Nuovi Scenari in Oftalmologia tra Innovazione e Sostenibilità

Alghero 19-20 Maggio 2017

Retina Medica: Patologia vascolare e degenerativa
Moderatori: A.Cau, P.Pintore, F.Zanetti, L.Valenti

Angio-OCT: Tecnologia ed applicazioni cliniche

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Disclosure

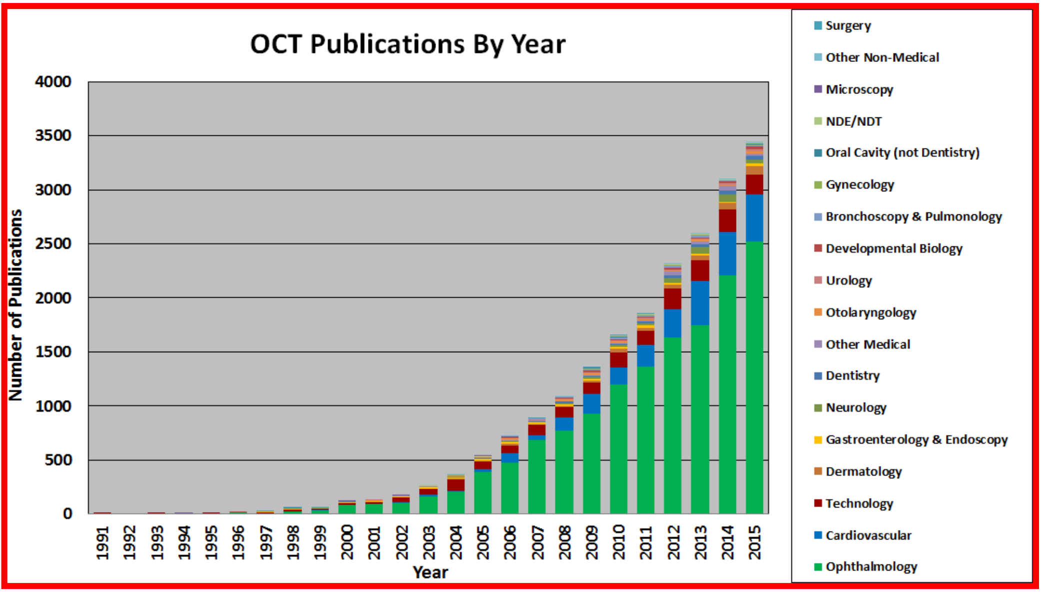
Consulting Free

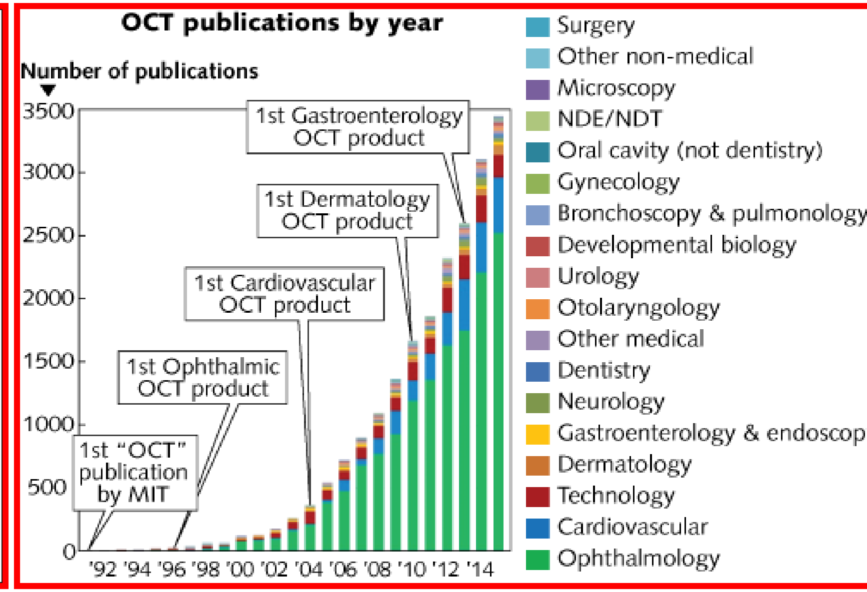
- Carl Zeiss Meditec
- Alfa Intes

Foreword: 25 Years of Optical Coherence Tomography

by:James Fujimoto and David Huang

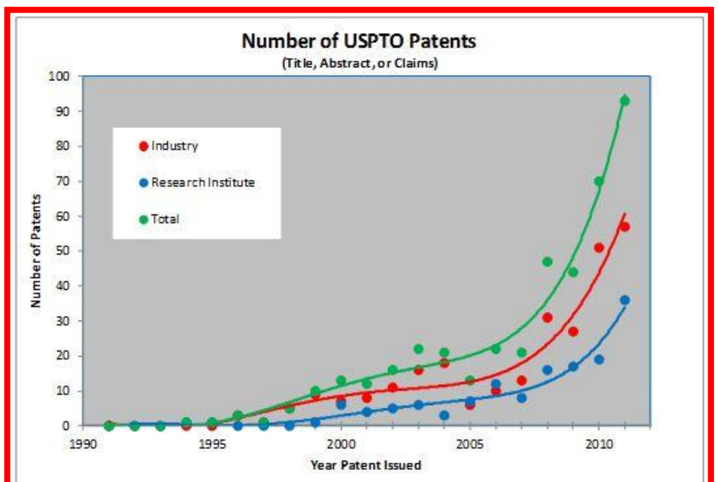
The market is just over $1B in 2012, and it is expected to grow by 18–30% per year for the foreseeable future





Pubblicazioni sugli OCT in PubMed per anno e per area di ricerca by Eric A. Swanson and http://www.sweptlaser.com

Pubblicazioni sugli OCT dal 1991 al 2015 nelle varie discipline mediche by Eric A. Swanson and http://www.sweptlaser.com)



Brevetti OCT rilasciati per anno in US by Eric A. Swanson and http://www.sweptlaser.com

Table 1: The comparison of the specifications of main OCTA systems

by Barak Turgut 2016

AngioPlex*	AngioVue[α]	Spectralis OCTA[β]	SS OCT Angio[γ]	AngioScan[δ]	Angio eXpert[ε]
• Commercially avaliable • OMAG algoritm • Used a light source of 840 nm and a bandwidth of 90 nm • OCTA mean scan time: 3.8 seconds • Real-time FastTrackeye tracking system • Allowing visualisation of both the retinal flow and structure 3×3 mm and 6×6 mm OCT angiograms (in 2016 planning 8×8 mm and 12×12 mm) • Segmentation algorithms including the maps of the superficial retina, the deep retina, avascular retina choriocapillaris and choroid • 68,000 A-scans/sec • OCTA requires 1 scan • Motion correction software to remove artifacts • En-face microvascular flow images en-face map of the retinal and choroidal blood flow	• Commercially avaliable • SSADA algoritm • Used a light source of 840 nm and a bandwidth of 45 nm • OCTA mean scan time: 3 seconds • Allowing visualisation of both the retinal flow and structure • 3x3 mm 4.5x4.5 mm, 6x6 mm and 8x8 mm OCT angiograms • Segmentation algoritms including plexus of the superficial retinal capillary plexus, the deep retinal capillary plexus, the choriocapillaris • 70,000 A-scans/sec • OCTA requires 2 separate scans • No eye tracking system • Motion Correction Technology software to remove artifacts • Angio quantification with AngioAnalytics quantification • En-face map of the retinal and choroidal blood flow	• Not available in all countries • Amplitude decorrelation algorithm • Used a light source of 870 nm with bandwidth of 50 nm • An automated, realtime mode and an Active Eye Tracking System • Expect a long acquisition time (1-2 minutes per eye) • 85,000 A-scans/sec with upgrading to new OCT2 module • Expect a good image quality • Basic software interface, not yet refined • No detailed information on segmentation capability • No detailed data on device specifications and software	• Not available in all countries • Swept Source OCT • OCTARA algorytm • Used a light source of 1,050 nm • 100,000 A scan/sec • Scan size (mm) 3.0x3.0 mm, 4.5x4.5 mm, 6.0x6.0 mm • SMARTTrack tracking software • Multi-modal SS-OCT/fundus camera with OCT Angiography • Expect a wide field, deep penetration • Segmentation algorithms including superficial, deep, outer retina and choriocapillaris • No active motion correction software	• Not available in all countries • Modified OMAG algorithm (motion detection and decorrelation analysis) • Used a light source of 880 nm • 3x3 mm, 6x6 mm, 9x9 mm scans plus 12x9 mm montage (12 3x3 mm scans) widest field of view • 53,000 A-scans/sec • Long scan time (40 sec+) • Real-time SLO based tracking system • Multiple scan patterns • Montage ability for panoramic image • Segmentation algorithms including superficial, deep, outer retina and choriocapillaris • The visualisation of the retinal and choroidal blood flow	• Not available in all countries • No data in web about the used OCTA algorithm • Used a light source of 855 nm ± 5 nm • Segmentation algorithms including superficial, deep, outer retina and choriocapillaris • 3x3 to 8x8 mm OCT angiograms • OCTA mean scan time: appr. 3.0 seconds • Maximum 70,000 A-scans/sec • The superficial and deeper blood vessels a designated layer • SLO tracking follow-up • Auto fundus tracking by SLO • No information on the visualisation of the retinal and choroidal blood flow • No detailed data on device specifications and softwares

