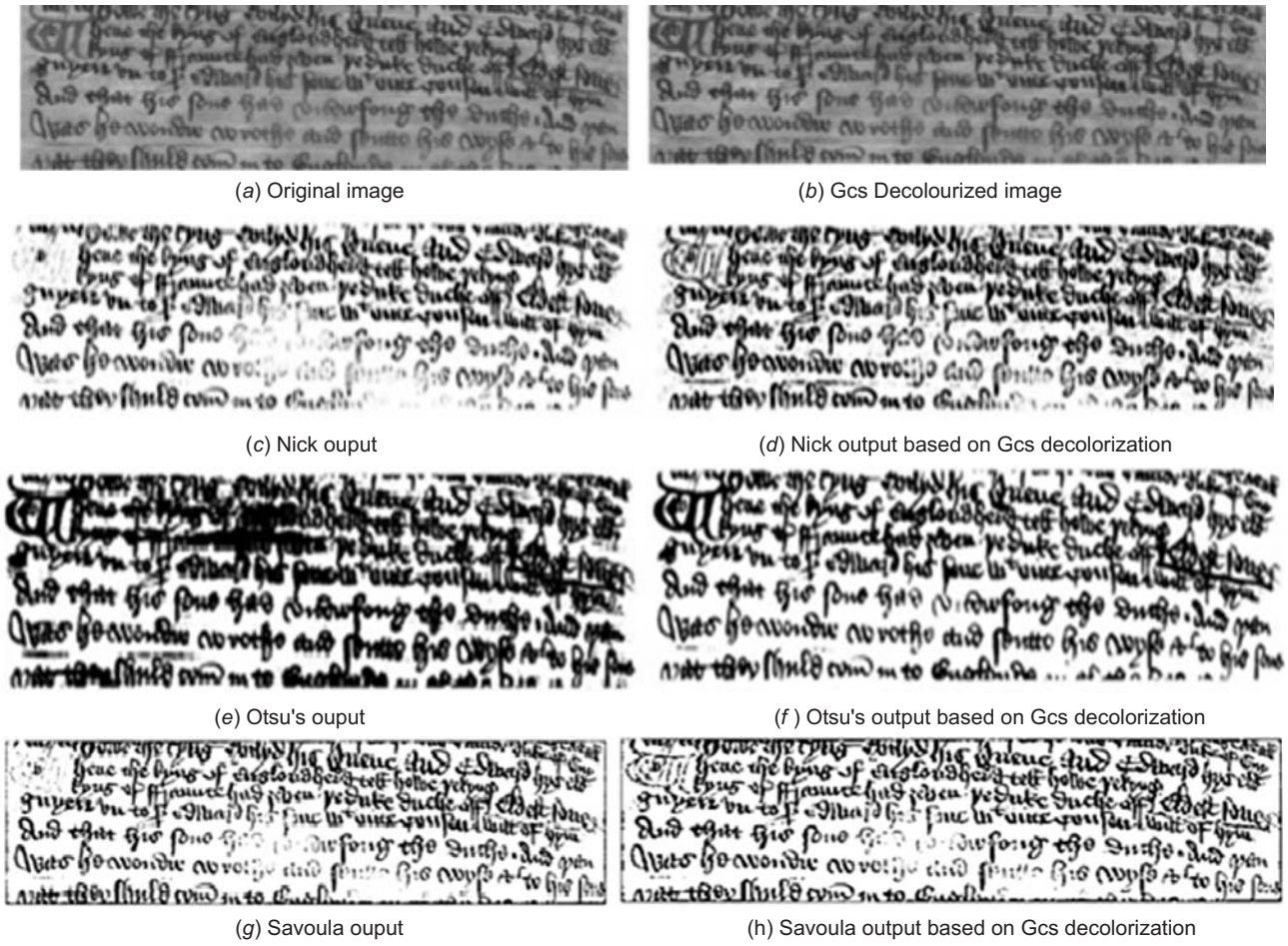
4. RESULTS AND DISCUSSION

We have compared the results of contemporary binarization algorithms (Otsu, Nick and Sauvola) based on conventional colour to gray conversion with Gcs based binarization algorithms and the binarised results of Eleventh- to Twelfth-Century Irish Manuscript[18]are shown in fig (2). We mainly concentrated on the pre-processing step that causes information loss. The Gcs based binarisation algorithm is evaluated on a set of 80 images utilizing Matlab. Proposed method is evaluated based on the PSNR value. Peak signal to noise ratio in dB (PSNR) is used to measure the quality of the binarised image with respect to the original image, which is given below.

$$PSNR = 10\log\left(\frac{R^2}{MSE}\right)dB \quad (6)$$

$$\text{MSE} = \frac{1}{MN}\sum\sum\left(O(i,j) - B(i,j)\right)^2 \tag{7}$$

Where R, O (i, j) and B(i, j) are the maximum intensity of the pixels in the input image, input image and binarized image respectively.



