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Novel and adaptive contribution of the red channel in pre-processing of colour fundus images

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Abstract

A new pre-processing method for colour fundus images with adaptive contribution of the red channel is proposed. Based on a condition that is developed in this paper, this method utilises the intensity information from both red and green channels instead of using only the green channel as in the usual practice. The histogram matching is used to modify the histogram of the green channel by using the histogram of the red channel (of the same retinal image) to obtain a new processed image having the advantages of both channels. This method can be used to correct non-uniform illumination in colour fundus images or as a pre-processing step in the automatic analysis of retinal images.

Results show that the use of histogram matched (HM) image give better performance than using the green channel image when employing the two-dimensional matched filter to detect retinal blood vessels. At specificity of 90%, in case of abnormal images, sensitivity increased from 76% when using the green channel image to 82% when using the HM image compared with 81% when using the piece-wise threshold probing method. In case of normal images, at the same specificity, the sensitivity obtained when using green channel image or HM image was 87% compared with 88% for the piece-wise threshold probing method.

Keywords: Medical image processing; Retinal images; Histogram matching

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1. Introduction

Automatic analysis of retinal images is a challenging research area that aims to provide automated methods to help in the early detection and diagnosis of many eye diseases such as diabetic retinopathy and age-related macular degeneration (AMD). Retinal images pre-processing, segmentation, and analysis are different forms of contributions for digital image processing techniques in this area.

Diabetic retinopathy remains the commonest cause of new blindness in the working age population in the UK [1]. Up to 98% of visual loss from diabetic retinopathy can be prevented by timely treatment [2,3]. Image processing techniques can contribute to the early detection and diagnosis of diabetic retinopathy in image enhancement, mass screening, and monitoring of the disease [4]. Diabetic retinopathy meets all the criteria for a disease that warrant screening, it has a long latent period before visual loss and is eminently treatable. As well, screening for retinopathy is non-invasive, cost-effective, and highly sensitive and specific [5].

AMD is now the leading cause of blindness in the developed countries [3] and the most common cause of vision loss in people over 50 years of age [6]. Over the last two decades, there has been continued interest in the use of digital techniques for quantification of macular pathology, particularly drusen [7]. Drusen identification and measurement play a key role in clinical studies of this disease. Current manual methods of drusen measurements are laborious and subjective, and there is a potential for use automated techniques [7,8] for detection and quantification of drusen in retinal images which will help in early detection and treatment of AMD.

Pre-processing of retinal images in the literature is used to reduce the effect of noise [9], help in the detection of anatomical structures [10,11], colour normalisation of retinal images [12,13], visual image quality assessment [14], and automatic mask generation [15]. Retinal images were smoothed by a 5×5 mean filter to reduce the effect of spurious noise in [9] and transformed using wavelet transform in [10], where the optic nerve head was enhanced by modifying the wavelet coefficients by suppressing the small scale coefficients and enhancing the larger scale coefficients. To detect the main components of the fundus, i.e. the optic disc, fovea, and blood vessels, Sinthanayothin et al. [11] presented a pre-processing step to reduce the effect of changing the contrast in different regions of the fundus image and to normalise the mean intensity. This was accomplished by transforming the intensities of the three colour bands to an intensity-hue-saturation representation, then enhancing the contrast of the intensity by a locally adaptive transformation.

Histogram matching was proven to be a good normalisation method for making colour images invariant with respect to background pigmentation variation between individuals, by selecting a particular retinal image as a reference image and use the histogram matching to modify the three channels of each colour image, which solve the problem of wide variations in the colour of the fundus from different patients [12] and improve the clustering of the different lesion types [13]. Histogram matching is also used in visual image quality assessment [14], where model histograms for the pixel and edge value distributions are used, these models were defined using a set of good quality images.

The region of interest in retinal images is the field of view (FOV) which contains anatomical structures as well as lesions abnormalities of anatomical structures. Mask generation aims to avoid processing the black region that surrounds the FOV of retinal images which will result in decreasing the required processing time. In [15], statistical