# SEGMENTATION AND TEXTURE ANALYSIS OF RETINAL OCT IMAGES

**Giannini D.[1-2], Lombardo M.[1], Ziccardi L.[1], Vichi M.[2], Grzywacz N. M.[3]**

[1] Fondazione G.B. Bietti IRCCS, Rome, Italy

[2] Dpt. Statistical Sciences, University of Rome "La Sapienza", Rome, Italy

[3] Dpt. of Biomedical Engineering , University of Southern California, Los Angeles, California

FONDAZIONE G.B. BIETTI
PER LO STUDIO E LA RICERCA IN OFTALMOLOGIA - ONLUS
IRCCS - Istituto di Ricovero e Cura a Carattere Scientifico
Rome (ITALY) - www.fondazionebietti.it

SAPIENZA UNIVERSITÀ DI ROMA

## Abstract

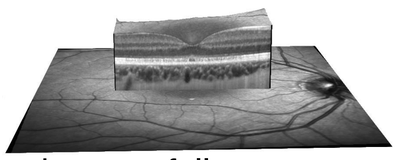
Inherited retinal dystrophies (IRD) lead to severe loss of foveal photoreceptors. Optical Coherence Tomography (OCT) is an imaging technology that allows monitoring retinal disease progression. We developed automated methods to analyze the OCT images in a patient suffering from Occult Macular Dystrophy (OMD) during 3 years follow-up. The methods included the segmentation and texture analysis of OCT images. We showed their reliability to quantify structural disruption of the photoreceptor layer.

## Purpose

To monitor disease progression by automated analysis of retinal layers using segmentation and texture analysis of OCT scans during 3 years follow-up in a patient suffering from OMD.

## Methods: Data acquisition

OCT images were acquired using the "follow-up scan protocol" by *Spectralis* (Heidelberg, Germany).



The scans were automatically aligned across follow-up examinations during acquisition. A volume scan of 10° x 15° in the high-resolution modality (12 and 4 µm lateral and axial resolution respectively) was used.

## Methods: Segmentation

In each retinal OCT scan, four layers were segmented, as shown in Fig.1, in order to identify the inner retina and the photoreceptors' layer.

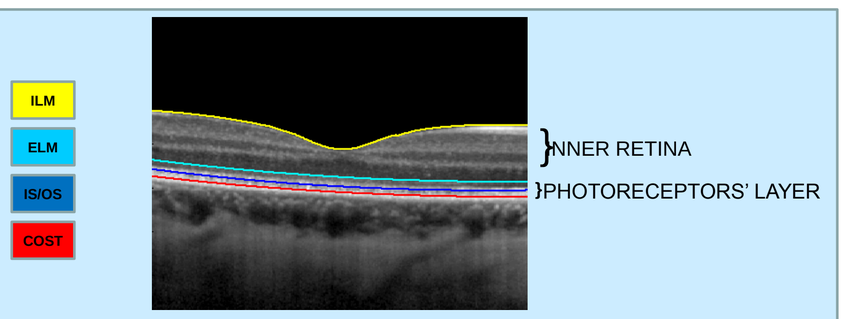
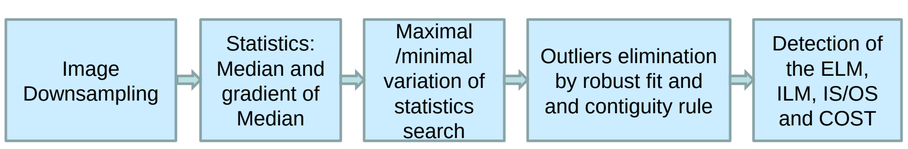



Figure 1: OCT scan with segmented layers. Yellow : Inner Limiting Membrane (ILM); cyan: External Limiting Membrane (ELM); blue: Inner Segment/Outer Segment Junction (IS/OS); red: cone outer segment tip (COST).

The algorithm performed the following tasks:

1.Identification of the innermost and outmost hyper-reflective retinal interfaces, i.e., the RNFL and RPE respectively (Fig 2);


2.Detection of the ELM, ILM, IS/OS and COST lines (Fig. 3);




3.Generation of retinal thickness maps (Fig. 4);

4.Texture analysis of the photoreceptors layers in the sections across the foveola (i.e., the most central region of the macula; Fig. 5).

