



AI-Based Lanczos Filtering for Feature Selection and Structural Metrics Analysis, and Classification Method for Automated Detection of Major Conjunctivitis in Retinal Color Fundus Images

Madhusudhan S, Anitha S



Abstract: Various eye diseases appear differently in red, green, and blue channels of RGB colour models. Colour channels provide the primary information for detecting eye diseases. Selection and training of these channels are the primary tasks in pre-processing colour fundus images and the automatic detection of various eye diseases. Improvements in quality and appearance, as well as image enhancements, are performed during the pre-processing stage without affecting the accuracy of fundus images. PSNR, MSE, DSSIM, FSIM, RMSE, UIQI, and SSIM are calculated to preserve structural information between the original image and colour-converted images. The test images are taken from the DRIVE fundus database and evaluated using colour-space structural models. The methods are tested using an OpenCV Python Jupyter notebook on a Windows platform with an Intel i5 processor at 3 GHz and 16 GB of RAM. The results are compared to determine the best colour space model for detecting cotton wool spots before post-processing.

Keywords: Cotton Wool Spot (CWS), PSNR, MSE, DSSIM, FSIM, RMSE, UIQI, and SSIM.

Nomenclature:

HR: Hypertensive Retinopathy

CWS: Cotton Wool Spots

Technology is helping develop automated systems that can efficiently detect retinal diseases. These systems are cost-effective, can save time in mass diagnosis, and help overcome the lack of health professionals. Hypertensive retinopathy (HR) presents with lesions categorised as soft and hard exudates. Soft exudates [2] are also known as Cotton Wool Spots (CWS). CWS are fluffy white-yellow spots, whereas hard exudates are bright yellow lesions. These Cotton Wool Spots are either seen isolated in fundus images or alongside other lesions [3], such as haemorrhages and hard exudates. CWS are the infarcts of the eye, which means tissue death caused by a lack of oxygen due to an obstruction. While detecting Cotton Wool Spot (CWS), artefacts [4] sometimes interfere with the optic disc and exudates, and are nearer to the OD area. CWS are difficult to filter out of the background; therefore, an automated technique is necessary for detecting CWS during screening for Diabetic Retinopathy [5] and other diseases.

I. INTRODUCTION

Ocular effects from various pathologies, such as microaneurysms, haemorrhages, exudates, and cotton-wool spots [1], are common. Diabetes affects the ocular nerves in many ways, including embolic, ischemic, neoplastic, connective tissue, and infectious conditions. Hypertension damages the blood vessels and leads to hypertensive retinopathy [2]. Cotton-wool spots indicate diabetes and appear as yellow bumps on the retina. These diseases can become fatal if left untreated in the early stages.

II. LITERATURE REVIEW

Syna Sreng, Noppadol Maneerat, Khin Yadanar Win et al [3]. The method is based on integrating principal component analysis and SVM. First image enhancement, adaptive thresholding for CWS extraction from the background, PCA and SVM for feature extraction from morphologies, first-order statistics, grey-level occurrence matrix, and lacunarity, uses 289 images with accuracy 90.47%, sensitivity 85.29%, and specificity 90.12%. Pavan Kumar Pagadala et al. [4]. Employs the Otus method for segmentation, feature extraction by GLCM, reduction of dimension by PCA and an adaptive support vector machine with an accuracy of 98.3%

The organization of the paper is as follows: Section I: Introduction and Literature Review. Section II proposed method, Section III results and discussion, Section IV conclusion, and future scope.

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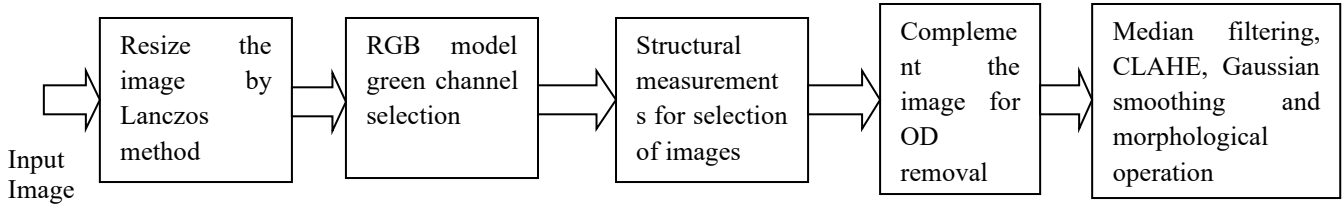
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III. PROPOSED METHOD



