Processing of spectral imaging of deep layers in the macula of the retina in diabetic macular edema

SPIE.

ATOM-N 2020

Yaroslav Penishkevich[1)], Ion Gruia[2)], Sergey Yermolenko*[3)], Dmitry Burkovets[3)]

[1)] Bukovinian State Medical University, Chernivtsi, Ukraine [2)] Faculty of Physics, University of Bucharest, Romania,

[3)] Correlation Optics Dept., Chernivtsi National University, Chernivtsi, Ukraine

*serg.yermolenko@gmail.com

YURIY FEDKOVYCH CHERNIVTSI NATIONAL UNIVERSITY

INTRODUCTION

Retinal image analysis is used for diagnosing and treating some eye diseases[1-2]. Examples of such diseases are as follows: glaucoma, diabetic retinopathy and other chronic diseases that can cause retinal complications such as cardiovascular and renal diseases. There are many benefits of using computerized retinal imaging. First, imaging is a non-invasive and safe procedure. The second reason is the availability of the retinal image itself. Third, with the increase in the elderly population, eye diseases are increasing worldwide, and with them the demand for ophthalmic services will increase. Therefore, in clinical practice there is a need to find cheaper ways to detect and treat retinal diseases. Computerized image analysis can meet these needs.

The described method is aimed at finding large hemorrhages, but it may be appropriate to identify small ("point") hemorrhages, for example, to diagnose the disease at an early stage. In some works methods of search of point hemorrhages are offered. For example, in [10] a method based on contrast enhancement using a Gaussian filter and construction of a KNN classification model with more than 20 signs of brightness and shape was proposed. The method achieves 100% sensitivity and 87% specificity on the sample of 100 images used by the authors of the article.

The proposed method allows for the processing of noisy and pathological images of the retina and provides good segmentation, especially in thinner vessels by the method of fuzzy clustering of C-means and comparison of results with other known methods.

METHODS

In this study, the green RGB image channel was used because it was shown that the vessels have the highest contrast against the green channel, while the use of the blue channel leads to a small dynamic range, and the red channel offers insufficient contrast, as shown in Figure 1. Moreover, Mendonca and Campilho[11] further confirmed the usefulness of the green channel by comparing different RGB image channels, the color space of the National Television Systems Committee's (NTSC) luminance channel, and the "a" component of the "Lab" color system, where the green channel was shown RGB image has better contrast. In addition, like most other studies, only pixels within the field of view (FOV) of the image are used for segmentation, because pixels outside this area are considered background and have no known medical application. Figure 2 illustrates a block diagram of the proposed method. These steps are discussed in detail in the following sections.

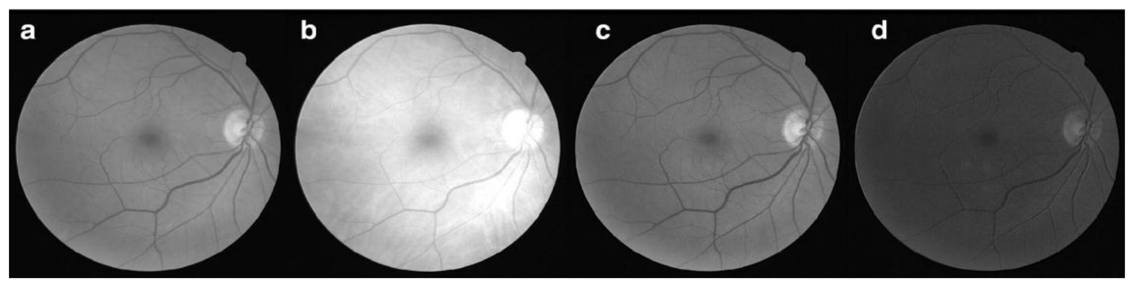

Figure 1. Color image of the fundus and various RGB channels. (a) RGB images, (b) the red channel, (c) the green channel and (d) the blue channel.