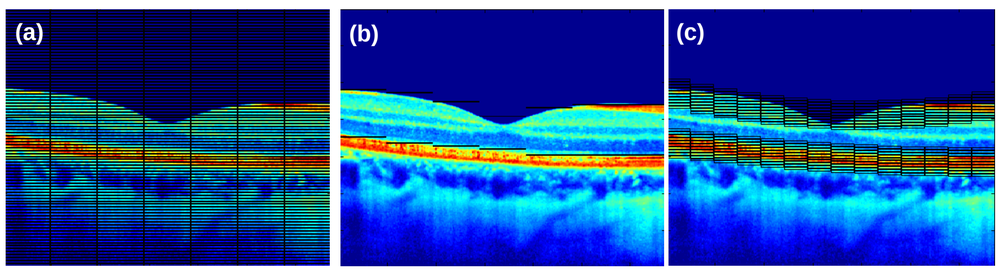



Figure 2 a-c: identification of the two hyper-reflective retinal interfaces: (a) division of the image in rectangles; (b) panel showing the rectangles corresponding to the maximum variation of the intensity; (c) separation of the to hyper-reflective retinal layers for subsequent search steps.

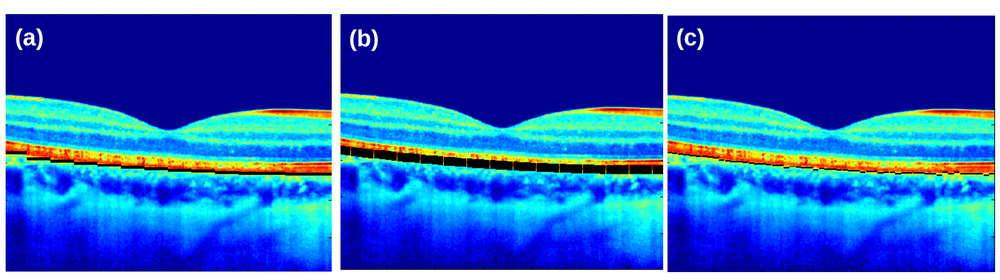
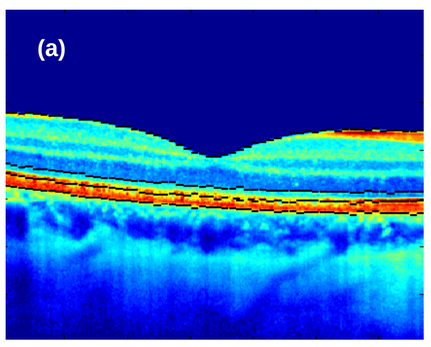



Figure 3 a-c: (a) first detection of the Bruch's Membrane (BM) line; (b) second search with smaller rectangles; (c) final detection after robust fitting selection. The COST line is identified, by inspection of the image, as the vertical translation (16 µm) of the BM.



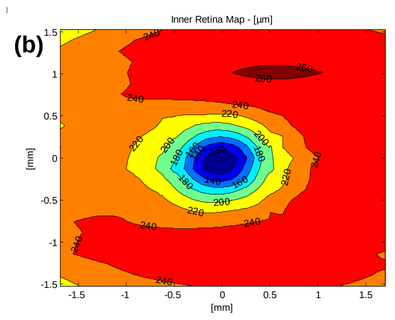




Figure 4: (a) OCT image with final sample rectangles; (b) Example of thickness map of the inner retina (ILM/ELM).

## Methods: Texture Analysis

The gray level co-occurrence matrix (GLCM) of the OCT scans was used in order to analyze the foveal region (Fig. 5). The matrix was calculated, considering 8 gray levels, for every image in the directions along 0°, 45°, 90° and 135°. From the GLCM matrix, several texture parameters were computed, such as the contrast, homogenity, energy and correlation.

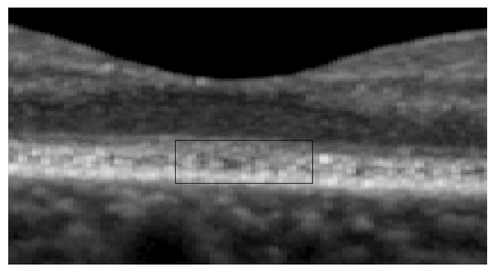


Figure 5: sample rectangle on the foveal area.

## Results

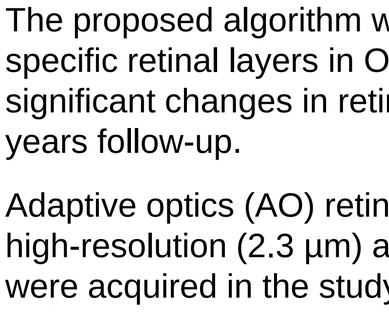



Figure 6: Thickness map of the inner retina with the three areas: foveola (diam. 0.35 µm); fovea (diam. 1.5 µm) and macula (diam. 3.0 µm).

