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OPTIC DISC DETECTION IN COLOUR FUNDUS IMAGE TO AID THE DIABETIC RETINOPATHY DIAGNOSIS

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ABSTRACT

Diabetic retinopathy has been revealed as the most common cause of blindness in developed countries. The colour fundus images have been the easiest way to analyse the eye fundus and prevent the progression of this ocular disease. An important prerequisite for automation is the segmentation of the main anatomical features in the image, particularly the optic disc.
Using the Ant Colony Optimization (ACO) algorithm preceded by anisotropic diffusion demonstrates good results for optic disc detection in retinal images.

INTRODUCTION

Diabetic retinopathy (DR) is a specific microvascular complication of diabetes and has been revealed as a serious public health problem in developed countries, since it is the most common cause of blindness among people of working age.
The colour fundus images have been used to analyse the eye fundus in screening programs in order to prevent some ocular diseases such as the DR. The automatic localization of the optic disk (OD) is of great importance in retinal image analysis because OD is used as a landmark for the other features in fundus images. For instance, the location of OD is usually used to locate the macular area; some blood vessels tracking methods start from the OD. Moreover, the accurate localization of OD is indispensable in the detection of some lesions such as exudates because the OD has similar attributes in terms of brightness and contrast (Ying et al. 2007). In fact, OD is characterized as a bright yellow disk from which the blood vessels emerge.
There are many works reported in the literature with the purpose of detecting and segmenting the OD based on its shape, brightness and size. Some of them locate the OD as the point of convergence of all retinal vessels (Fleming et al. 2007; Foracchia et al. 2004; Hoover and Goldbaum 2003; Ying et al. 2007; Youssif et al. 2008). Hough transform has been used to detect the OD as a circular shape (Abdel-Ghafar et al. 2004; Fleming et al. 2007; Zhu et al. 2010). Also morphological filtering techniques have been employed to segment the OD yielding reasonable results (Reza et al. 2009; Walter et al. 2003). Li and Chutatape (2004) applied the Principal Component Analysis (PCA) to locate the OD and included a modified Active Shape Model (ASM) to detect its contour. The papers (Chanwimahuang et al. 2003; Xu et al. 2007) present methods to segment the OD based on snake active contour model.
In this work, a different approach to locate the OD is presented.

METHODOLOGY

The approach described here starts with anisotropic diffusion followed by the ACO algorithm.
Anisotropic diffusion is similar to the process that generates a scale-space where an image is embedded into a parameterized family of successively more and more blurred images based on a diffusion process. In fact, anisotropic diffusion is normally implemented by means of an approximation of the generalized diffusion equation and each new image in the family is determined by applying this equation to the previous image (Weickert 1998). Thus, the anisotropic diffusion is an iterative process continued until a sufficient degree of smoothing is obtained (Weickert 1998; Kim 2006). Qualitatively, the effect of anisotropic diffusion

is to smooth the original image while preserving brightness discontinuities (Sapiro 2001). In the retinal images, the diffusion process aims to smooth the retinal blood vessels and other dark structures and the smallest bright structures.

Thus, then the ACO algorithm, inspired by the study of Tian et al. (2008), segments the other bright edges corresponding, essentially, to the OD.

Ant Colony Optimization is a stochastic local search method inspired by the foraging behaviour of some ant species. The proposed approach utilizes a number of ants moving on the image driven by the local variation of the image's intensity values. This variation establishes a pheromone matrix that represents the edge information at each pixel location of the image (Tian et al. 2008).

The process starts with an initialization stage, and then runs for N iterations to construct the pheromone matrix by iteratively performing both the construction and the update processes. At the end, a decision process is performed to determine the edges.

RESULTS AND DISCUSSION

The DRIVE dataset, a publicly available dataset developed by Staal et al. (2004), was used to test the proposed approach. It is compound of 40 images, in which 7 present signs of mild early diabetic retinopathy. Results of the proposed approach applied to some retinal images are shown in figure 1. This figure illustrates the original image (above) and the result of the ACO algorithm (below). It can be noticed from this figure that the proposed approach could be an effective way to detect the optic disc. Moreover, it can be seen that this approach overcomes the main problems characteristic to the retinal images. That is, with ACO algorithm preceded by anisotropic diffusion it is possible to segment the OD in images with great variability between them and inside them without any pre-processing.

