Automatic Detection of Capillary Dilation and Looping in Patients with Diabetic Retinopathy from OCTA

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Introduction

- Diabetic retinopathy (DR) is one of the most common causes of blindness in the western world [1].
- Microaneurysms (MA) are the hallmark of diabetic retinopathy (DR) [2].
- We present a machine learning algorithm for the automatic detection of pathologic capillary dilation and looping, features consistent with MAs, as an aide in the diagnosis of MAs.

Data

- Patients were enrolled at the New England Eye Center at Tufts Medical Center in Boston.
- OCTA data were acquired from 8 patients with varying severities of DR using an OptoVue Avanti device.
- 16 OCTA volumes with field sizes of 3x3 mm were acquired in each imaging session.
- The Avanti software was used to segment the retinal layers and generate en face projections.
- An expert grader at the Boston Imaging Reading Center generated annotated data by labeling vascular abnormalities such as dilation and looping.
- Three data sets were used as test sets (see figure 2).

Method

- Structure tensor and Hessian matrix features were computed on the en face projections.
- The projections and their features, see figure 1, were tiled into 11x11 pixel patches.
- A random forest was trained to classify the center pixel of each patch as being normal or abnormal.
- The algorithm was implemented in Python using scikit-learn and scikit-image [3].
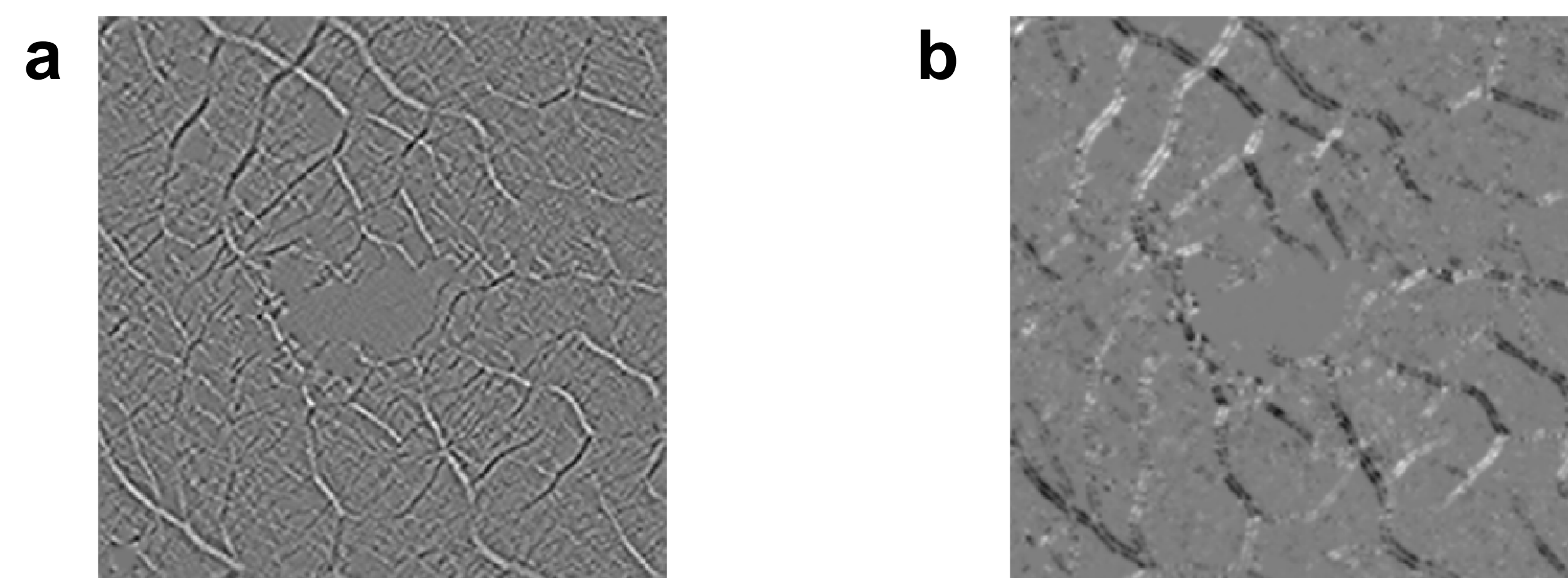

Figure 1: Features from en face projection using the Hessian matrix (a) and the structure tensor (b).