The resulting green band from the original image of the fundus was first filtered using a 3 × 3 median filter to reduce image noise. Because the images of the fundus of the retina show high contrast at the edges of the image, which leads to the detection of false-positive vessels around the edges of the image, the edges are smoothed using the method proposed in[12]. The initial FOV mask was calculated by determining the channel illumination threshold in the CIElab color space calculated from the original RGB image. The mask was then expanded by one pixel iteratively, where the value of the new pixel was calculated as the average of 8 connected neighboring pixels. This process was repeated 50 times to ensure that no false vessels were detected near the FOV border

RESULTS

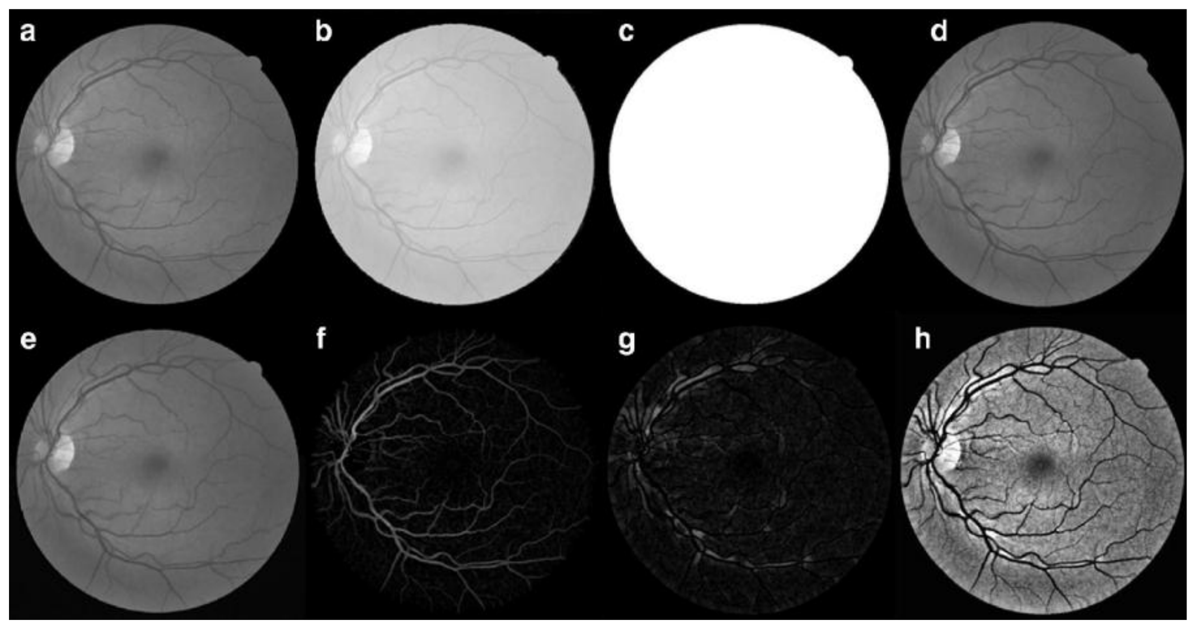

Figure 2. Sample image from the DRIVE data set illustrating the various stages of pre-processing. (a) image of the colored fundus, (b) illumination channel of the CIElab color space, (c) FOV mask, (d) green RGB color space channel, (e) image after median and morphological filtering, (f) morphological Top-hat, (g) morphological Bottom-hat; and (h) image after morphological filtering.