[Fig.1: Processing Stages in Automatic Detection of CWS]

Fundus images from various databases, such as DRIVE, STARE, and Messidor [5], are considered; primarily, the images vary in size. These images are first resized into a common size by using the Lanczos method. Colour models are applied to measure structural information; images are selected and then complemented to remove the Optic disc. The images are median-filtered, CLAHE [7]-enhanced, Gaussian-smoothed, and subjected to morphological operations. The method's output is a preprocessed image, ready for post-processing in the automatic detection of CWS.

A. Resize the Image by the Lanczos Method

The Lanczos method is used to improve image quality. It is the best method for fundus [8] and retinal image preprocessing, effectively preserving diagnostic details. It is often used for medical imaging datasets with deep-learning preprocessing pipelines [9].

For a functional $f(x)$, the interpolated value at position x is given by

$$f(x) = \sum_{i=-a}^a f(i) \cdot L(x-i) \quad (1)$$

Where: $L(x)$ is the Lanczos kernel:

$$L(x) = \text{sinc}(x) \cdot \text{sinc}\left(\frac{x}{a}\right), |x| < a \text{ And } L(x) = 0 \quad (2)$$

$$\text{otherwise, Where } \text{sinc}(x) = \frac{\sin(\pi x)}{\pi x} \quad (3)$$

B. RGB Model Green Channel Selection

RGB colour model: uses three primary colours, red, green, and blue, with a 3D cube. Secondary colours are combinations of primary colours. RGB format is additive in nature. Means that other colour models can be obtained by linear or nonlinear transformation [5]. The RGB colour model is given by

$$\begin{aligned} r &= \frac{R}{R+G+B}, & g &= \frac{G}{R+G+B}, \\ b &= \frac{B}{R+G+B} \end{aligned} \quad (4)$$

C. Structural Measurements for Selection of Images

To preserve the structural information after the model conversion, it is necessary to check and compare the mean square error, peak signal-to-noise ratio, root mean square error, Structural Similarity Index Measure, Structural Dissimilarity Index, Feature Similarity Index Measure, and Universal Image Quality Index between the original image and the green channel image. Mean square error is used to

evaluate the filtering and denoising in the preprocessing stage,

$$MSE = \frac{1}{MN} \sum_{i,j=0}^{M,N} [I(i,j) - K(i,j)]^2 \quad (5)$$

Root mean square error is the smallest value of MSE, which can be interpreted as the same units as image intensity

$$RSME = \text{sqr}(MSE) \quad (6)$$

Peak signal-to-noise ratio [8] compares the original and colour-converted images with enhancement methods.

$$PSNR = 10 \log_{10} \left(\frac{MAX^2}{MSE} \right) \quad (7)$$

To check for any structural distortions in blood vessels, the optic disc, and lesions, and to convert to a colour model, these measurements give accurate results.

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \quad (8)$$

This measurement provides the percentage of structural information lost while processing image $DSSIM = 1 - \frac{SSIM}{2}$.

This measurement gives the amount of preservation done with blood vessels, CWS exudates [9]

$$FSIM(IK) = \frac{(\sum_{x \in \Omega} Pcm(x) \cdot SI(x))}{(\sum_{x \in \Omega} Pcm(x))} \quad (9)$$

It provides information about the luminance distortion, contrast distortion, and structural distortion applied to the preprocessing evaluation

$$UIQI = \frac{(4\sigma_{xy}\mu_x\mu_y)}{(\sigma_x^2 + \sigma_y^2)(\mu_x^2 + \mu_y^2)} \quad (10)$$

D. Complement the Image for OD Removal

In preprocessing a fundus image, the optic disc and the lesions appear with the same brightness, so to distinguish this, image complements are used. The complement operation, Image complementation, inverts the intensity values of a grayscale or RGB image [6], converting bright regions into dark regions while making it easier to remove OD.



