



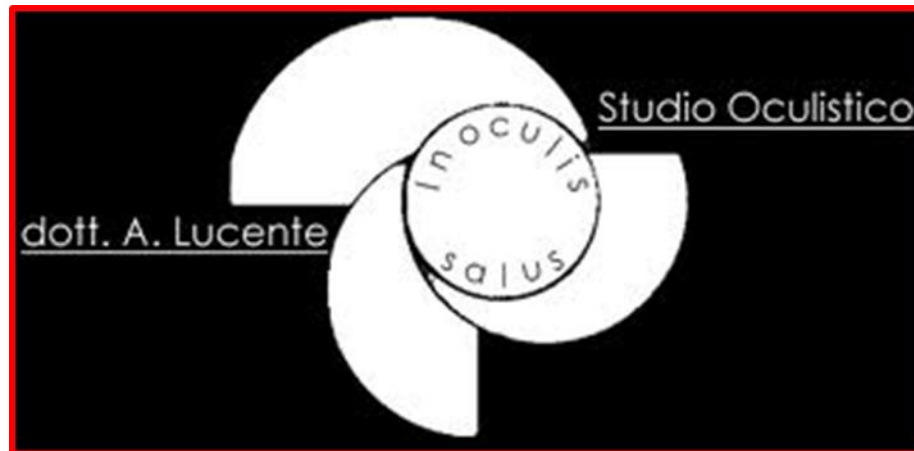
## EVENTO CONGIUNTO ASMOOI-SOC

### **CORSO AVANZATO DI SEMEIOTICA STRUMENTALE**

*Responsabile Scientifico: Amedeo Lucente*



# Algoritmi di decorrelazione e nuove performances degli Angio-OCT



7-8 OTT 2016 CATANZARO UNIVERSITÀ "MAGNA GRAECIA"

# Disclosure

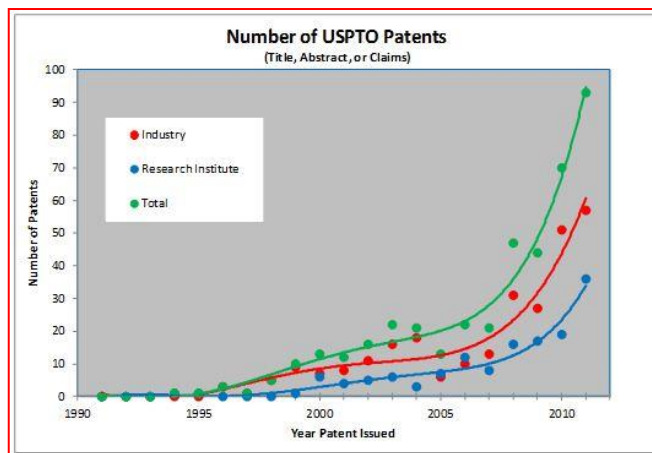
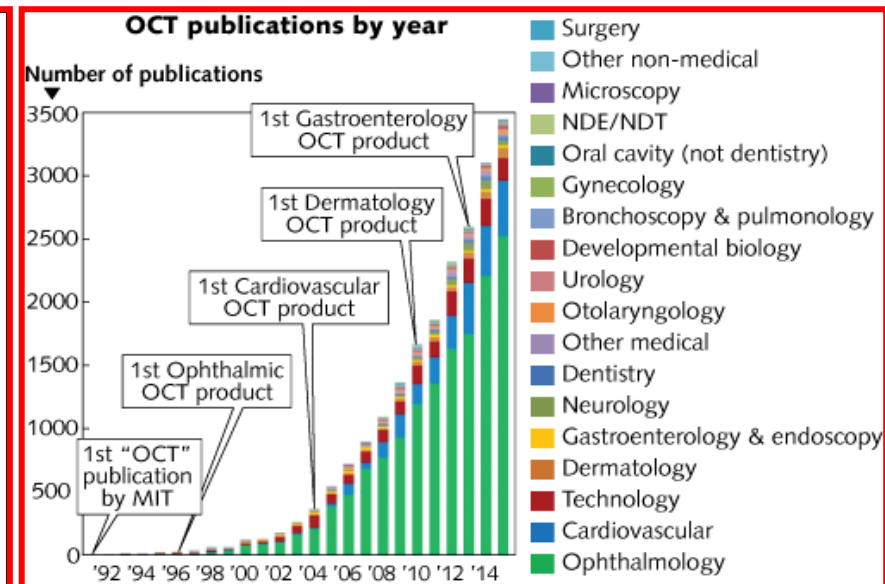
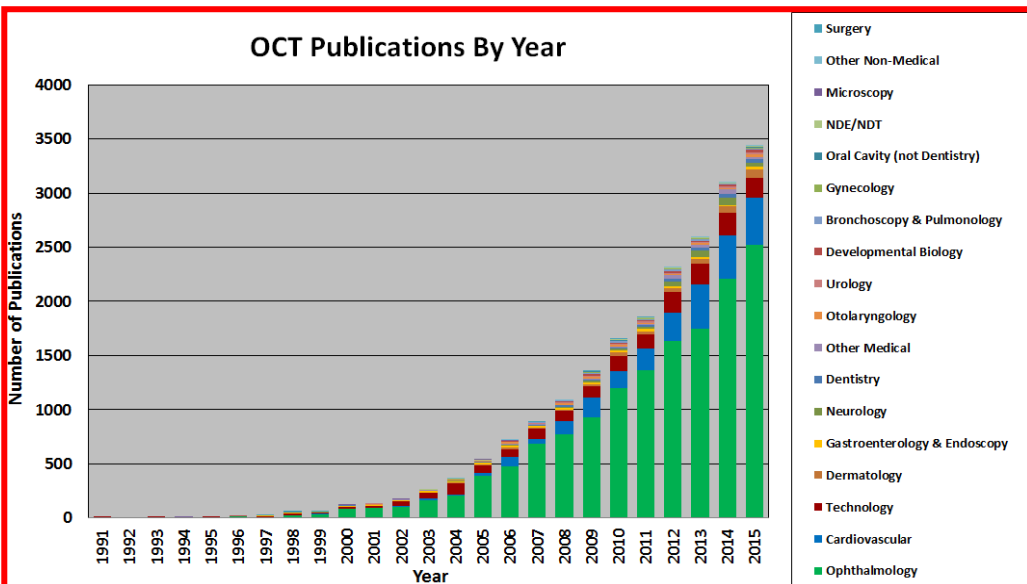
Consulting Free