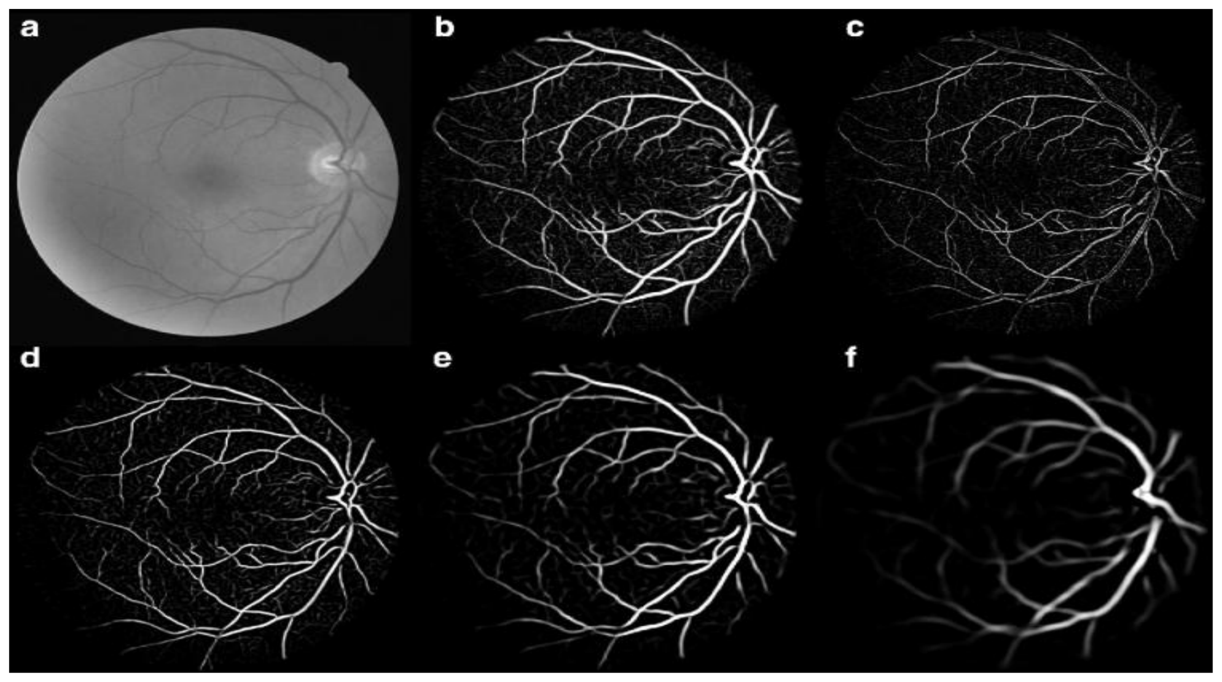

Figure 3. Sample image from the DRIVE data set and the effects of various anti-aliasing parameters of the Frangi filter. (a) Input image, (b) σ = {1,1.1,1.2,1.3,..., 4}, (c) σ = 1, (d) σ = 2, (e) σ = 4 and (f) σ = 8

