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

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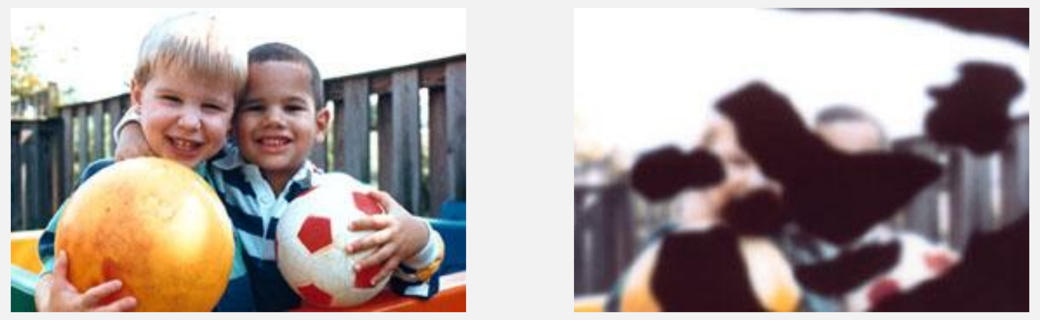
Introduction

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 vision of an healthy eye (left) and of an eye with DR (right)

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.

Digital colour fundus image

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.

Methodology

Anisotropic Diffusion → smooth the retinal blood vessels, other dark structures and the smallest bright structures

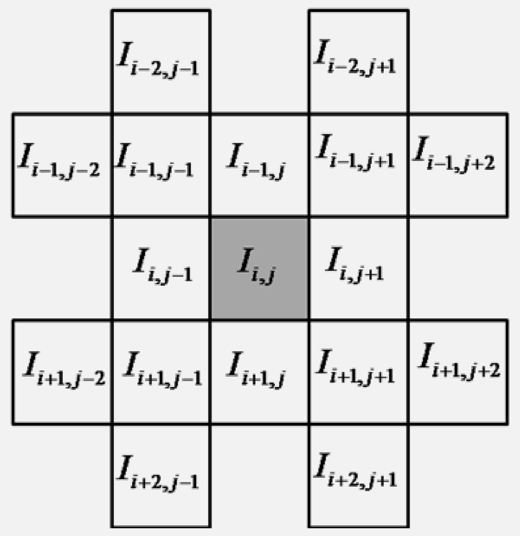
Ant Colony Optimization → segments the bright structures

Binarization → T chosen based on Otsu´s method

Anisotropic diffusion was implemented by means of an approximation of the generalized diffusion equation (below) and each new image in the family is determined by applying this equation to the previous image. Thus, the anisotropic diffusion is an iterative process continued until a sufficient degree of smoothing is obtained (Weickert 1998).

$$I(s,t+1) = I(s,t) + \frac{\lambda}{|\eta_s|}\sum_{p\in\eta_s} g\left(|\nabla I_{s,p}(t)|\right)\nabla I_{s,p}(t)$$

Ant Colony Optimization (Tian et al. 2008) 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:



$$\begin{aligned} V_c(I_{i,j}) = f\big(&|I_{i-2,j-1} - I_{i+2,j+1}| + |I_{i-2,j+1} - I_{i+2,j-1}| + \\ &|I_{i-1,j-2} - I_{i+1,j+2}| + |I_{i-1,j-1} - I_{i+1,j+1}| + \\ &|I_{i-1,j} - I_{i+1,j}| + |I_{i-1,j+1} - I_{i-1,j-1}| + \\ &|I_{i-1,j+2} - I_{i-1,j-2}| + |I_{i,j-1} - I_{i,j+1}|\big) \end{aligned}$$

This variation establishes a pheromone matrix that represents the edge information at each pixel location of the image. This pheromone matrix is updated twice during the ACO process:

- After the movement of each ant

$$\tau_{i,j}^{(n-1)} = \begin{cases} (1-\rho).\tau_{i,j}^{(n-1)} + \rho.\Delta_{i,j}^{(k)}, & \text{if } (i,j) \text{ is visited by the current } k\text{-th ant} \\ \tau_{i,j}^{(n-1)}, & \text{otherwise} \end{cases}$$