- Carl Zeiss Meditec
- Alfa Intes

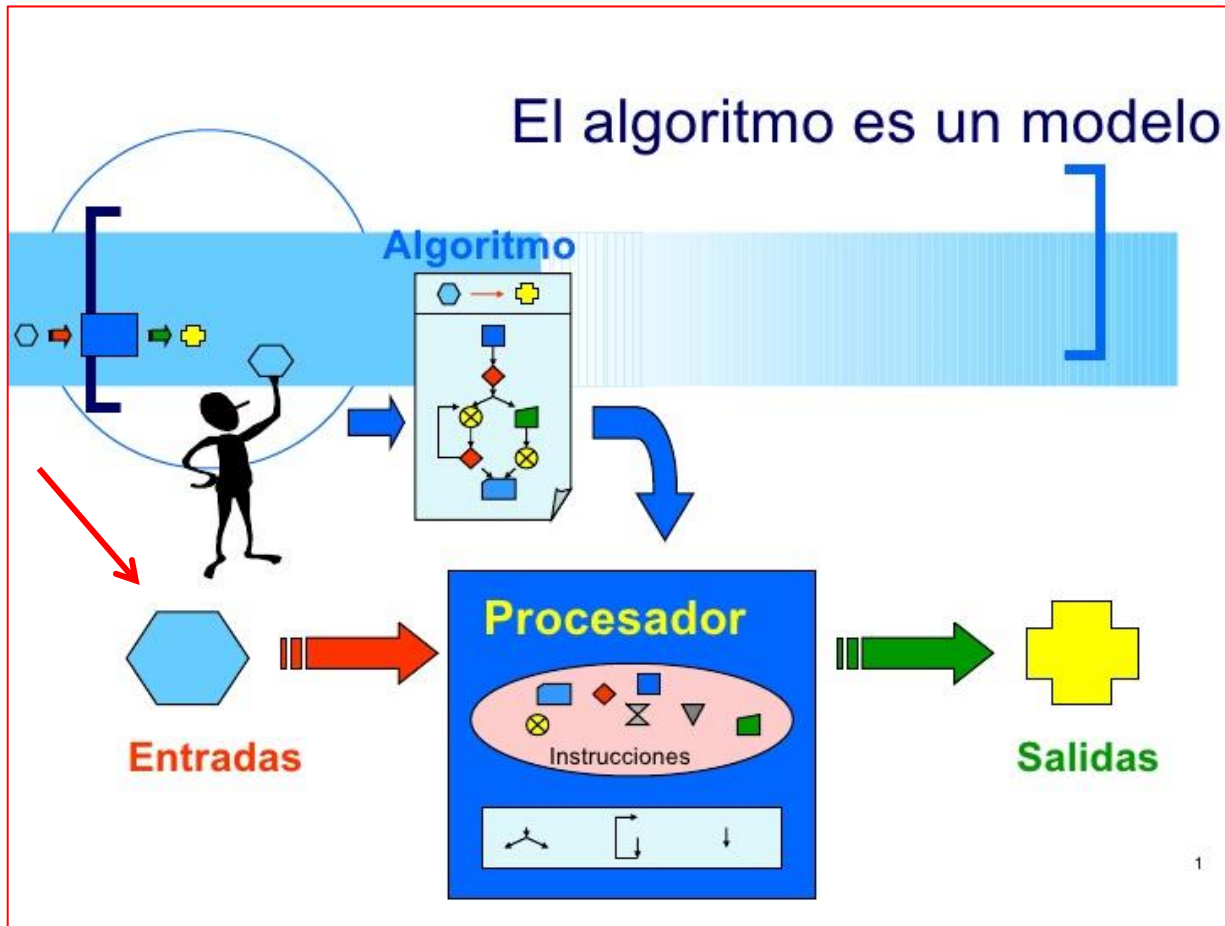
# Foreword: 25 Years of Optical Coherence Tomography

by: James Fujimoto and David Huang

The market is just over \$1B in 2012, and it is expected to grow by 18–30% per year for the foreseeable future



# Algoritmo




al-Khwarizmi محمد خوارزمی  
(Corasmia o Baghdad, 780 – 850 d C circa)

Atomicità, Non ambiguità, Finitezza, Terminazione, Effettività

Una sequenza ordinata e finita di passi (operazioni o istruzioni) elementari che conduce a un ben determinato risultato in un tempo finito.

