Retina Image Analysis System for Glaucoma Detection

Rüdiger Bock*, Jörg Meier*, László G. Nyúl*, Georg Michelson#, Joachim Hornegger*
* Institute of Pattern Recognition, University of Erlangen-Nuremberg, Martensstr. 3, 91058 Erlangen
# Department of Ophthalmology, University of Erlangen-Nuremberg, Schwabachanlage 6, 91054 Erlangen
Email: ruediger.bock@informatik.uni-erlangen.de

Abstract

Glaucoma is a disease of the optic nerve that threatens the eyesight of the patients and is one of the leading causes of blindness. Because healing of died retinal nerve fibers is not possible early detection and prevention is essential. Robust, automated mass-screening will help to extend the symptom-free life of affected patients. We devised a novel, automated glaucoma classification system that does not depend on segmentation based measurements. Our purely data-driven approach is applicable in large-scale screening examinations. It applies a standard pattern recognition pipeline with a 2-stage classification. Our system has an 86% success rate on a data set containing a mixture of 200 real images of healthy and glaucomatous eyes. The performance of the system is comparable to human medical experts in detecting glaucomatous retina fundus images.

1 Introduction

Around 5 million people live with a glaucoma risk while around 800.000 people suffer from glaucomatous damages in Germany [1]. Early detection is essential for patients to stop disease progression. Glaucomatous changes can be observed on the fundus morphology even before any visual loss. Screenings based on digital images of the retina have been performed in the past few years in the clinics but they still lack robust automated assistance. We devised an automated system that detects glaucomatous eyes based on acquired fundus images (see Figure 1). In contrast to other approaches, we use image-based features that do not depend on exact measurements obtained by image segmentation techniques. This appearance based approach is new in the field of retina image processing.

Our vision is to build a screening system that allows fast, robust and automated detection of glaucomatous changes in the eye fundus. Such a system could help to discover suspected glaucomatous cases and warn the subject, so that careful evaluation can be done in time to control disease progression.

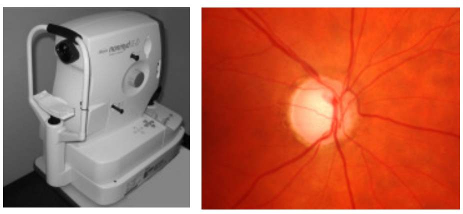

Figure 1 Kowa nonmyd digital fundus camera and an acquired image example.

2 Materials and Methods

We devised a database driven framework to process, analyze and classify retina images. It follows the standard image processing pipeline: preprocessing, image-based feature extraction, and classification (see Figure 2).

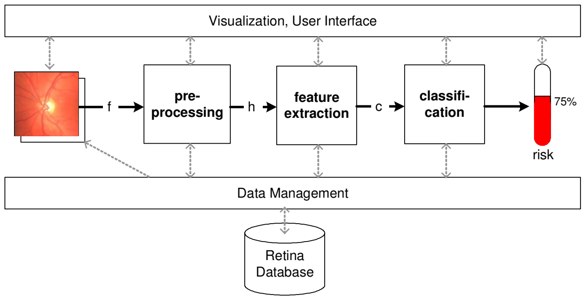

Figure 2 System overview of database driven framework to analyze and classify retina images.

2.1 Preprocessing

On one hand, nonuniform illumination is a general problem with retina images. We correct such inhomogenities by robust homomorphic surface fitting [2]. On the other hand, blood vessels introduce a high variation in retina images which seems to be a distracting feature when diagnosing glaucoma. In our study, blood vessels are removed by computing a vessel mask and interpolating the missing pixel values by morphological inpainting. The neuroretinal rim around the optic disc (papilla) is the most important region for glaucoma detection [3]. We normalize the images such that the papilla is centered and appears in the same size. This normalization is required for the feature computation by appearance based approaches.

2.2 Feature Extraction

To capture different aspects of the image information, we use four types of feature extraction. (i) The first set of features is obtained by taking the pixel values directly as input to principal component analysis (PCA) which is used here as a dimensionality reduction technique. (ii) The second feature group comes from texture filter responses [4]. The filter output is also compressed using PCA. (iii) The third set of features is computed from the coefficients of the Fast Fourier Transform (FFT) and contains translation invariant global frequency information. Again, PCA is used for data reduction. (iv) A Gaussian mixture model is fitted to the intensity histograms using maximum likelihood estimation and the found distribution parameters, such as the mean and the variance values, serve as features.

2.3 Classification

We found that a 2-stage classification scheme performs better than classification using any of the four feature sets alone or using a single pooled feature set. First, the four sets of feature values are classified separately by support vector machines (ν-SVM [5]). In case of texture features a feature selection was performed before classification. Then, the probability score of belonging to the glaucoma class, obtained from each of the four classifiers is taken as a new feature vector input to another classifier. This final SVM-classifier decides whether the sample is considered glaucomatous or not.

3 Results

For evaluation, we took 200 images (50 images each of healthy and glaucomatous eyes for training and a similar mixture for separate testing; age of the subjects: 57 ± 10 years) randomly selected from the Erlangen Glaucoma Registry (EGR). Diagnosis was done by an ophthalmologist using anamnesis, image data and other measurements. The images were acquired by a Kowa nonmyd digital fundus camera. We computed the overall classification correctness and also the F-measure (the harmonic mean of sensitivity and precision) for healthy and glaucomatous eyes. The experiments were performed with a cross-validation and a separated test set.

When applying the second classification step, 86% classification correctness is achieved with an F-measure of 83% for healthy and 88% for glaucomatous samples.

4 Discussion

The classification performance of our system is similar to that of human experts. According to [6], experienced observers achieved by qualitative assessment of optic disc stereophotographs (63 normal and 29 glaucomatous subjects) an average F-measure of 91% for detecting normals and 79% for detecting glaucoma.

In conclusion, our retina image analysis system identifies glaucomatous eyes in fundus photographs and can be applied in large scale screening examinations for early detection of the disease. With appropriately adapted preprocessing and feature extraction, the same scheme can also be used for detecting other diseases. To our knowledge, this is the first data-driven feature computation and classification system for glaucoma detection from retina images.

5 References

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