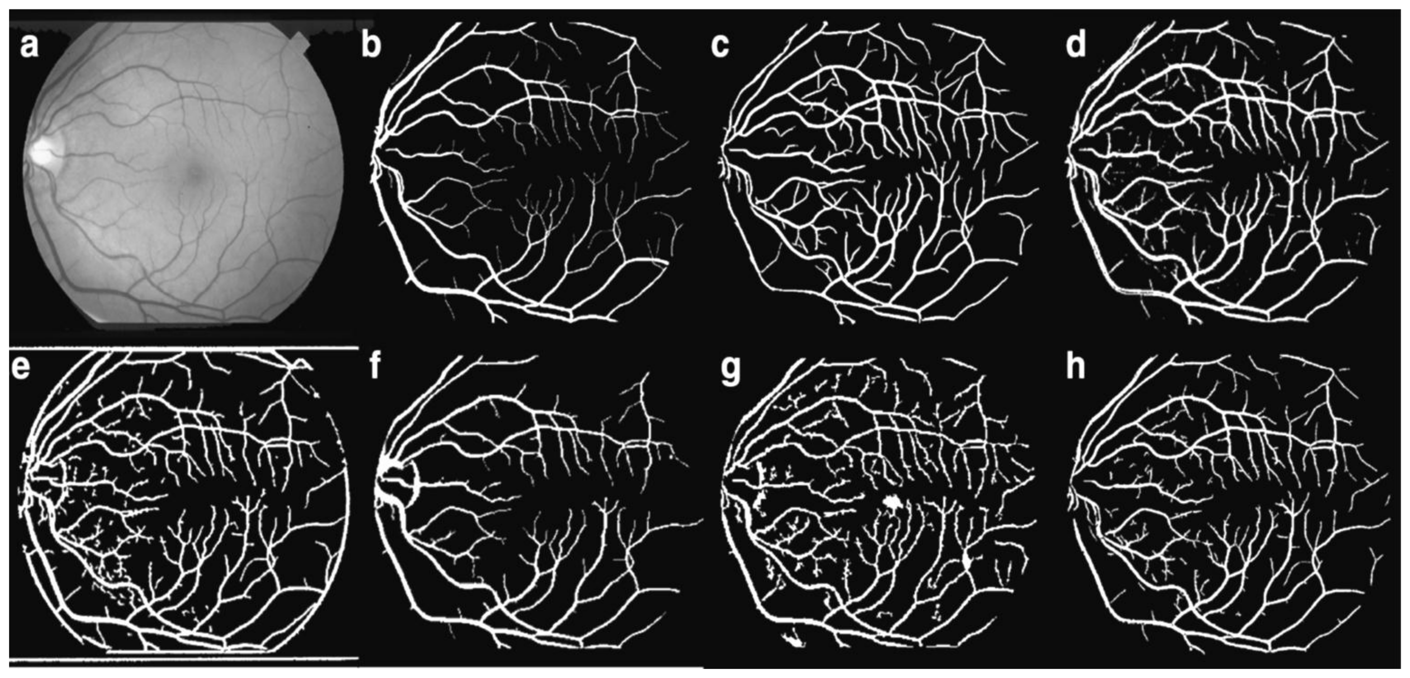

Figure 4. Visual comparison between different methods of retinal vessel segmentation in the image from the STARE data set. (a) color image of the fundus, (b) manual segmentation, (c) proposed segmentation, (d) Bankhead method, (e) Vlachos and Dermat method, (f) Martinez-Perez method, (g) Azzopardi method, and (h)) Bahadar Khan method

With the obtained force of the ball, the level of installation will be slow near the boundary of the object and will depend on the smoothing function without the need for any manual intervention. There may be small perm-like areas consisting of mismatched pixels that are incorrectly identified as vessels in retinal images due to noise or anatomical structures. As a result, the segmented image after processing is processed by removing blob-like and mismatched areas containing less than 30 pixels. Figures 6-8 illustrates the proposed segmentation on a sample image from the DRIVE dataset.