(dal matematico persiano al-Khwarizmi محمد خوارزمی inventore numero Zero)

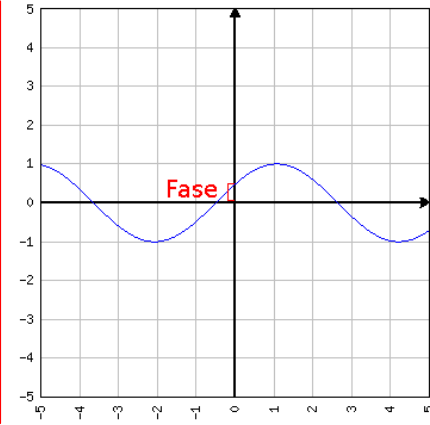
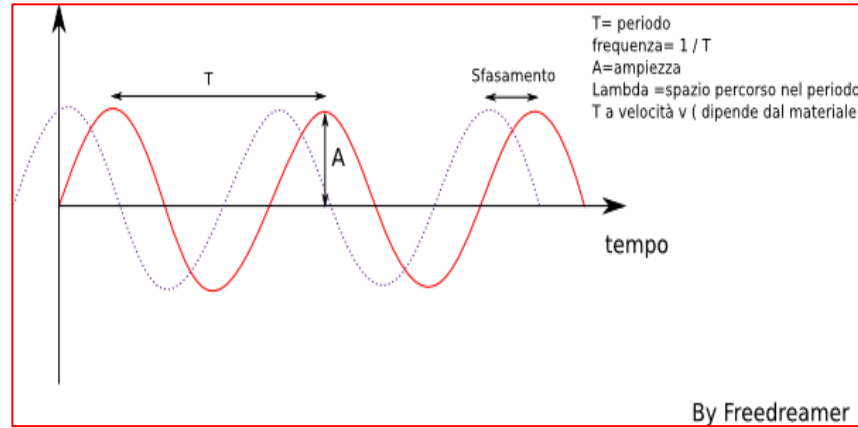
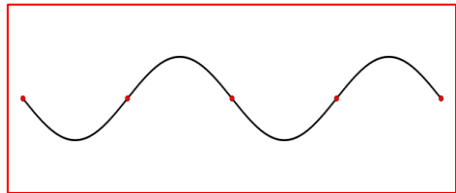
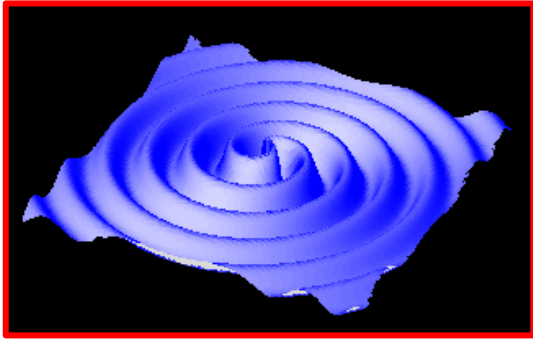
- **Optovue** → RTvue Avanti AngioVue
  - **Zeiss** → AngioPlex Cirrus 5000
  - **Topcon** → **DRI OCT Triton**
  - **Heidelberg** → Spectralis con modulo OCT2
  - **Nidek** → RS-3000 Advance OCT
  - **Canon** → OCT-HS100 Angio Expert con modulo AX (Gruppo Haag-Streit)
- 55,9% Zeiss **OCT**
  - 35,6% Heidelberg By Mark Hillen
  - 6,4% Topcon
  - 2,1% Nidek

- **RTvue Avanti Optovue** **70.000** A-Scan/Sec → **SSADA**  
(Split Spectrum Amplitude Decorrelation Angiography)
- **HD-Cirrus Zeiss** **68.000** A-Scan/Sec → **OMAGc**  
(Optical Microangiography complex)
- **SS OCT DRI OCT Topcon** **100.000** A-Scan/Sec → **OCTARA**  
(OCT Angiography Ratio Analysis)
- **Spectralis Heidelberg** **70.000** A-Scan/Sec → **Full SADA**  
Spectrum Amplitude Decorrelation Algorithm

In teoria dei segnali la correlazione incrociata (correlazione mutua o cross-correlazione o correlazione) rappresenta la misura di similitudine di due segnali

**Decorrelazione (*decorrelation*)**: è un processo matematico utilizzato nell'elaborazione dei segnali per modificare l'autocorrelazione (comparazione del segnale con se stesso) o le correlazioni incrociate (cross-correlazioni, comparazione delle immagini nel tempo); si preservano alcune qualità del segnale a discapito di altre per esaltarle (**Flusso**)