*Data on all OCTA devices and systems have been provided from the catalogues, manuals and web pages. * Zeiss, [α]Ocuvue, [β]Heidelberg, [γ]Topcon, [δ]Nidek, [ε]Canon. OCT = optical coherence tomography; OCTA = optical coherence tomography angiography; OCTARA = OCT angiography Ratio Analysis; OMAG = optical microangiography; SLO = scanning laser ophthalmoscope; SS = swept-source; SSADA = split-spectrum amplitude decorrelation angiography.*

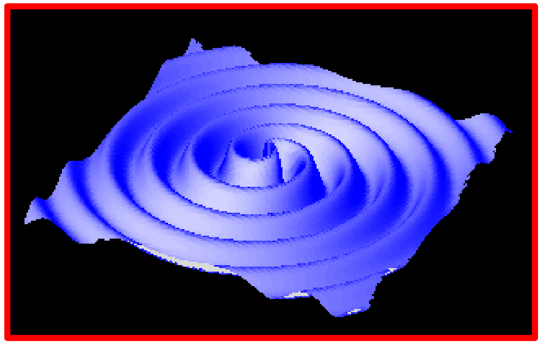
- **Optovue** → RTvue Avanti AngioVue
- **Zeiss** → AngioPlex Cirrus 5000
- **Topcon** → DRI OCT Triton
- **Heidelberg** → Spectralis con modulo OCT2
- **Nidek** → RS-3000 Advance OCT Angio-Scan
- **Canon** → OCT-HS100 Angio-eXpert con modulo AX (Gruppo Haag-Streit)

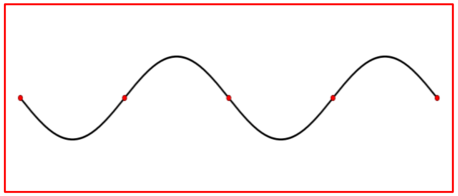
- **RTvue Avanti Optovue** **70.000** A-Scan/Sec → **SSADA**
(Split Spectrum Amplitude Decorrelation Angiography)
- **HD-Cirrus Zeiss** **68.000** A-Scan/Sec → **OMAGc**
(Optical Microangiography complex)
- **SS OCT DRI OCT Topcon** **100.000** A-Scan/Sec → **OCTARA**
(OCT Angiography Ratio Analysis)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

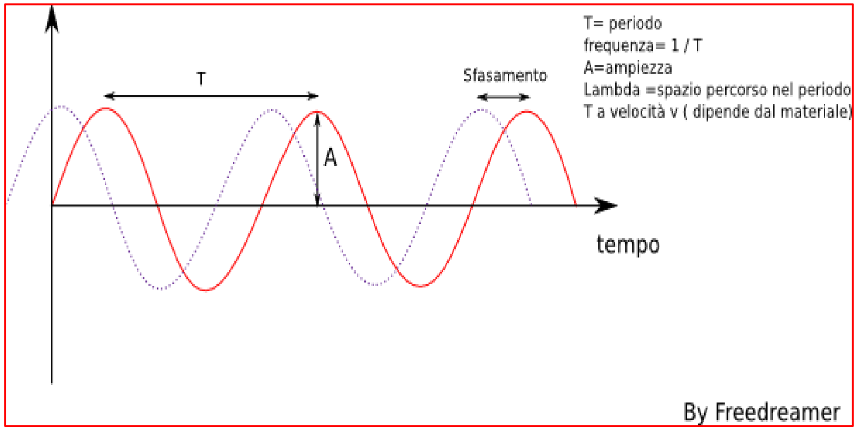
In teoria dei segnali la **correlazione** (correlazione mutua, cross-correlazione o correlazione incrociata) rappresenta la misura di similitudine di due segnali

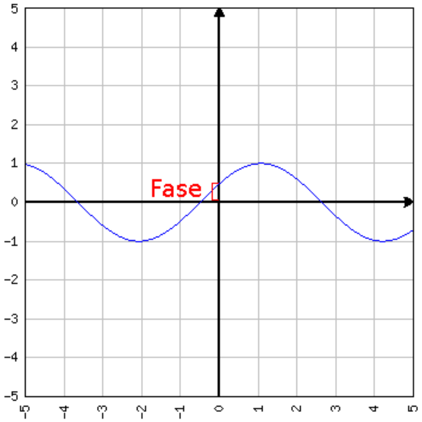
Decorrelazione (decorrelation): è un processo matematico utilizzato nell'elaborazione dei segnali per modificare l'autocorrelazione (comparazione del segnale con se stesso) o le correlazioni incrociate (comparazione delle immagini nel tempo); si annulla il segnale statico e si individua la differenza del segnale: il **Flusso**