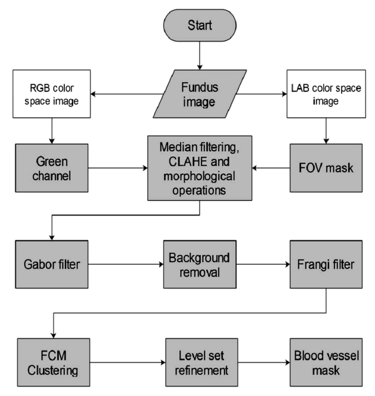

Figure 5. Block diagram of the proposed method of vascular segmentation

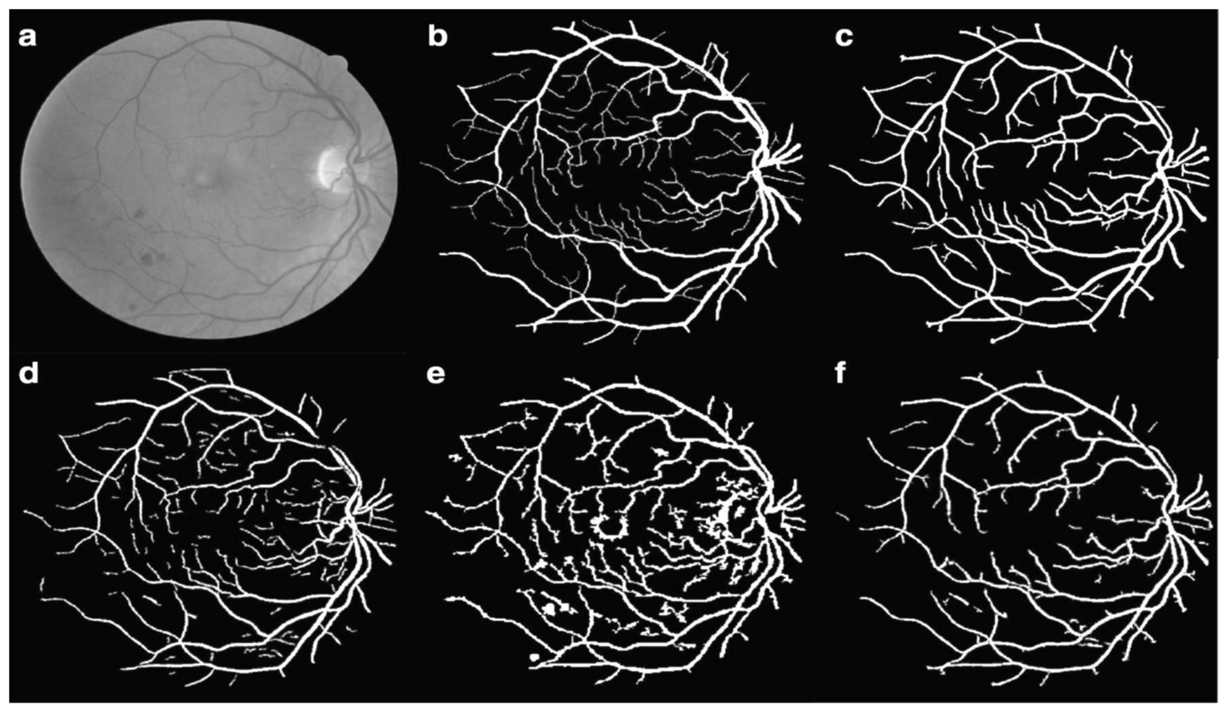

Figure 6. Visual comparison between different methods of retinal vessel segmentation on a pathological sample image from the DRIVE data set. (a) fundus image, (b) manual segmentation, (c) proposed segmentation, (b) (d) Dai method, (e) Bankhead method, and (f) Bahadar Khan method.

CONCLUSIONS

1) The method of vascular segmentation is considered as one of the main approaches of creating tools for automated retinal analysis. Improved retinal image analysis, which can be used segmented vascular tree to calculate vessel diameter and tortuosity, distinction of veins and arteries together with measurement of arteriovenous ratio.

2) Segmented retinal vessels can be used to classify retinal diseases and systematically identify diseases such as diabetes, stroke or hypertension. An algorithm for retinal vessel segmentation based on fuzzy C-means clustering and a level setting method is proposed.

3) Morphological processes, CLAHE and appropriate image filtering methods were used to improve the picture before fuzzy vascular pixel clustering. A segmentation method is proposed on publicly available data sets that use common validation indicators in retinal vessel segmentation, where the results are DRIVE (sensitivity = 0.761, specificity = 0.981), STARE (sensitivity = 0.782, specificity = 0.965) and CHASE_DB1 (sensitivity = 0.7, specificity = 0.968) was comparable to other methods from the literature.

4) The proposed method allows the processing of noisy and pathological images of the retina and provide good segmentation, especially in thinner vessels.

REFERENCES

[1] Congdon, N.G., Friedman, D. S., and Lietman T., "Important causes of visual impairment in the world today," JAMA: The Journal of the American Medical Association, 290(15), 2057–2060 (2003).

[2] Abramo, M., Garvin, M., and Sonka,M., "Retinal imaging and image analysis," IEEE Reviews in Biomedical Engineering, 3,169–207 (2010).

[3] Huiqi, Li, , Chutatape, O., "Automated feature extraction in color retinal images by a model based approach," IEEE Transactions on Biomedical Engineering, 51, 246–254 (2004).

[4] Chernomorets, A.A., "Automated processing of retinal images," 21-th International Conference on Computer Graphics GraphiCon, 78– 81 (2011).