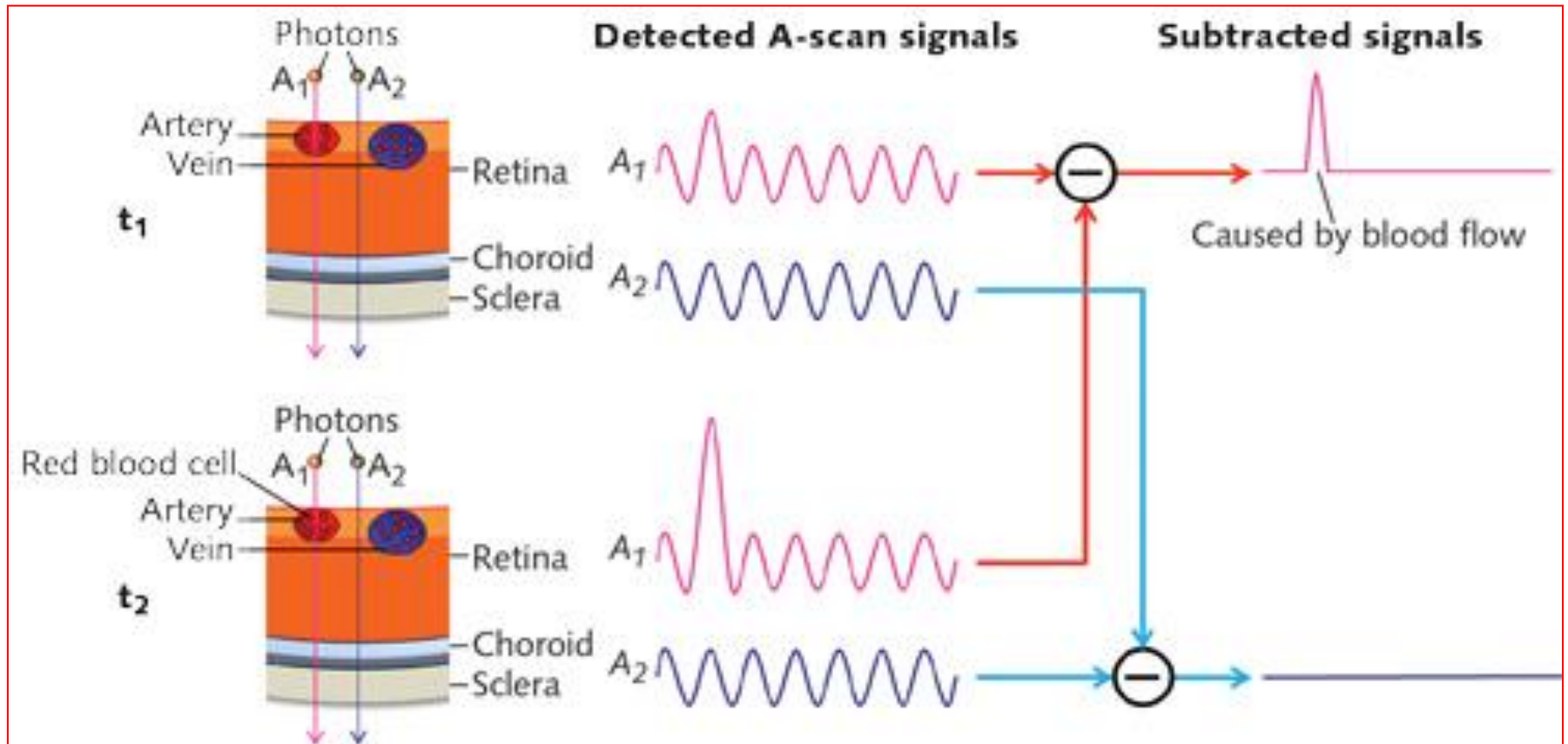
# Decorrelazione dyeless del segnale tomografico



What is a wave? «energy propagated through matter» A. Einstein

- Angiografia dyeless basata **sull'ampiezza** del segnale OCT
- Angiografia dyeless basata **sulla fase** del segnale OCT
- Angiografia dyeless basata **sull'ampiezza e sulla fase** del segnale OCT (complex signal)

# How OCTA Works



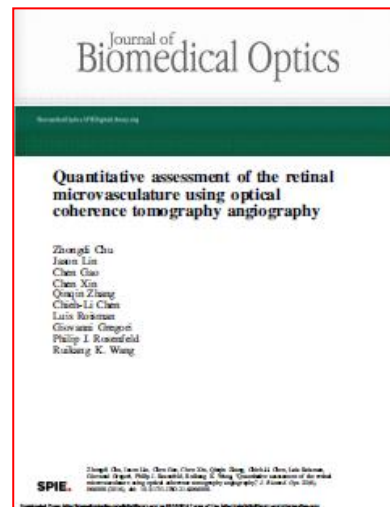
As moving blood cells pass through vessels, they generate changes in OCT signals. Based on this concept, a blood flow signal can be extracted by subtracting the OCT signals from the same location but at different time points (red path). The OCT signals will be different at these locations, while OCT signals from surrounding retinal tissues will remain steady (blue path) by CHIEH-LI CHEN 11/13/2015 Bio Optics World