$$I_c(x,y) = 255 - I_{green}(x,y) \quad (11)$$

$$T(i) = \text{floor}[(L - 1. \sum_{j=0}^i \frac{c(i)}{N})] \quad (13)$$

E. Median Filtering, CLAHE, Gaussian Smoothing and Morphological Operation

The median filter effectively preserves the cotton wool spot boundaries and removes impulse noise, denoising the image.

$$I_{filtered}(x,y) = \text{median}\{I(i,j) | (i,j) \in N(x,y)\} \quad (12)$$

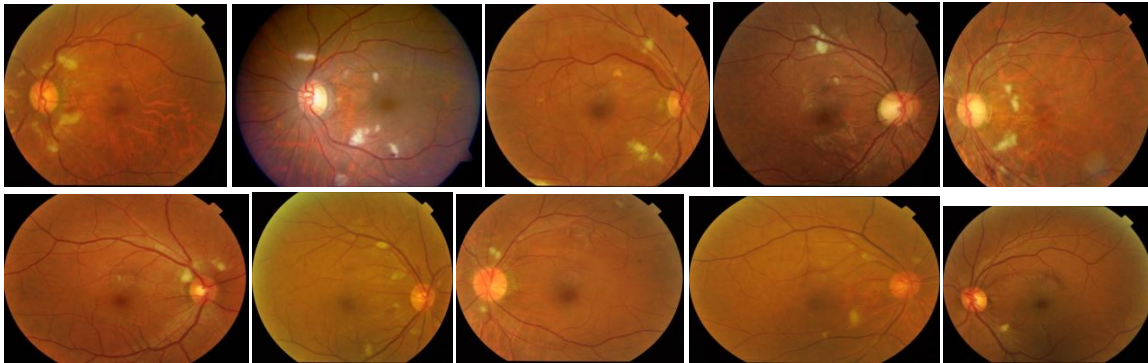
The Contrast Limited Adaptive Histogram Equalization makes the cotton wool spots visible by local contrast operation

The high-frequency noise can be reduced by applying a Gaussian filter [10], which also preserves structural information for post-processing operations such as segmentation [11].

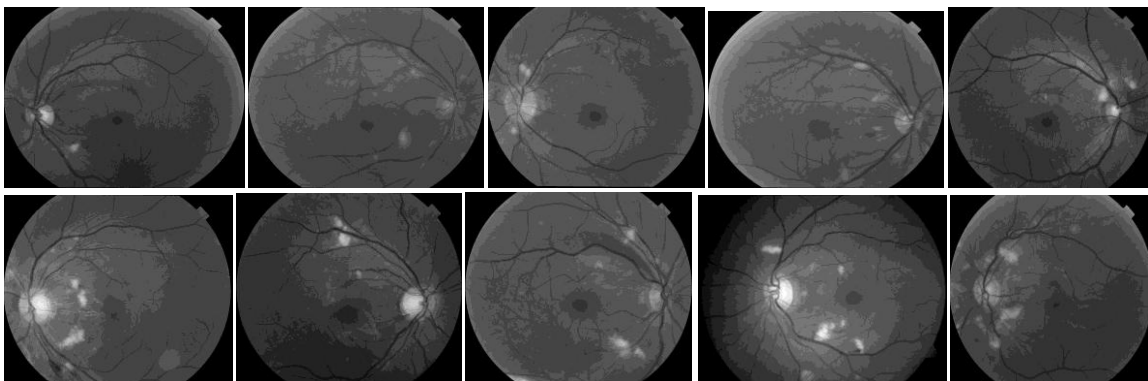
$$I_{smooth}(x,y) = \sum_{i,j} G(i,j)I(x - i, y - j) \quad (14)$$

The morphological operations, such as erosion, dilation, opening, and closing, have been performed manually when needed.

