Abstract

We present here a new method to identify the position of the optic disc in retinal fundus images. The method is based on the preliminary detection of the main retinal vessels by means of a vessel tracking procedure. All retinal vessels originate from the optic disc and then follow a parabolic course towards retinal edges. Thus, a geometrical parametric model was proposed to describe the direction of these vessels and two of the model parameters were identified by means of a simulated annealing optimization technique. These estimated values provide the coordinates of the center of optic disc. A Matlab® prototype implementing this method was applied to a set of 40 images of both normal and pathological subjects. In all these images, the optic disc position was correctly identified, even in rather difficult pathological situations. An extensive validation on a set of 81 images (STARE project data set) is currently in progress to assess the robustness of the proposed technique.

Introduction

• The optic disc appears as a round region usually brighter than the surrounding (Fig. 1).

• Locating its position is crucial, especially in automatic analysis:
  • important image landmark
  • affected by many retinal pathologies
  • might easily be confounded with exudative lesions
  • caliber of the main vein at its edge used as a length reference (125 μm).

• Many techniques proposed to detect the optic disc, based e.g. on its relatively high brightness (see e.g. [1–4]). They often fail on pathological images.

• Other techniques exploit the information provided by the vessel network, i.e., the fact that all main retinal vessels originate from the optic disc [5].

• Our method is also based on the detection of vessel network, but with additional robustness from the a priori knowledge included in the model of vessels direction. Using a geometrical description of the vascular structure, it derives the coordinates of the origin of main retinal vessels, which is inside the optic disc and very near its center (Fig. 1).

• The course of the main vessels originating from the optic disc can be modeled as two parabolas, having a common origin inside the optic disc (Fig. 2).

• This can be described by the geometrical locus \( \Gamma \)

\[ \Gamma = \{(x,y) \in \mathbb{R}^2 : ay^2 + bx = 0\} \]

Model of retinal vessels direction

• The model parameters (x

OD

, y

OD

) represent the best positioning of the optic disc according to the model fit on the available samples (xi,yi) of the vessels direction.

• Minimization of RSS with classical gradient-based techniques is rather critical, since RSS has many local minima. Fig. 4 represents, e.g., a plot of RSS as a function of parameters x

OD

 and y

OD

 only.

• Simulated Annealing (SA) optimization procedure [9] was used, a probabilistic technique with the capability of moving out of local minima.

• SA was run six times for each image, starting from different initial points in the parameter space, and the lowest value reached was assumed as the absolute minimum.

\[ RSS = \sum_{i} \left[ \theta(x_i,y_i) - \theta^{mod}(x_i,y_i) \right]^2 \]

Method identification

Minimization of the residuals sum of squares RSS is performed with respect to model parameters (x

OD

 and y

OD

) (minus sign indicates a direction difference).

\[ \theta(x,y) = \arctan \left( \frac{\text{sign}(x)\text{sign}(y)}{2|y|} \right) + \beta^* \]

where \( \beta^* \) is a term modelling the increasingly diverging direction when moving away from the parabolas; (a,β) are model parameters, and vector \( \vec{p} \) includes the optic disc center coordinates (x

OD

, y

OD

).

Results and discussion

• Matlab® prototype realized and tested on 40 fundus images (605x700 pixels, 45° field of view) with vessels already tracked, from normal and pathological subjects (STARE project [10]).

• The method was able to correctly position the optic disc in all 40 images.

• Four examples of pathological images shown in Fig. 4. Despite their problems, the technique was able to correctly detect the position of the optic disc in all of them.

Fig. 1. Retinal fundus images with vessels and optic disc (yellowish circle on the right hand side).

Fig. 2. Parabolic model of main vessels course.

Fig. 3. Complete model of vessels direction.

Fig. 4. Plot of RSS values as a function of model parameters (x

OD

, y

OD

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Acknowledgments

This work was supported in part by a research grant from Nidek Technologies, Italy. The authors wish to thank Prof. Adam Hoover, Clemson University, SC (USA), for having kindly provided images and tracking data from the STARE project data set. MF is now with NF Scientific Computing, Italy.

Bibliography


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