# Overview of the quantitative OMAG algorithm

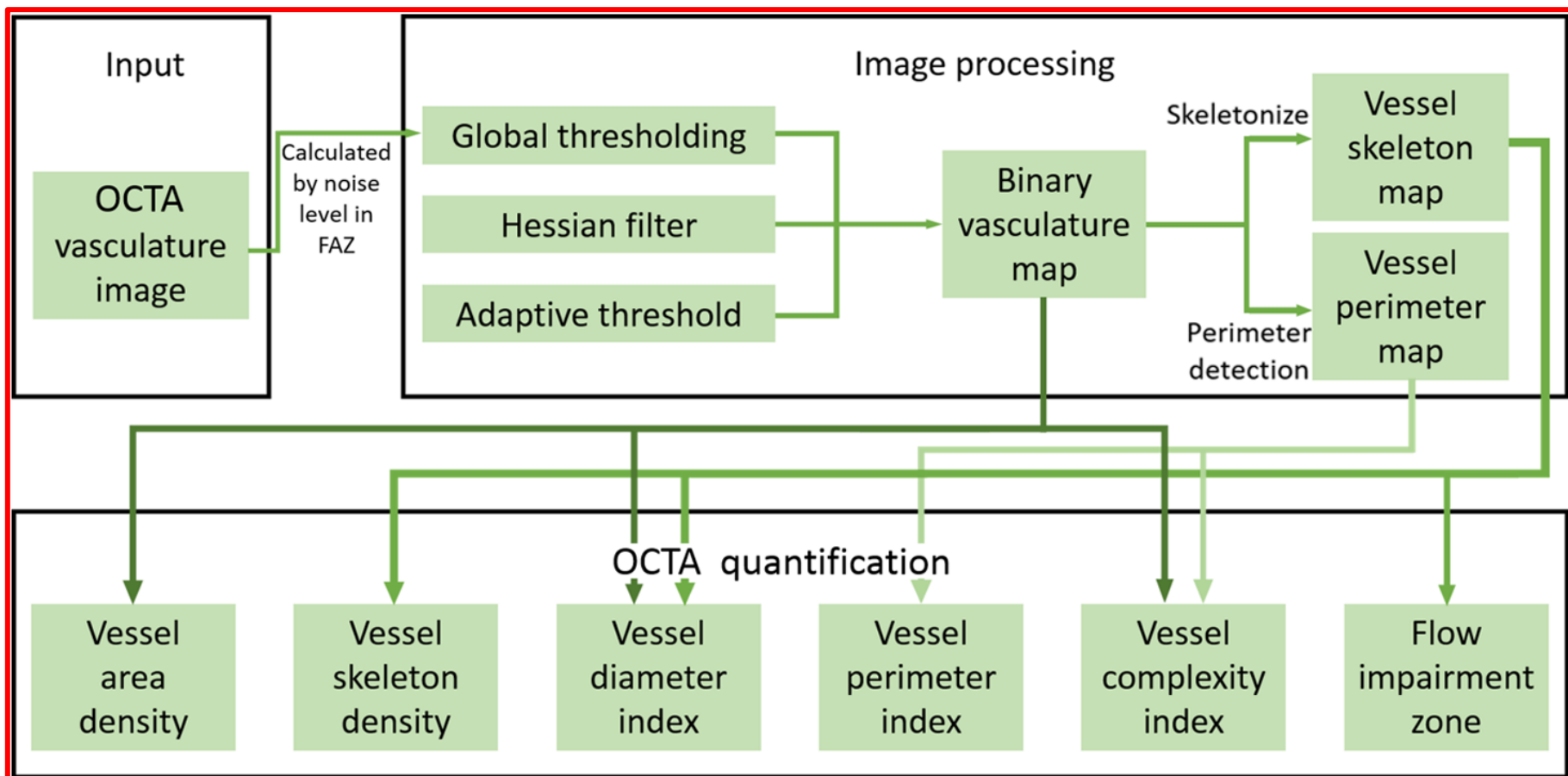
Flowchart

MATLAB è un ambiente per il calcolo numerico e l'analisi statistica

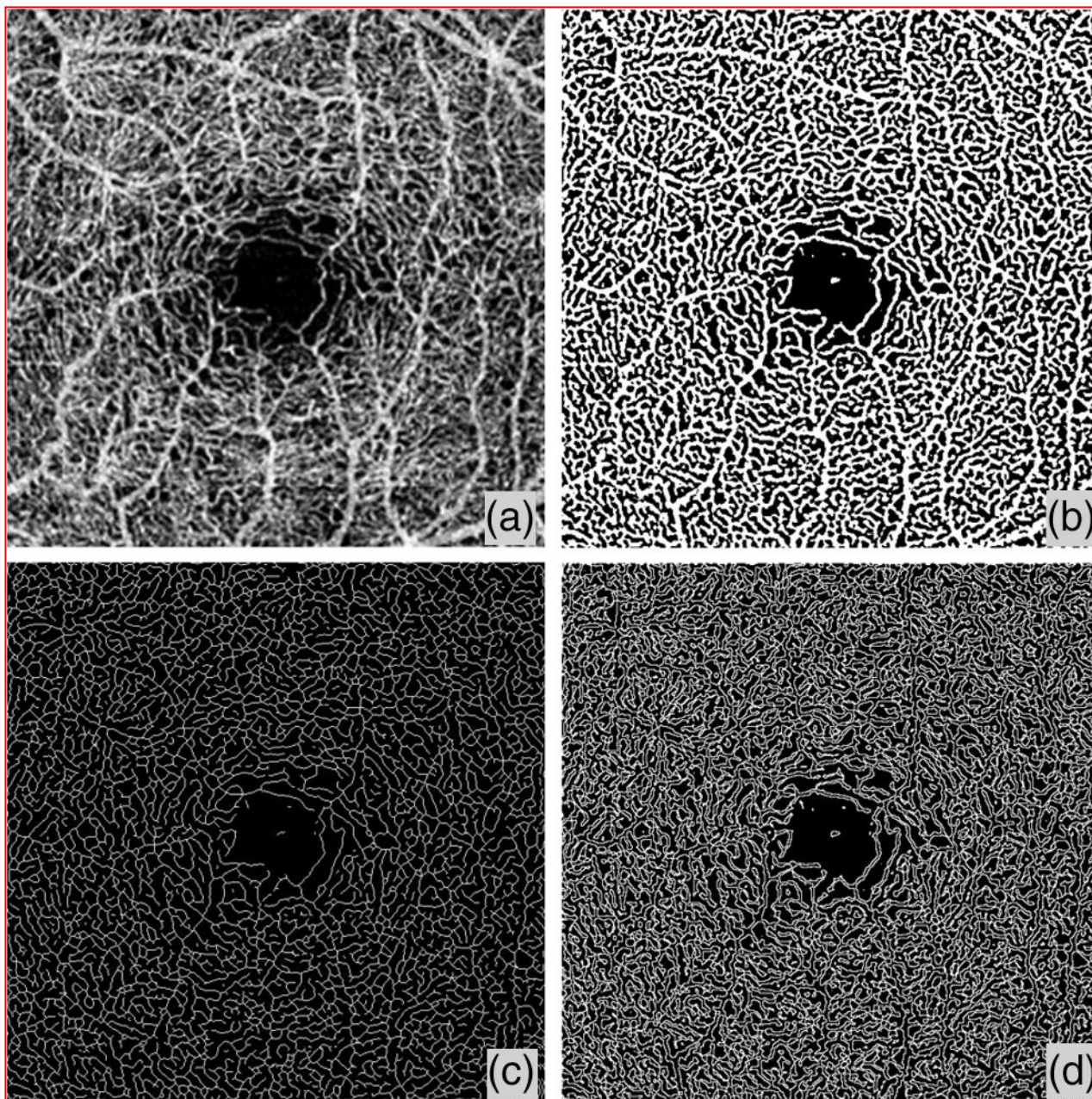
vessel area density  
vessel skeleton density  
vessel diameter index  
vessel perimeter index  
vessel complexity index