IV. EXPERIMENTAL RESULTS AND DISCUSSION



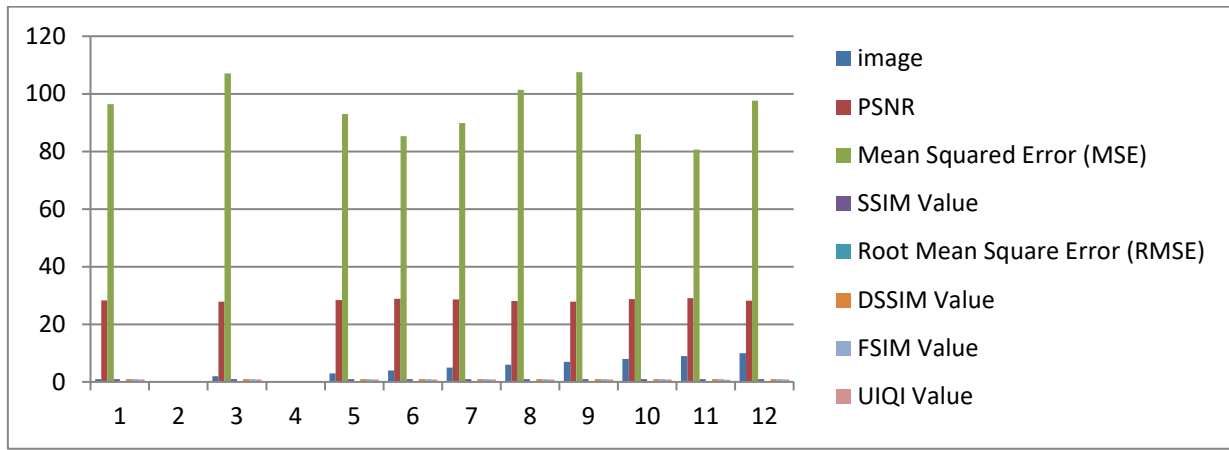
[Fig.2: Original Cotton Wool Spot Images [7]]



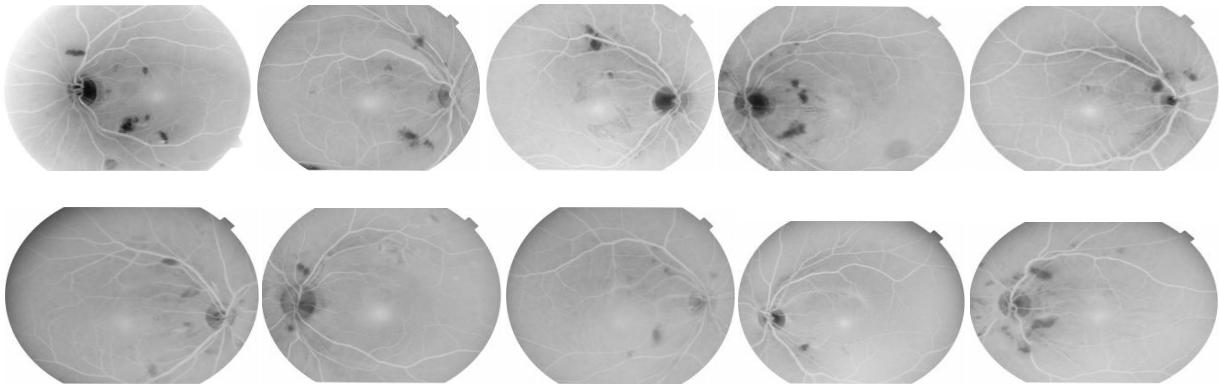
[Fig.3: Green Channel RGB Colour Model Images]

Table I: Structural Measurement Values Calculated for Green Channel RGB Colour Model Images