After segmentation, the thickness maps were developed (Fig.6). The average thickness of the inner retina and photoreceptor layers during 3 years of follow-up are shown in Tab. 1. No significant changes in thickness of retinal layers were found over time. This result is consistent with preserved visual acuity during follow-up.

Mean values of the texture analysis parameters are shown in Tab. 2. Values of the OMD patient resulted different from the values of three age-matched healthy subjects.

| RETINAL LAYER | | RIGHT EYE | | | LEFT EYE | | |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 |
| | | MEAN | MEAN | MEAN | MEAN | MEAN | MEAN |
| INNER RETINA | FOVEOLA | 117.15±9.70 | 114.23±9.62 | 117.29±11.59 | 118.96±8.28 | 121.23±10.70 | 120.27±9.48 |
| | FOVEA | 194.15±28.36 | 194.33±29.70 | 194.39±30.22 | 195.85±26.09 | 194.84±26.46 | 196.32±26.57 |
| | MACULA | 244.38±11.20 | 244.56±11.03 | 244.95±11.28 | 243.26±10.01 | 242.52±10.08 | 243.31±9.98 |
| PHOTORECEPTOR | FOVEOLA | 69.34±1.27 | 71.80±1.46 | 72.92±1.71 | 71.66±1.39 | 69.83±2.59 | 73.70±2.24 |
| | FOVEA | 68.90±1.24 | 68.73±2.02 | 70.39±2.58 | 69.46±1.92 | 68.10±2.19 | 69.94±2.87 |
| | MACULA | 69.25±1.78 | 68.25±1.63 | 70.00±1.73 | 70.09±1.62 | 69.09±2.08 | 70.24±1.99 |

Table 1: Mean (±SD) retinal layers thickness in foveola, fovea and macula.

| SUBJECT | MEAN HOMOGENEITY | | | | MEAN CONTRAST | | | | MEAN ENERGY | | | | MEAN CORRELATION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 45° | 90° | 135° | 0° | 45° | 90° | 135° | 0° | 45° | 90° | 135° | 0° | 45° | 90° | 135° |
| Controls | 0.90±0.02 | 0.76±0.02 | 0.77±0.02 | 0.75±0.02 | 0.21±0.03 | 0.58±0.08 | 0.54±0.08 | 0.60±0.10 | 0.14±0.02 | 0.10±0.02 | 0.10±0.02 | 0.09±0.02 | 0.96±0.01 | 0.88±0.01 | 0.89±0.01 | 0.88±0.01 |
| OMD_LE | 0.85±0.02 | 0.78±0.02 | 0.84±0.01 | 0.79±0.01 | 0.33±0.04 | 0.48±0.03 | 0.33±0.02 | 0.47±0.02 | 0.14±0.01 | 0.12±0.01 | 0.15±0.01 | 0.12±0.01 | 0.87±0.01 | 0.80±0.01 | 0.87±0.01 | 0.81±0.01 |
| OMD_RE | 0.85±0.02 | 0.78±0.02 | 0.84±0.01 | 0.79±0.01 | 0.33±0.06 | 0.48±0.07 | 0.33±0.01 | 0.46±0.04 | 0.13±0.01 | 0.12±0.01 | 0.14±0.01 | 0.12±0.01 | 0.88±0.04 | 0.82±0.05 | 0.88±0.03 | 0.82±0.05 |

Table 2: Mean (±SD) values of texture parameters at the foveola in the OMD subject (LE and RE=left and right eye respectively) and controls.

## Conclusions and Future Directions

The proposed algorithm was helpful to monitor the thickness of specific retinal layers in OCT images of an OMD case. No significant changes in retinal thickness were found during 3 years follow-up.

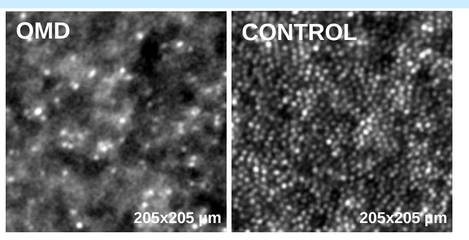



Figure 7: AO images of the photoreceptor layer

Adaptive optics (AO) retinal imaging was performed on the study case. The AO technology offers high-resolution (2.3 µm) and direct visualization of photoreceptors. AO images of the cone mosaic were acquired in the study case during follow-up, showing severe cone loss (Fig. 7). Future work will include the analysis of AO images of the cone mosaic in order to develop a more sensitive method to monitor patients suffering from IRD.

## References

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