Project Proposal

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Diagnosis of Diabetic Retinopathy

Diabetic retinopathy is the leading cause of legal blindness in adults in developed countries. Computer assisted diagnosis is desired because it allows for mass screening for the disease. All diabetics could be screened for the disease, even if their vision is not degrading. Early diagnosis allows for early treatment, which is critical because retinal damage is irreversible.

Bright lesions, in the form of exudates and cotton wool spots, and dark lesions, such as hemorrhages, are indicators of the disease. Challenges in this field include segmentation of these features, as well as blood vessels. The literature has used various techniques such as matched-filtering, morphological operations, scale-spaced region growing, edge detection, local thresholding, nearest neighbor pixel segmentation, and neural network pixel segmentation.

We have found a database of retinal images. This database consists of 40 retinal images, including ground truth segmentation of blood vessels (performed by a physician). Seven of these images show signs of the disease. These images were taken with a camera designed for capturing the fundus. There exists another database with 20 more images.

Challenges

- Non uniform illumination
- Presence of other anatomical structures (e.g. optic disc, lesions)
- Variable vessel characteristics that do not generalize
- Noise

Literature Summary:

[1] Ridge based vessel segmentation in color images of the retina

The authors of this paper present a method for automated segmentation of vessels using a ridge based approach. First, image ridges are extracted and used to compose line element primitives, which in turn divide the image into smaller patches. A k nearest neighbor classifier is then used to extract features which form the line segments of the segmented image. The proposed method achieves an AUC of 0.952 as compared to the algorithm in [5], which has an AUC of 0.933. Manual segmentation is used as ground truth. The authors acknowledge that errors in segmentation of small vessels reduce accuracy and suggest possible improvements.

[2] Comparative study of retinal vessel segmentation methods on a new publicly available database.

Five different vessel segmentation algorithms are compared in this paper. Manual segmentation was used as the ground truth in the study. The average accuracy over a database of 40 images is used as a basis for comparison. The pixel classification method of [1] produces the largest AUC. The authors note problems with vessels of sub-pixel widths and JPEG compression artifacts. Optic disk segmentation to exclude it from the analysis is also suggested as a way to reduce false positives.

[3] A Contribution of Image Processing to the Diagnosis of Diabetic Retinopathy-Detection of Exudates in Color Fundus Images of the Human Retina.

This paper aims to detect the diabetic retinopathy indicators called exudates. Due to the similar visual properties, the optic disc is detected before the exudates to avoid misclassification. In both steps, the authors use morphological operations. They achieve a sensitivity of 0.928. The authors declare that specificity is a meaningless statistic, because it is always near 1, due to the nature of the segmentation and ground-truth. Instead they use a measure called "predictive value" = TP/(TP + FN), which they claim to get to 0.924.

[4] Image Processing and Retinopathy: A Novel Approach to Computer Driven Tracing of Vessel Network.

The authors segment retinal images using matched filtering. Their filters are 2-D oriented Gaussians. This type of filter was chosen because blood vessels look Gaussian in the direction perpendicular to the principal axis. Multiple orientations of the 2-D Gaussian filters are used because the vessels can be modeled as piecewise linear. Although there is a section titled "Numerical Results," no numerical results are present. But we do have some pretty pictures.

[5] Adaptive Local Thresholding By Verification-Based Multithreshold Probing with Application to Vessel Detection in Retinal Images

This article examines the application of adaptive local thresholding using a verification-based multithresholding scheme to retinal images. The basic procedure is to apply thresholds at multiple levels, which will uncover a different set of binary images. Then a verification scheme will determine whether the object is to be "accepted". The verification scheme functions as a kind of classification that will make decisions based on the type of characteristics associated with the particular application. The different binary segmentations are then combined into a final segmentation.

[7] Locating blood vessels in retinal images by piecewise threshold probing of a matched filter response

Matched filtering is used to preprocess the image. They then thin the filter response and break the branches into line segments. A custom region growing algorithm is then used to complete the tree. This paper did not use the DRIVE database.

Algorithm

We propose to use a matched filter approach to segment the vessels. Existing methods use Gaussian models to approximate the characteristics of blood vessels. The use of Gaussian models has not been challenged in literature and we would like to validate their use.

We propose using image patches from our training set to generate the filters. The patches we will select will be linear vessel segments, over many orientations and will include both thin and thick vessels. We believe this will result in a better fit than current practice.

We will then try to fit a function to these sample filters. These closed-form mathematical models can then be turned into filters, which we can compare to the traditional Gaussian filters. This will be advantageous because the algorithm can be generalized. The image sample approach is camera dependent, but a model based approach may be more robust.

Noise reduction will be accomplished through the matched filter. Background subtraction will be used to eliminate non-uniform illumination. We hope to use morphological operations to remove artifacts.

Evaluation Criteria

The performance of our algorithm will be compared against the Gaussian model, to its use as an adequate technique to approximate blood vessels. Staal has created a standard graph used to compare the performance of various vessel segmentation algorithms on the DRIVE website. We will conform to this standard, so that our algorithm can be quantitatively compared against the other algorithms, as well as a human.

The Plan

3/1 - Problem Presentation
3/15 - Test algorithm on synthetic images, implement evaluation measure
3/28 - Run algorithm on retinal images
4/15 – Create model of vessels & evaluate performance
5/1 – Final presentation & report

References

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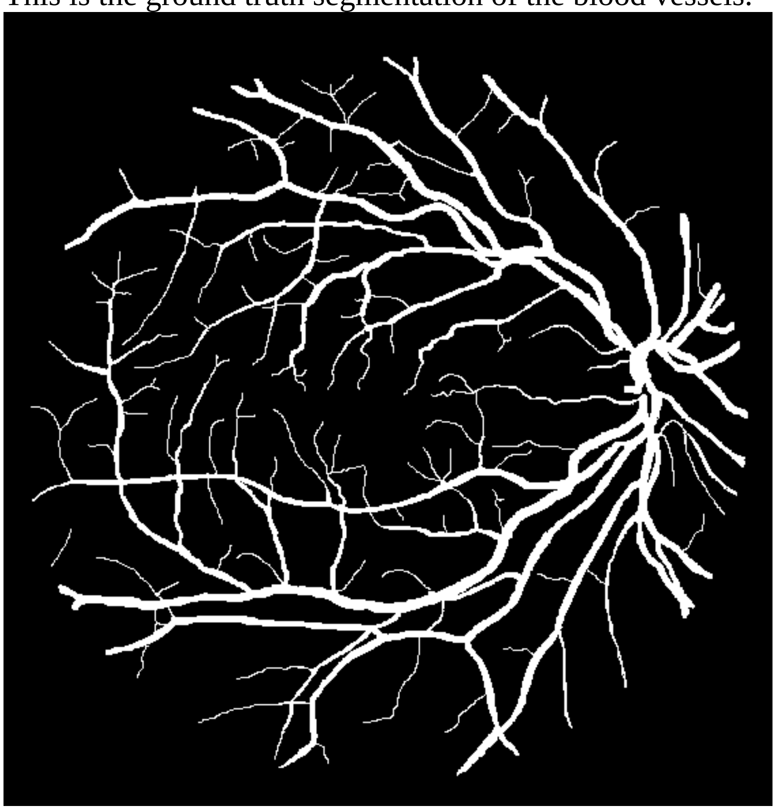
The following image is a normal retinal image.

This is the ground truth segmentation of the blood vessels.



This is a diseased retinal image.

This is the blood vessel segmentation of the diseased eye.