Decorrelazione dyeless del segnale tomografico









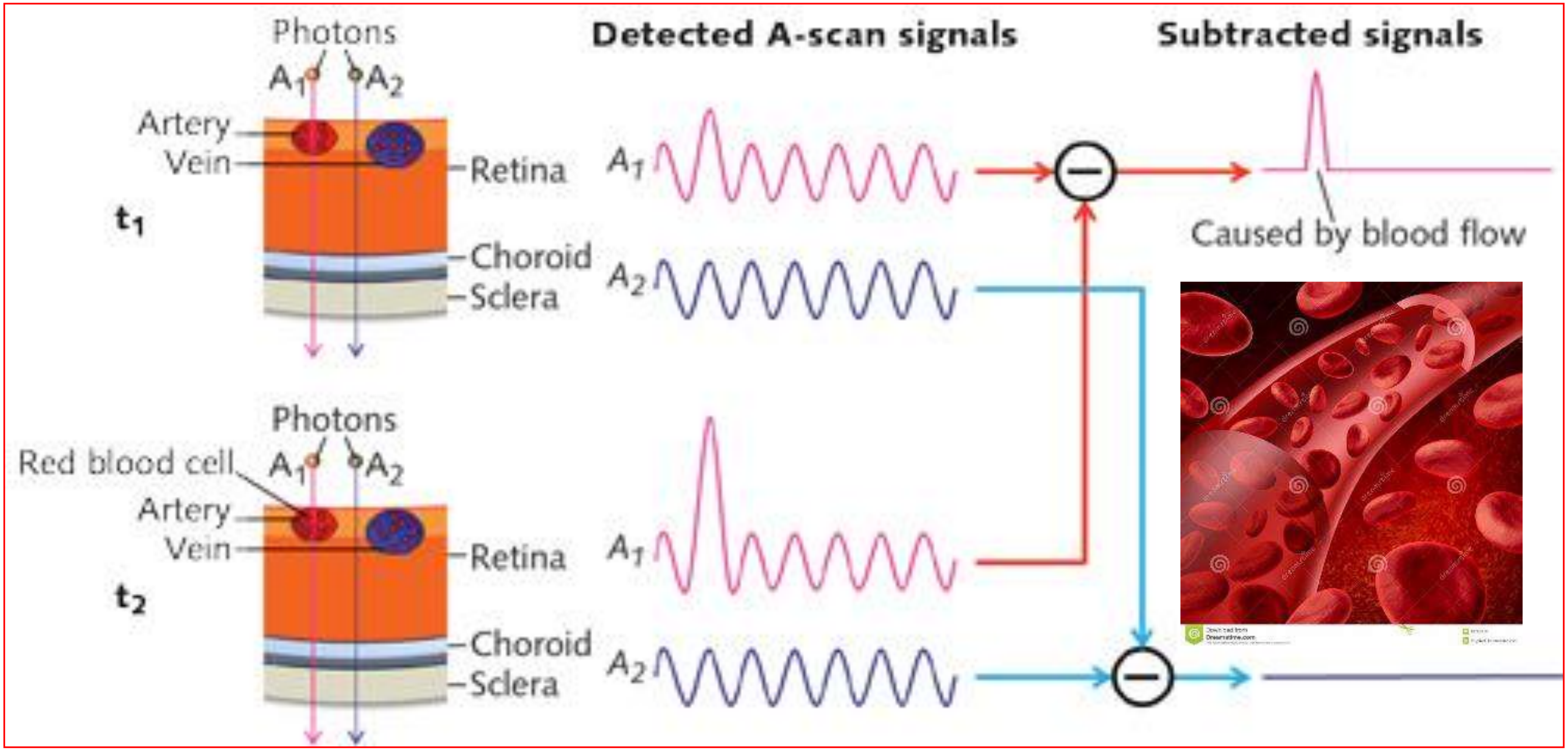
What is a wave? «energy propagated through matter» A. Einstein

a)Angiografia dyeless basata ***sull'ampiezza*** del segnale OCT

b) Angiografia dyeless basata ***sulla fase*** del segnale OCT

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

How OCTA Works



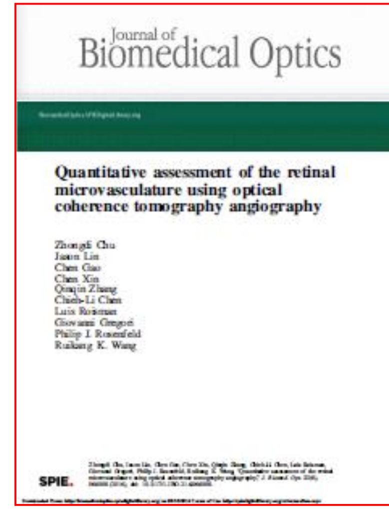
As moving blood cells pass through vessels, they generate changes in OCT signals. Based on this concept, a blood flow signal can be extracted by subtracting the OCT signals from the same location but at different time points **(red path)**. The OCT signals will be different at these locations, while 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