by Zhongdi Chu et al. Journal of Biomedical Optics 21(6), 066008 (June 2016)







Representative OMAG images to illustrate the quantitative analysis algorithm.

**(a) Original en face OMAG image.**

**(b) Vessel area map**, a binarized vasculature image using hessian filter and adaptive threshold. This image is used for VAD, VDI, and VCI quantification.

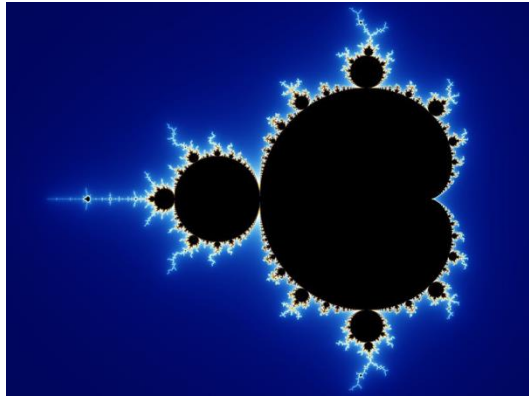
**(c) Vessel skeleton map**, which is obtained by iteratively deleting the pixels in the outer boundary of the vessel area map until one pixel remained along the width direction of the vessels. This image is used for VSD and VDI quantification.

**(d) Vessel perimeter map**, which is obtain by detecting the edge of vessels in the vessel area map and deleting pixels that are not on the edge of vessels. This image is used for VPI and VCI quantification

