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# Segmentation of retinal layers and lesions by loosely coupled level sets in eyes affected by CSR and AMD

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**Purpose** : We present and evaluate an approach to segment retinal layers and lesions in eyes affected by central serous retinopathy (CSR) and age-related macular degeneration (AMD).

**Methods** : The proposed approach extends our loosely coupled level set (LCLS; Novosel et al, MedIA, 2015) method by allowing it to deal with local intensity variations and topology-disrupting pathologies, such as drusen and fluid pockets. In this extended approach, interfaces between layers are simultaneously segmented based on local difference between signals of layers surrounding an interface. Further, lesions are modelled as an additional layer by introducing auxiliary interfaces. In the absence of lesions, this additional layer will have near zero thickness.

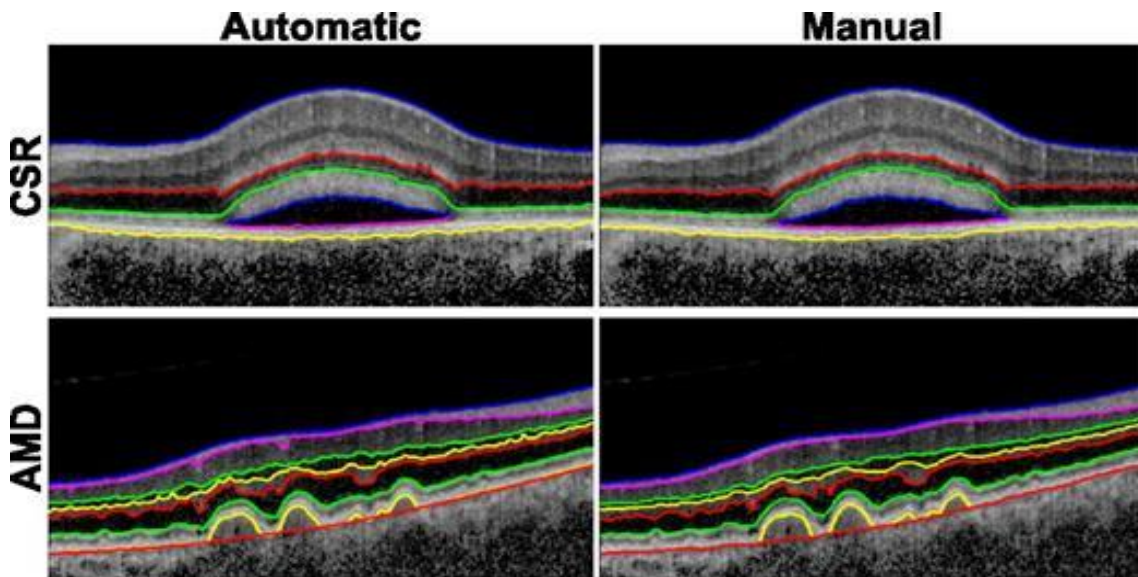
One eye of five patients with CSR or AMD was imaged with a Spectralis OCT system (Heidelberg Engineering, Germany; AMD data from Srinivasan et al, BOE, 2014). Two B-scans from each eye were used to evaluate the method's accuracy. In CSR, the fluids and four interfaces (the vitreous-RNFL and OPL–ONL interface and the IS ellipsoid's and posterior RPE boundary) were considered. In AMD, in addition to the drusen and the aforementioned interfaces, the RNFL–GCL, IPL–INL, INL–OPL interfaces and Bruch membrane were considered. Differences between manual and automatic segmentations were expressed as the root mean square error (RMSE) and mean absolute deviation (MAD). For fluids and drusen, the Dice coefficient was used to assess the segmentation quality.

**Results** : Examples of the segmentation on a B-scan of a CSR and AMD eye are shown in Fig 1. Evaluation results are listed in Table 1. The MAD of the segmentation was 2.5 – 10.4  $\mu\text{m}$

and 3.8 – 9.0  $\mu\text{m}$  for CSR and AMD subjects, respectively. By comparison, the MAD of the earlier LCLS segmentation in normal eyes was 2.7 – 5.9  $\mu\text{m}$  (Novosel et al, MedIA, 2015). The Dice coefficient for fluid and drusen was 94 % and 77 %, respectively

**Conclusions :** The approach achieved a high accuracy in segmenting eyes affected by CSR and AMD. The achieved accuracy of the segmentation remains similar to that in normal retinas. As such, the proposed method shows a potential for clinical use as it can handle both normal and topology-disrupting retinas with similar accuracy. To further enhance this potential, the framework could be extended to other retinal diseases.

This is an abstract that was submitted for the 2016 ARVO Annual Meeting, held in Seattle, Wash., May 1-5, 2016.



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Fig 1. Segmentation results for a CSR and an AMD eye

Interface	CSR		AMD	
	RMSE ( $\mu\text{m}$ )	MAD ( $\mu\text{m}$ )	RMSE ( $\mu\text{m}$ )	MAD ( $\mu\text{m}$ )
Vitreous – RNFL	3.1	2.5	4.4	3.8
RNFL – GCL	n/a	n/a	6.8	4.7
IPL – INL	n/a	n/a	11.6	7.5
INL – OPL	n/a	n/a	10.2	6.5
OPL – ONL	14.8	10.4	13.8	9.0
IS ellipsoid boundary	13.1	7.7	5.8	3.7
Posterior RPE boundary	8.2	6.3	10.4	6.6
Bruch membrane	n/a	n/a	6.8	5.1
Fluid/Drusen (Dice)	93 %		77 %	