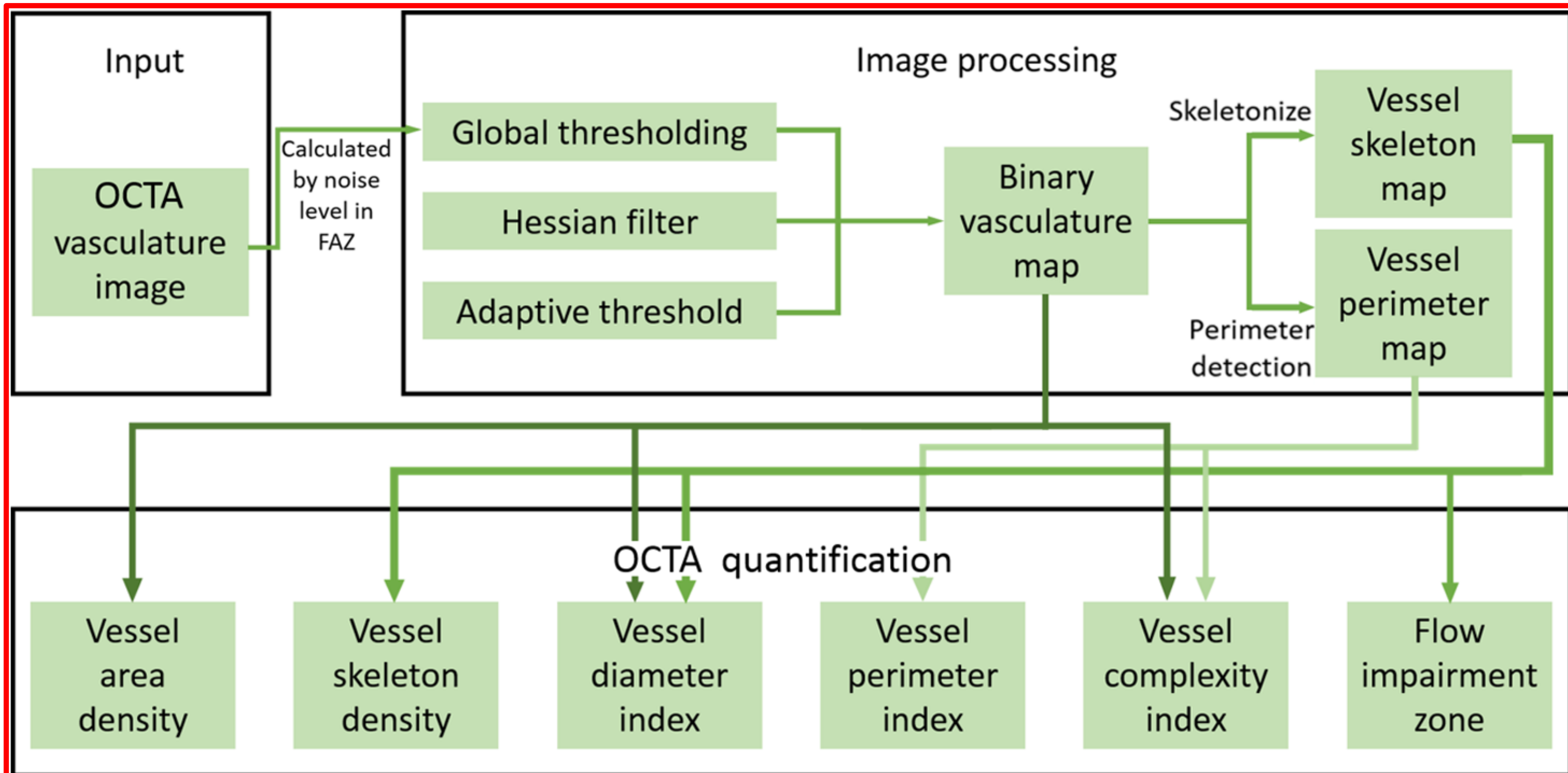
vessel area density
vessel skeleton density
vessel diameter index
vessel perimeter index
vessel complexity index
flow impairment zone

Flowchart

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



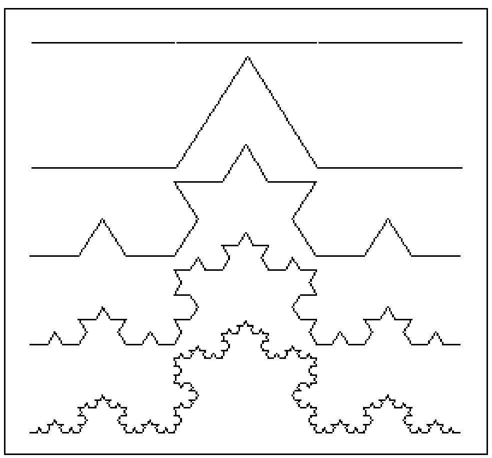
by Zhongdi Chu et al. Journal of Biomedical Optics 21(6), 066008 (June 2016)