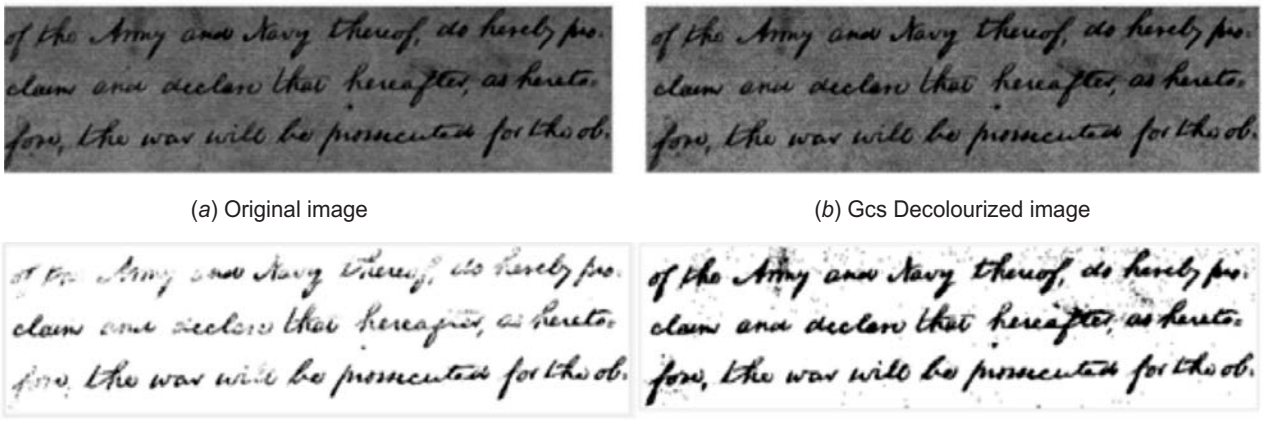
(*a*) Original image (*b*) Gcs Decolourized image

(*c*) Nick ouput (*d*) Nick output based on Gcs decolorization

(*e*) Otsu's ouput (*f*) Otsu's output based on Gcs decolorization

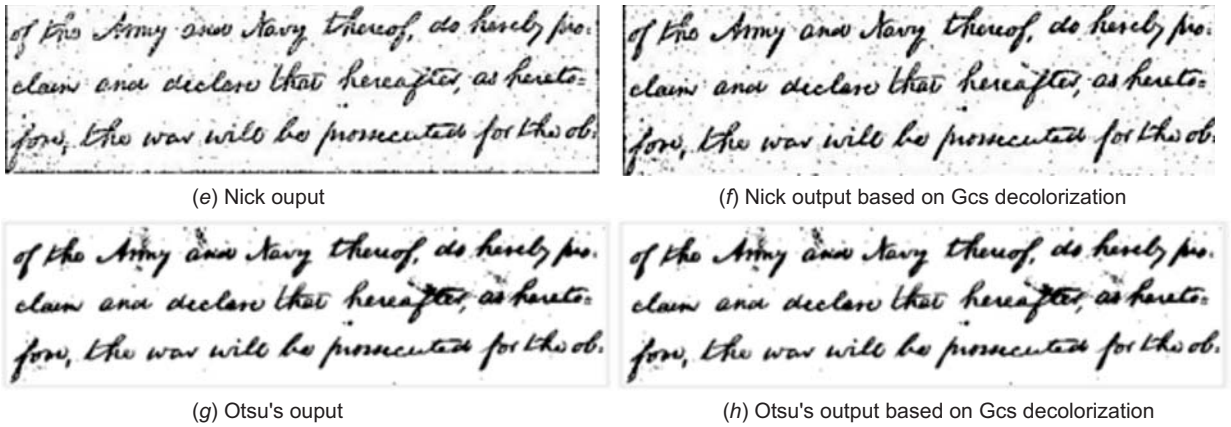
(*g*) Savoula ouput (h) Savoula output based on Gcs decolorization

Figure 2



(*a*) Original image (*b*) Gcs Decolourized image

(*c*) Savoula ouput (*d*) Savoula output based on Gcs decolorization



(*e*) Nick ouput (*f*) Nick output based on Gcs decolorization

(*g*) Otsu's ouput (*h*) Otsu's output based on Gcs decolorization

Figure 3

Also figure 3 shows the efficiency of proposed method on DIBCO 2010 dataset. In table 1 the PSNR value of proposed method (performed on DIBCO 2010 data set) is compared with contemporary binarization methods using conventional gray scale conversion to obtain a one dimensional image from a three dimensional colour image. The numerical results stating average PSNR value of the proposed strategy is superior to the contemporary binarization methods.Table 1 contains PSNR A for binarised image with contemporary binarization methods (Nick and Savoula) and PSNR B for the proposed method with Gcs based decolorization.

Table 1

Method	*PSNR A(dB) (using conventional color to gray conversion)*	*PSNR B(dB) (using GCS based color to gray conversion)*
OTSU	15.89	16.97
SAUVOLA	9.39	12.23
NICK	18.06	19.17

5. CONCLUSION

This paper proposes a Gcs based binarization tool for the application in the field digitization of historical document images. Experimental results show a preferable performance of the proposed Gcs based approach in relative to the conventional colour to gray conversion for contemporary binarization methods in terms of obtained PSNR values. If the image contains complex background then binarization with proper pre-processing alone could not produce better results. Hence we are working on suitable post processing measure to improve the OCR performance.

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