Results and Discussion

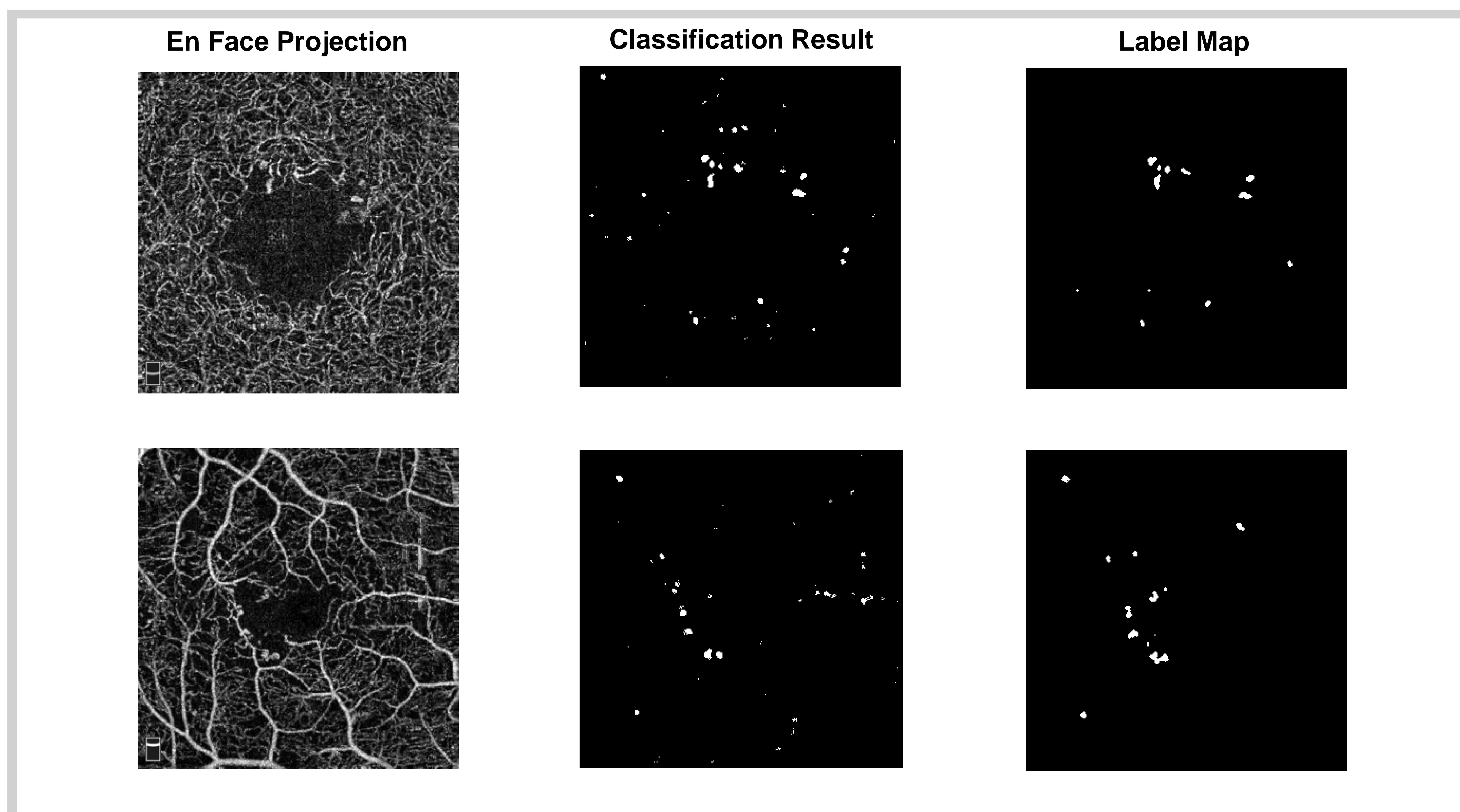| En Face Projection | Classification Result | Label Map |

Figure 2: Results of detection algorithm on two test data sets. The top row shows the deep capillary plexus of a 66 year old male and the bottom row the superficial capillary plexus of a 28 year old male patient. White areas in the classification and label map columns denote areas pathologic capillary dilation and looping.

Accuracy	0.96
Precision (TP / (TP + FP))	0.91
Recall (TP / (TP + FN))	0.62
F1-Score	0.74

Table 1: Classification results using 3-fold cross-validation

- The majority of individual MAs were classified correctly.
- False positives were apparent, of which the smaller ones can be excluded based on size.
- Parts of larger vessels were classified as MAs.

Conclusions

This approach shows that it is possible to fully automate the detection of vascular abnormalities consistent with MAs, thereby enabling detection of early stage DR, even with a small amount of training data. More training data are needed to improve the classification.

References

[1] Choi et al. "Ultrahigh Speed Swept Source Optical Coherence Tomography Angiography of Retinal and Choriocapillaris Alterations in Diabetic Patients with and without Retinopathy". In: Retina 37.1, pp. 11-21, 2017.
[2] Couturier et al. "Capillary Plexus Anomalies in Diabetic Retinopathy on Optical Coherence Tomography Angiography". In: Retina 35.11, pp. 2384-2391, 2015.
[3] F. Pedregosa et al. "Scikit-learn: Machine Learning in Python". In: JMLR 12, pp. 2825-2830, 2011.

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