- After the movement of all K ants

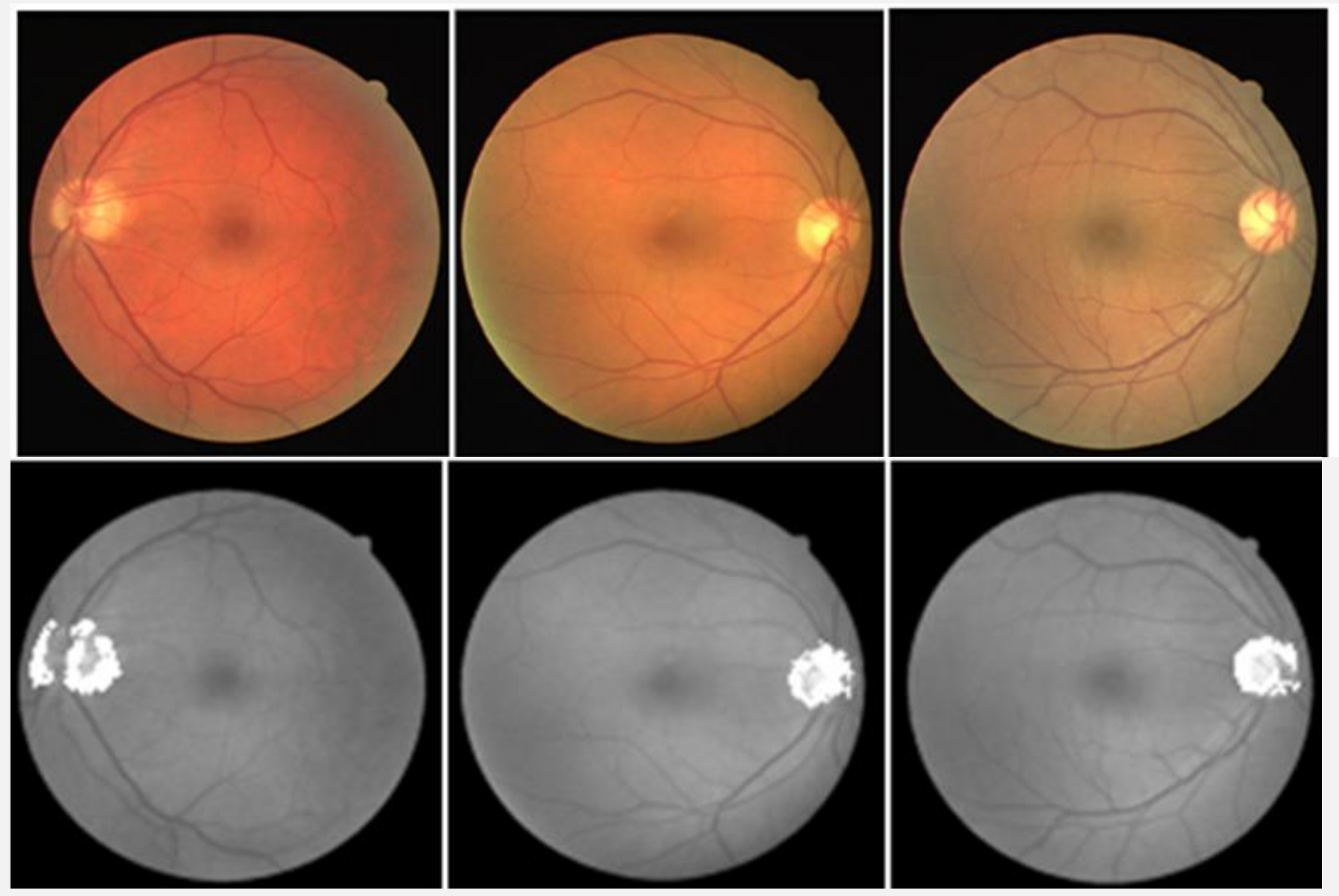
$$\tau^{(n)} = (1-\varphi).\tau^{(n-1)} + \varphi.\tau^{(0)}$$

At the end, a decision process is performed on the pheromone matrix to determine the edges.

Results

original 5 iterations 15 iterations

The effect of applying anisotropic diffusion to the green plane of the fundus image



Original images with great variability (above) and the results of the proposed approach superimposed on the green plane image (below). The ants concentrate their movements on the optic disc.

Conclusion

The 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 (Staal et al. 2004). 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.
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.

Acknowledgment

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References

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