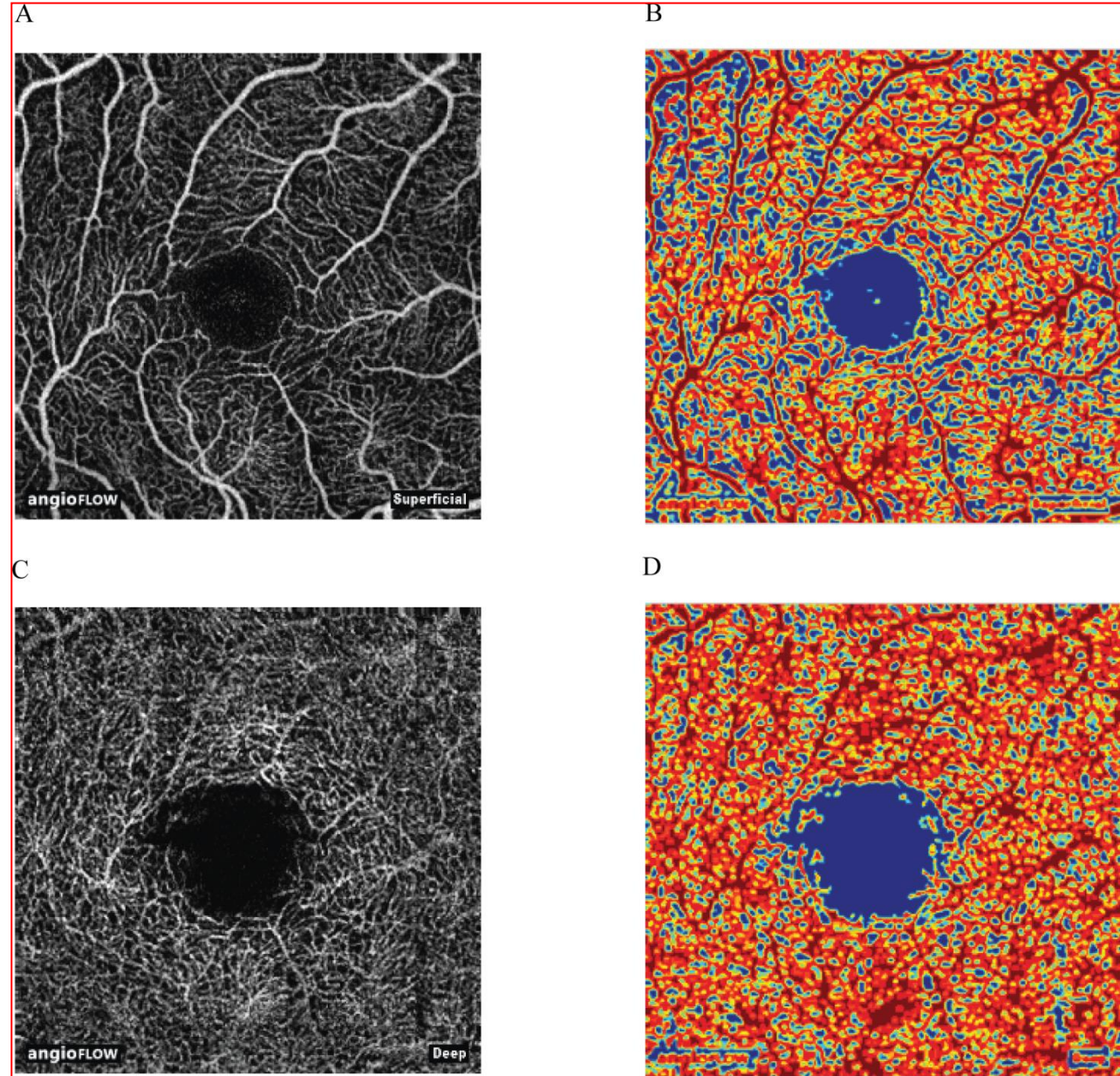
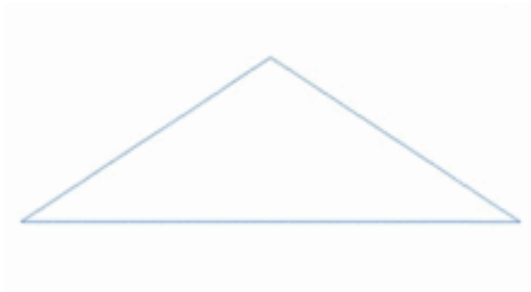
vessel area density (**VAD**), vessel skeleton density (**VSD**), vessel perimeter index (**VPI**), vessel complexity index (**VCI**), vessel diameter index (**VDI**). by Zhongdi Chu et al. Journal of Biomedical Optics (June 2016)

# Quantification of Vessel Density in Retinal Optical Coherence Tomography Angiography Images Using Local Fractal

by Santosh G. K. Gadde, [Dimension data/Journals/IOVS/934840/](https://doi.org/10.1167/16.10.3484) on 10/04/2016



Frattale di Mandelbrot



# Flow Index and Vessel Density

The flow index is defined as the average decorrelation values in the segmented area

$$\frac{\int_A D \cdot V dA}{\int_A dA} \quad (V=1, \text{ if vessel; } V=0,$$

The vessel density is defined as the percentage area occupied by vessels the segmented area

$$\frac{\int_A V dA}{\int_A dA} \quad (V=1, \text{ if vessel; } V=0,$$

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**Inventori David Huang, Yali Jia, Jason Tokayer, Ou Tan**