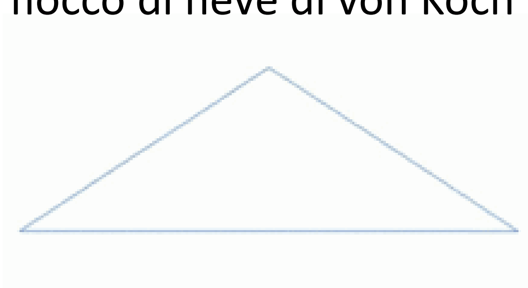
Quantification of Vessel Density in Retinal Optical Coherence Tomography Angiography Images Using Local Fractal

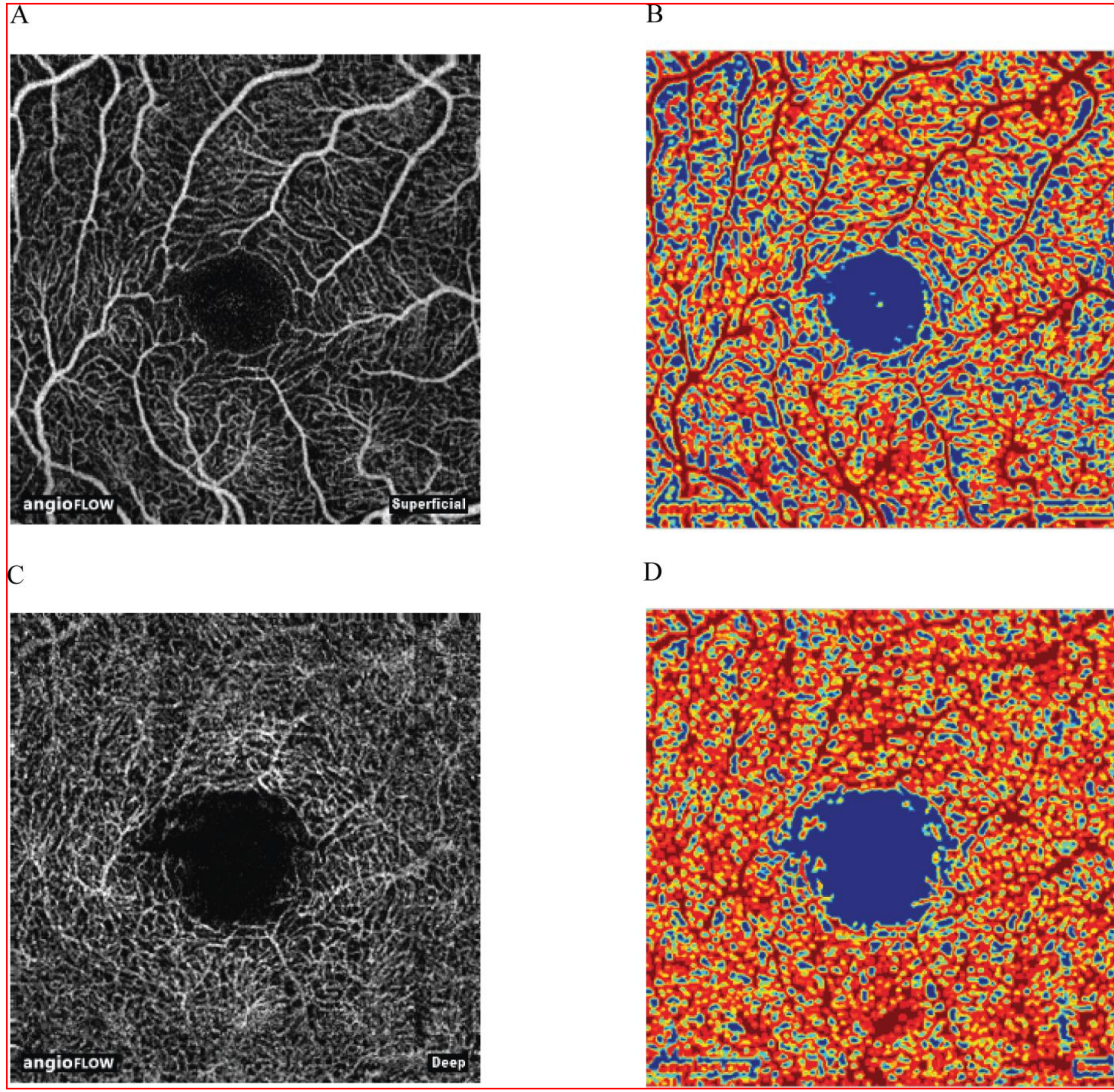
by Santosh G. K. Gadde, Dimension data/Journals/IOVS/934840/ on 10/04/2016

