Blood Vessel Density and Distribution in Fundus Images

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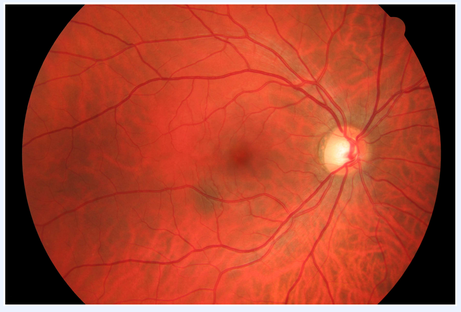
Background and Purpose

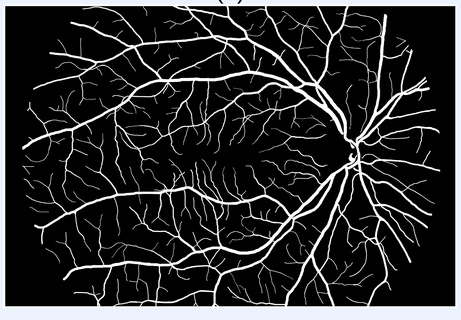
Our goal is to analyze and visualize the **distribution of blood vessels** in fundus images to support the medical diagnosis by providing quantitative measurements and **detecting diseases and abnormalities like diabetes**.

Methods: Data

- Our images are taken by a CANON CF-60UVi fundus camera
- All the images have a resolution of 3504x2336 pixels
- 15 color fundus images of healthy subjects
- 15 color fundus images of diabetic retinopathy patients
- Manual segmentation done by experts
- Automatic segmentation results [1]



(a)



(b)

Figure 1: An example input fundus image of a healthy subject(a) and its input manual vessel segmentation(b)

All data used are free to use for research purposes:
www5.informatik.uni-erlangen.de/research/data/fundus-images

Methods: Generated Maps

Three maps are generated for both the manual and automatic vessel segmentations. These maps are visualized using color coded images to aid the medical diagnosis:

1. **Vessel density map:**
   generated by counting the number of vessel pixels in a large neighborhood (radius is 100 pixels)
   (see Figure 2)
2. **Vessel distance map:**
   encodes distance of each pixel to the closest segmented vessel
   (see Figure 3)
3. **Vessel thickness map:**
   shows the thickness in the center line of each vessel
   (see Figure 4)

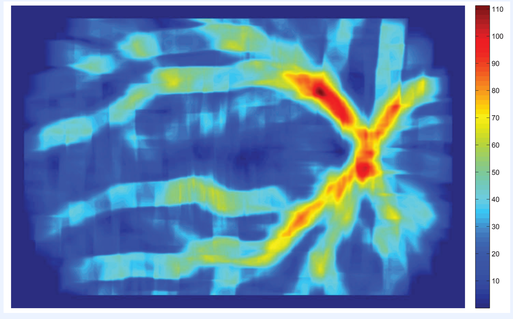


Figure 2: Generated vessel density map of image in Figure 1a

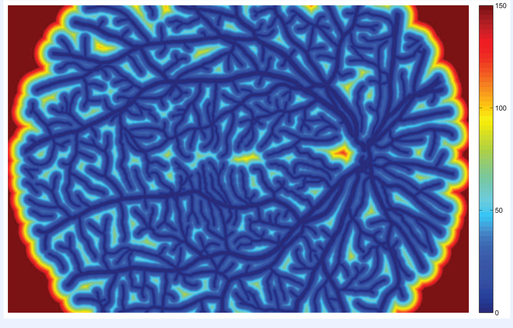


Figure 3: Generated vessel distance map of image in Figure 1a

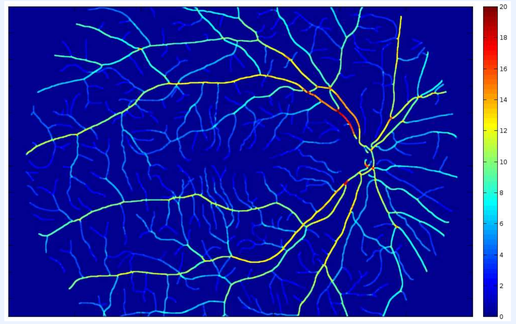


Figure 4: Generated vessel thickness map of image in Figure 1a

Histograms of each map is generated to show the distribution of the densities, distances and diameters (see Figure 5). The statistical moments of these histograms are calculated:

Mean, Variance, Skewness, Kurtosis, Maximum, Median

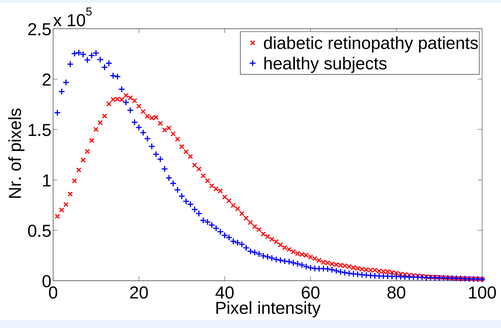


Figure 5: Average histograms of density maps in cases of healthy and diabetic images

Methods: Classification & Evaluation

Four **classifiers were trained to discriminate between healthy and diabetic retinopathy subjects** using a physician's diagnosis as gold standard:

Naive Bayes, K-Nearest Neighbors, AdaBoost, Decision tree

A 10-fold cross-validation is used to evaluate the classification. We compared the results based on the manual and automatic vessel segmentation to the gold standard.

Results

The best results were generated by AdaBoost. The following table its accuracy, TP/FP rates and area under the ROC curve:

Segmentation	Accuracy	TP rate	FP rate	ROC area
manual	0.933	0.933	0.067	0.953
automatic	0.805	0.800	0.200	0.931

Conclusion

We provide **methods to analyze and visualize the distribution of vascular tree** of the human eye. We developed a **novel classification method to distinguish between diabetic retinopathy and healthy subjects** using vessel tree based features only.

Outlook

The presented classification algorithm has to be tested on a bigger database to analyze its reliability

Support

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Commercial Relationship

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References

[1] A. Budai et al.: Multiscale Approach for Blood Vessel Segmentation on Retinal Fundus Images, Invest Ophthalmol Vis Sci 2009;50: E-Abstract 325. ARVO 2009