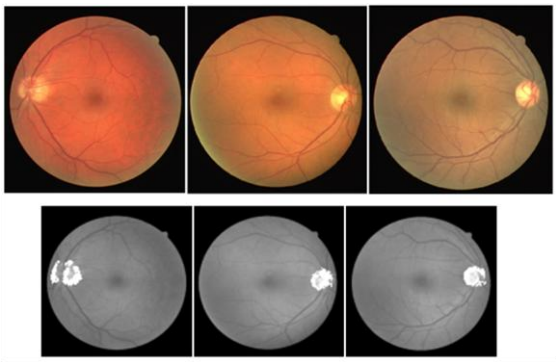

Figure 1: – Results of applying the proposed approach to three different images with great variability

Furthermore, this approach outperforms the work developed by Kavitha and Ramakrishnan (2010) in segmenting the optic disc. As the images of their paper show, their algorithm is affected by noise and by the presence of great variability in the image background. In fact, as the results of this study show, it would be easy to detect the optic disc and differentiate it from the other pixels also detected, due to the use of the anisotropic diffusion.

CONCLUSION AND FUTURE WORK

In this study, ACO algorithm preceded by anisotropic diffusion was successfully applied in retinal images to segment the optic disc. In fact, the optic disc was detected in all the images tested. The superior performance in images with great variability intra and inter images could be considered the major advantage of this approach.

The proposed approach could be an essential step towards the development of a computer aided diagnosis system to be applied in regular screening programs to detect diabetic retinopathy. In fact, the segmentation of the optic disc is just a small step of a large project, that pretends the development of an automatic system for the diagnosis of the diabetic retinopathy by means of fundus image analysis. In that way, as future work, it would be important apply the ACO algorithm combined with other techniques to segment the other structures of the image, specially the lesions characteristics of the diabetic retinopathy.

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REFERENCES

Abdel-Ghafar, R. A., et al. 2004, "Detection and characterisation of the optic disk in glaucoma and diabetic retinopathy". In *Proc. Conf. Med. Image Understand. Anal.*, London, UK.

Chanwimaluang, T. and G. Fan. 2003, "An efficient algorithm for extraction of anatomical structures in retinal images". In *Proc. ICIP*, pp. 1193-1196.

Fleming, A. et al. 2007. "Automatic detection of retinal anatomy to assist diabetic retinopathy screening". *Phys. Med. Biol.*, 52, pp. 331-345.

Foracchia, M. et al. 2004. "Detection of optic disc in retinal images by means of a geometrical model of vessel structure". *IEEE Trans. Med. Imag.*, 23(10), pp. 1189-1195.

Hoover, A. and M. Goldbaum. 2003. "Locating the optic nerve in a retinal image using the fuzzy convergence of the blood vessels". *IEEE Trans. Med. Imag*., 22(8), pp. 951-958.

Kavitha, G. and S. Ramakrishnan. 2010. "An Approach to Identify Optic Disc in Human Retinal Images Using Ant Colony Optimization Method", *J. Med. Syst.*, 34(5), pp. 809-813.

Kim, H.Y. 2006. "*Gradient Histrogram-Based Anisotropic Diffusion*." Personal Communication.

Li, H. and O. Chutatape. 2004. "Automated feature extraction in color retinal images by a model based approach". *IEEE Trans. Biomed. Eng*., 51(2), pp. 246-254.

Reza, A. W. et al. 2009. "Automatic tracing of optic disc and exudates from color fundus images using fixed and variable thresholds". *J. Med. Syst.*, 33, pp. 73-80.

Sapiro, G. 2001 *Geometric partial differential equations and image analysis*. Cambridge Univ. Pr.

Staal, JJ, et al. 2004. "Ridge-based vessel segmentation in color images of the retina". *IEEE Trans. Med. Imag*.; 23(4): 501-509.

Tian, J. et al. 2008. "An ant colony optimization algorithm for image edge detection". In *Proc. IEEE Congress on Evolutionary Computation*, pp. 751 – 756.

Walter, T. et al. 2003. "A contribution of image processing to the diagnosis of diabetic retinopathy - detection of exudates in color fundus images of the human retina". *IEEE Trans. Med. Imag*., 21(10), pp. 1236-1243.

Weickert, J. 1998. *Anisotropic diffusion in image processing.* ECMI Series, Teubner-Verlag, Stuttgart, Germany.

Xu, J. et al. 2007. "Automated optic disk segmentation via a modified snake technique". In *Proc. IEEE Int. Conf. Control, Automation, Robotics and Vision*, Singapore, pp. 1-6.

Ying, H. et al. 2007. "Fractal-based Automatic Localization and Segmentation of Optic Disc in Retinal Image". In *Proc. IEEE Int. Conf. Engineering in Medicine and Biology Society*. Lyon, pp 4139–4141.

Youssif, A. et al. 2008. "Optic disc detection from normalized digital fundus images by means of a vessels' direction matched filter". *IEEE Trans. Med. Imag*., 27(1), pp.11-18.

Zhu, X. et al. 2010. "Detection of the optic nerve head in fundus images of the retina using the Hough transform for circles". *J. Digital Imaging*, 23, pp. 332-341.

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