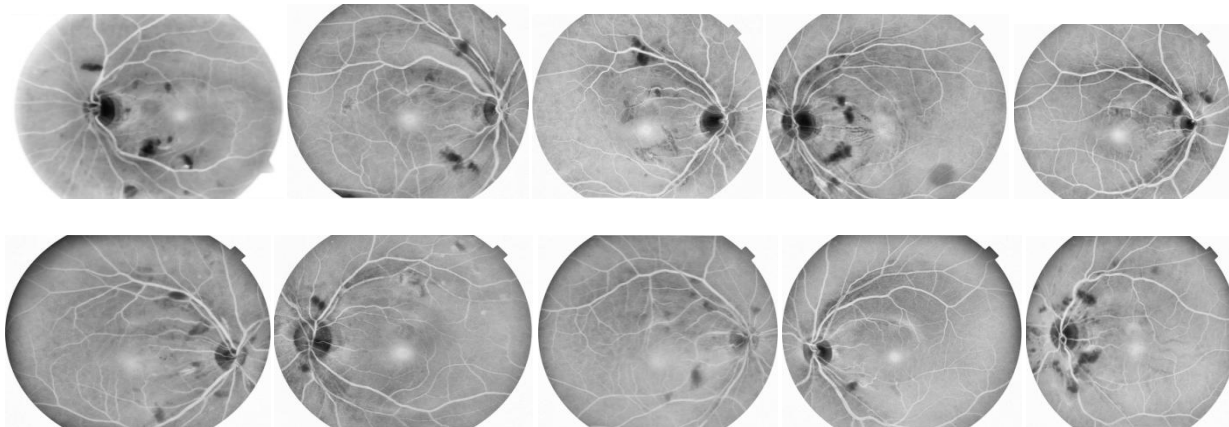
Image	PSNR	MSE	SSIM Value	RMSE	DSSIM Value	FSIM Value	UIQI
1	28.2915	96.3651	0.97561	0.04480	0.97563	0.98765	0.8940
2	27.8323	107.108	0.97507	0.05157	0.97510	0.98738	0.8876
3	28.4440	93.0253	0.97172	0.05956	0.97173	0.98565	0.8958
4	28.8215	85.2949	0.9812	0.0388	0.9812	0.9905	0.8944
5	28.5941	89.8709	0.9660	0.0683	0.9660	0.9827	0.8876
6	28.0706	101.379	0.9759	0.0592	0.9760	0.9876	0.8936
7	27.8142	107.5578	0.9706	0.0465	0.9707	0.9851	0.8952
8	28.7867	85.9773	0.9695	0.0625	0.9695	0.9845	0.8864
9	29.0632	80.6416	0.9613	0.0461	0.9615	0.9803	0.7954
10	28.2362	97.5980	0.9613	0.0652	0.9613	0.9802	0.8677



[Fig.4: Value of Various Structured Measures]



[Fig.5: Complemented Image from the Green Channel Image]



[Fig.6: Filtered Image, Dark Spots Showing CWS's]

Figure 2 shows the original 10 CWS colour fundus images taken from the DRIVE database [7]. The images are of different resolutions: 7 images at 3046X2572 resolution, 2 images at 768X576 resolution, and 1 image at 2300X1900 resolution [8]. Figure 3 shows the RGB colour model images in the green channel. The RGB colour model outputs 3 channels: red, green, and blue; among these, the green channel provides clear visibility in CWS. Figure 4 shows the Values of the various structured measures presented in Table 1, indicating the amount of structured information preserved by the particular colour models. Figure 5 shows the Complemented image [11] from the green channel Image, which is used to mask the OD optical disc and highlight the CWS. Figure 6 shows the CWS visibility after filtering and morphological operations, which is ready for post-processing such as segmentation and detection.

V. CONCLUSION AND FUTURE SCOPE

The proposed method processes the colour fundus image to detect CWS and Major conjunctivitis by using the green channel, preserving the structural information of the original image, making CWS and Major conjunctivitis clearly visible, and removing the optic disc. Average values of the parameters obtained are PSNR of 28.5941, MSE of 96.3651, DSSIM of 0.97507, FSIM of 0.98565, RMSE of 0.04480, UIQI of 0.8940, and SSIM of 0.97172, and the deviation in structural information by the applied colour model with respect to the original image is assessed. This method can be applied to detect lesions and exudates in future work. The algorithms are tested using an OpenCV Python Jupyter notebook run on a Windows



platform with an Intel i5 processor at 3 GHz.

DECLARATION STATEMENT

Some of the cited references are older and are noted explicitly as [2]. However, these works remain significant for the current study, as they are pioneering in their fields.

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted objectively and without external influence.
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