Un frattale è un oggetto geometrico dotato di omotetia interna: si ripete nella sua forma allo stesso modo su scale diverse, ingrandendo una qualunque sua parte si ottiene una figura simile all'originale. Questa caratteristica è spesso chiamata auto similarità oppure autosomiglianza. Il termine frattale venne coniato nel 1975 da Benoît Mandelbrot



fiocco di neve di von Koch





Perfusion Density/Flow Index and Vessel Density

$$Perfusion\ Density = \frac{Area\ Perfusa\ [mm^2]}{Area\ Totale\ [mm^2]}$$

$$Vessel\ Density\ [mm^{-1}] = \frac{Lunghezza\ Vasi\ [mm]}{Area\ Totale\ [mm^2]}$$

The VD was defined as the **percentage** of signal-positive pixels/area of interest.

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

The Vessel Density is defined as the **percentage** area occupied by vessels the segmented area

$$\frac{\int_A D \cdot V dA}{\int_A dA}$$

If not

(V=1, if vessel; V=0,

$$\frac{\int_A V dA}{\int_A dA}$$

If not

(V=1, if vessel; V=0,

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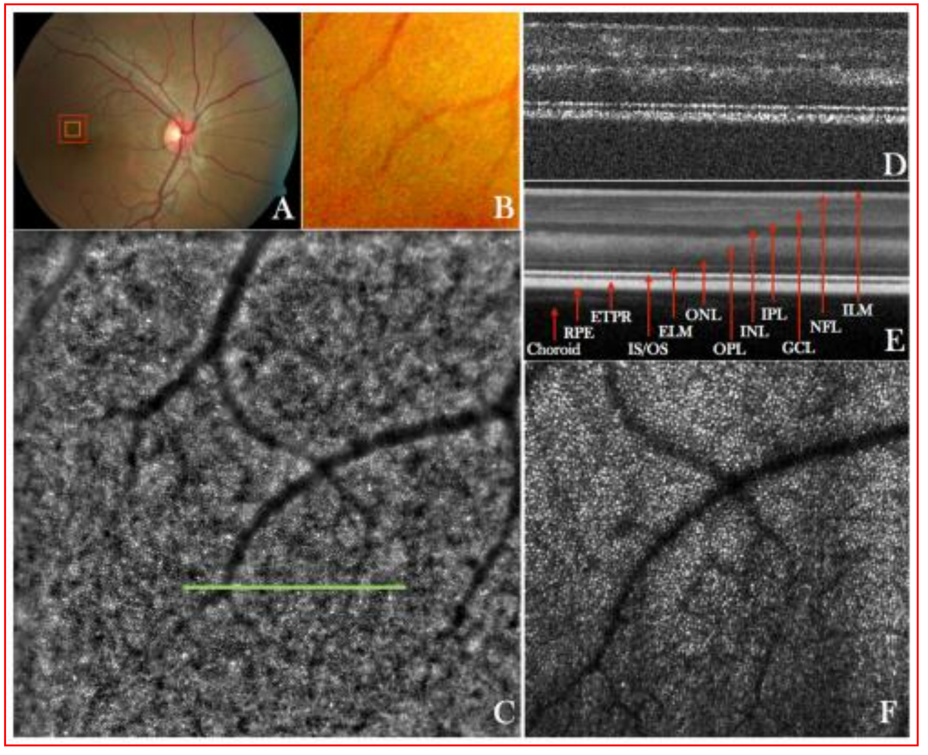
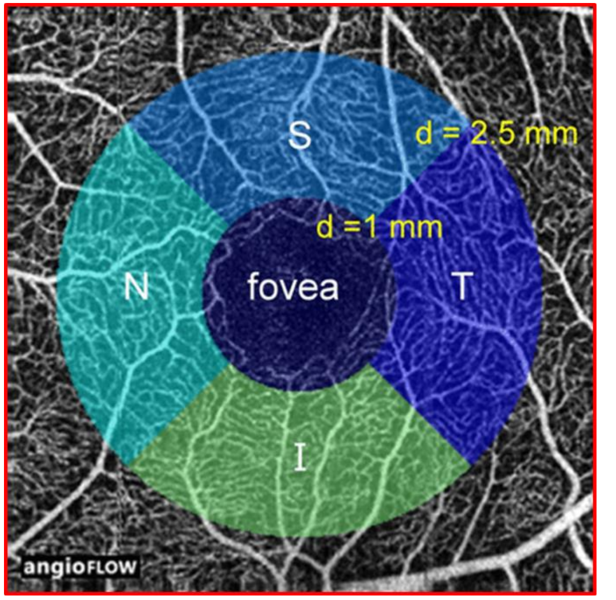
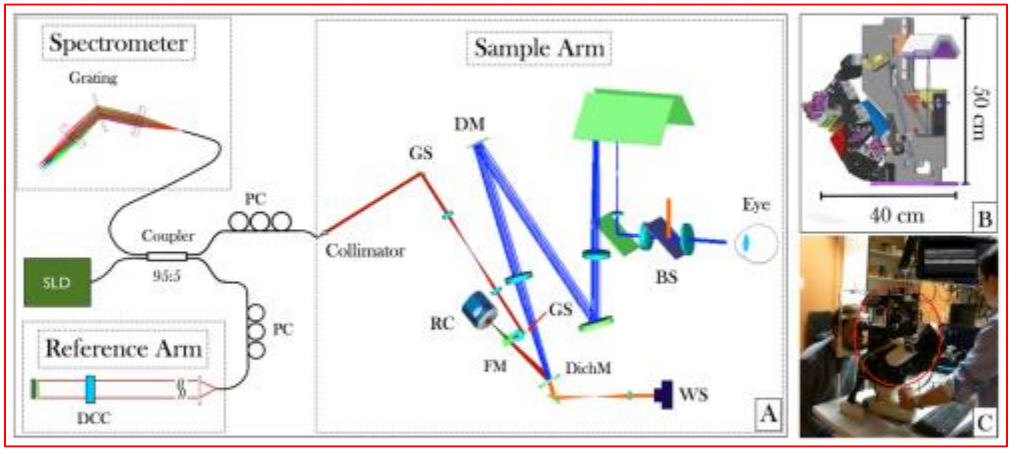
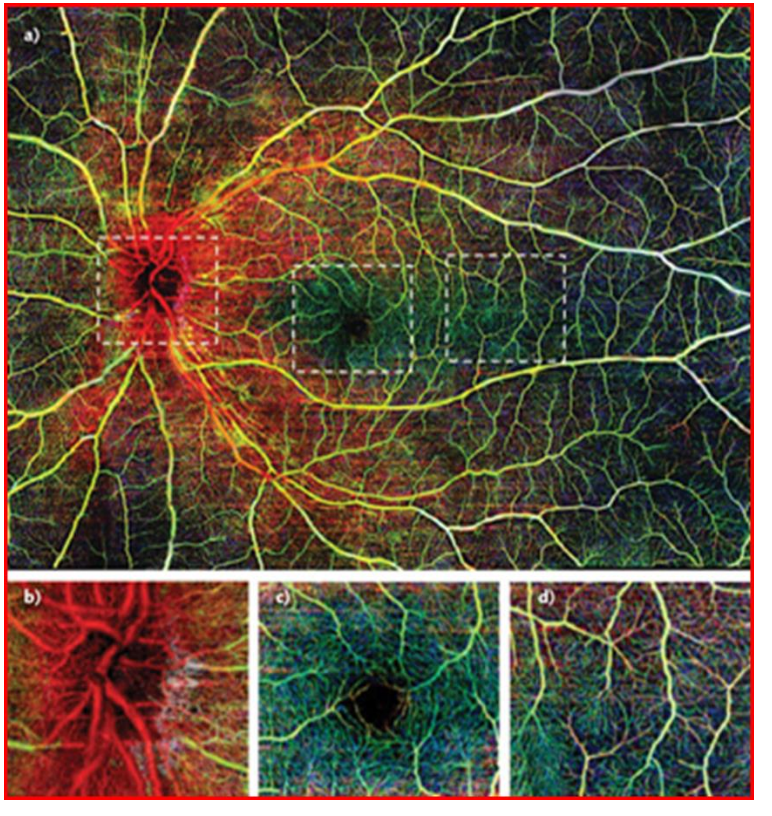
Multi-modal adaptive optics system including **fundus photography** and **OCT** optical coherence tomography 200 KHz A-scan for the clinical setting

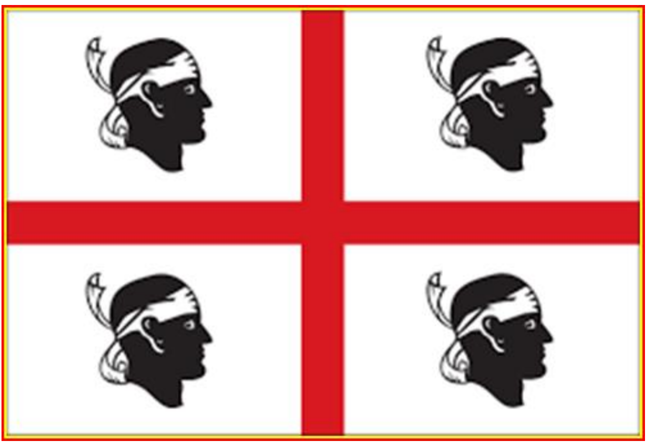
by Matthias Salas, Wolfgang Drexler et al. BIOMEDICAL OPTICS EXPRESS Apr 2016











Thank you for your kind attention!

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