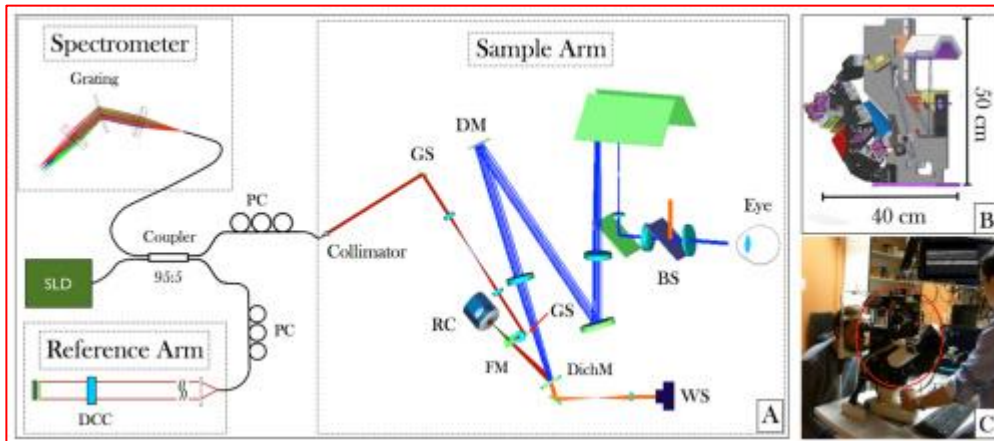
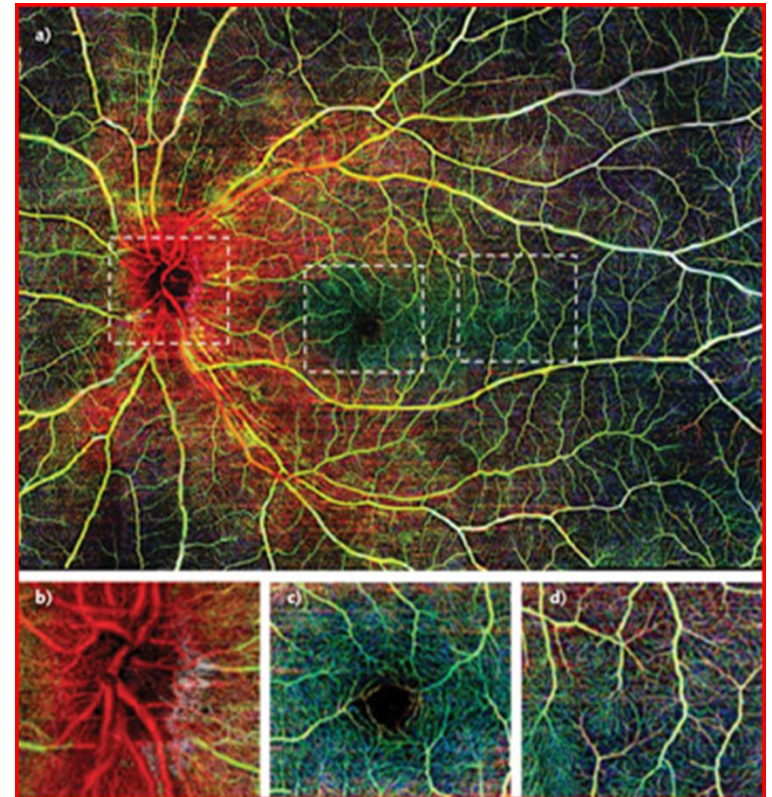
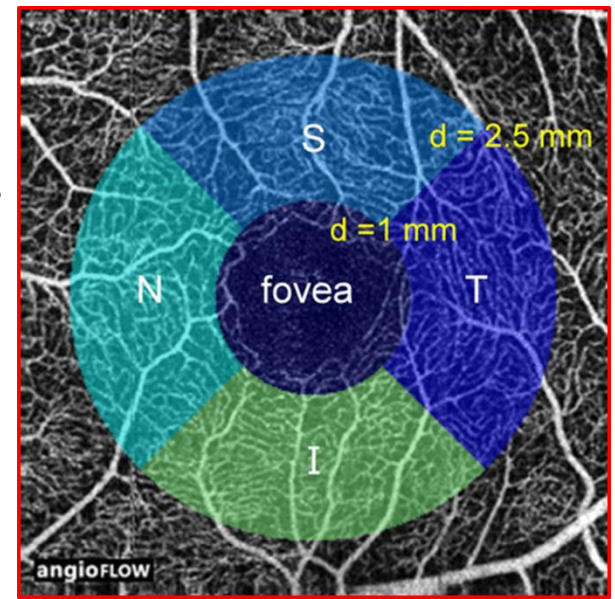
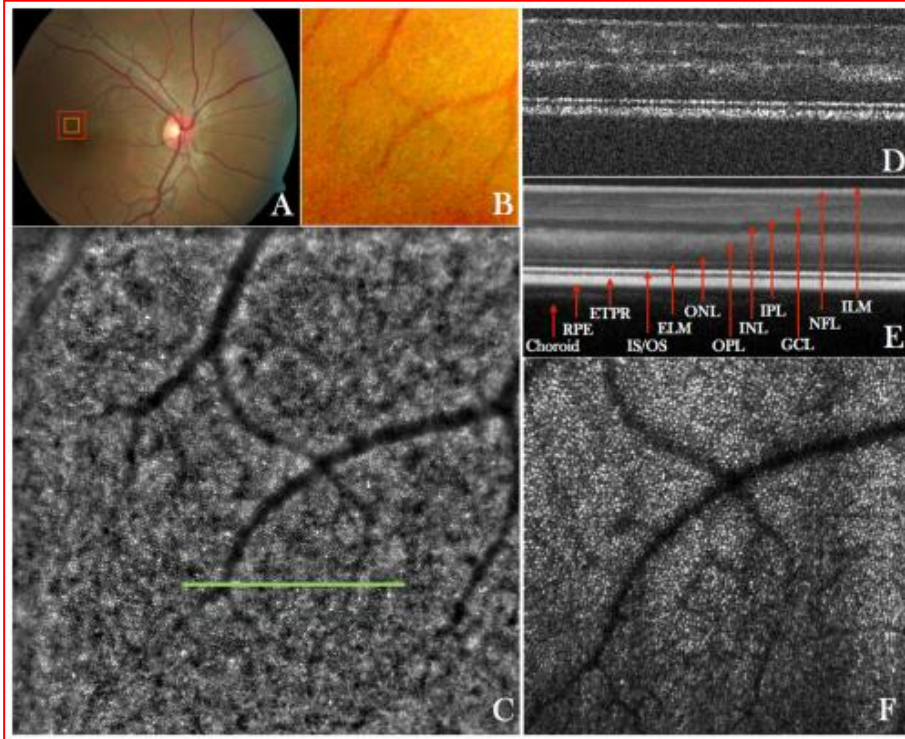
Candidato Oregon Health & Science University

Esporta citazione BiBTeX, EndNote, RefMan

Citazioni di brevetti (5), Con riferimenti in (1), Classificazioni (15), Eventi legali (4)

# Multi-modal adaptive optics system including fundus photography and optical coherence tomography for the clinical setting

by Matthias Salas, Wolfgang Drexler et al. BIOMEDICAL OPTICS EXPRESS Apr 2016





*Thank you for your kind attention!*

