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Fully-Automated Drusen Segmentation in OCT using Deep Learning with Pyramid U-net

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Purpose

- The clinical hallmark of early and intermediate age-related macular degeneration (AMD) is the presence of drusen. **Quantitative drusen measurements** such as drusen volume are becoming an important factor in **assessing disease progression**.
- We propose a **new deep learning model for drusen segmentation** in OCT.

Methods and Patients

- First, we developed a U-net convolutional neural network (CNN) as a baseline method to segment outer retinal layers and drusen. Second, **spatial pyramid pooling** was introduced into the CNN to improve the automated end-to-end drusen segmentation model.
- Usually, segmentation algorithms detect the drusen boundaries by segmenting RPE and BM surfaces, and not by segmenting drusen directly.
- We decided to define four-class segmentation task: **Drusen, RPE region, BM region and Background**. This introduction of additional classes helps the network to learn how drusen class interacts with the neighboring classes.
- B-scans were supplied to the CNN without any preprocessing and outputs were evaluated without post-processing.
- To enable training and validation, **435 OCT volume scans of 38 patients (50 eyes)** with intermediate AMD (AREDS II or higher) acquired with Heidelberg Spectralis were included.

Results

- We **quantitatively evaluated** the segmentation performance by computing the Dice score measuring the overlap between the segmentations and the annotated reference standard.
  - Our CNN achieved a mean patient Dice score of **0.75.**
  - By using the pyramid layer, our proposed method was able to outperform the two other baseline networks.
  - Table 1 shows the results of this evaluation, per B-scan-based Dice and per patient-based Dice.
- **Qualitative evaluation** showed that the proposed deep learning model was able to segment drusen in a precise and reproducible manner (Fig. 1).

	Basic U-net	PSPNet	Pyramid U-net
Mean Dice Coefficient	**67.53 %**	**68.02 %**	**70.08 %**
Dice Coefficient per patient	**72.65 %**	**72.96 %**	**74.65 %**

Table 1: Quantitative evaluation: The first row shows mean dice coefficient across all the B-scans. The second row shows mean dice coefficient after first grouping per patient.

Conclusion

Accurate quantification of retinal changes is important to determine the individual progression risk of AMD patients to advanced, disabling disease stages.

- Our proposed deep learning method is capable of **characterizing drusen in a precise and reproducible manner.**
- This is a promising step towards the **management of AMD patients using artificial intelligence**.

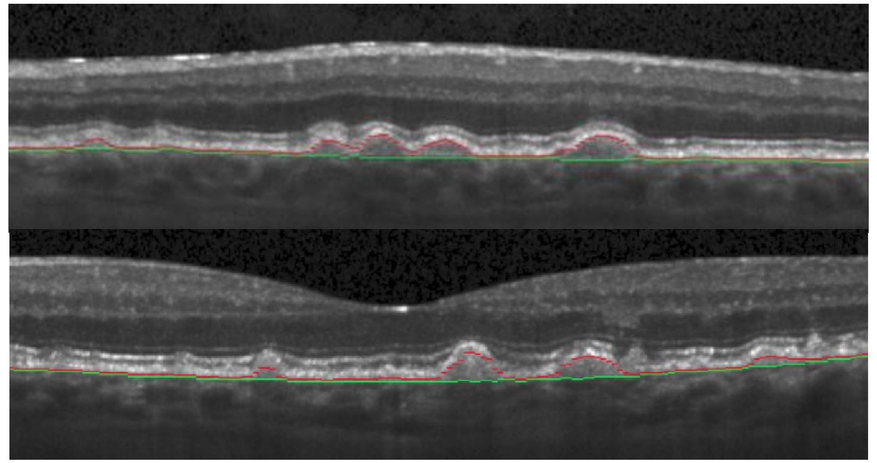

Figure 1: Two representative examples of the drusen segmentation, showing the **BM in green** and the **lower RPE boundary in red**.

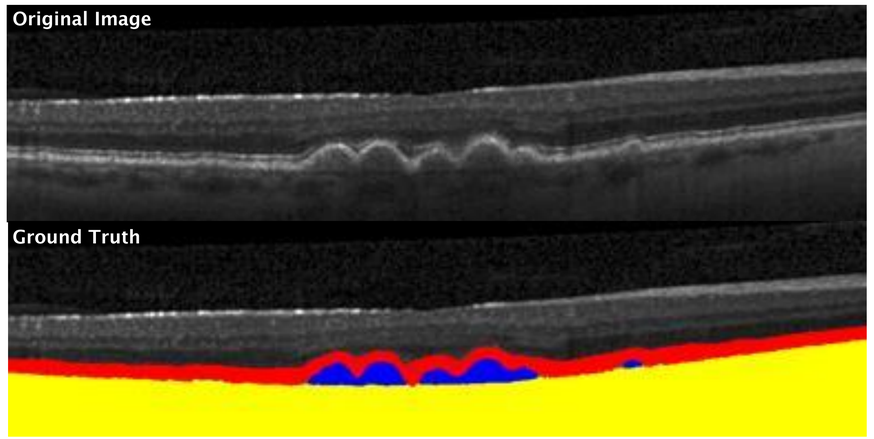

Figure 2: Upper OCT B-scan: **intensity image**, and below its **reference annotation** with the three classes: Drusen (blue), RPE (red) and BM (yellow).

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