2022 Young researchers biophotonics summer meeting

June 16th. 16.00-18.30

16:00–16:10 **WELCOME Visual Sciences Committee @SEDOPTICA**
M Viñas-Peña | Harvard Medical School

16:10–17:00 **KEYNOTE SPEAKER**
A universal framework for adaptive optics microscopy
Martin Booth | University of Oxford
Moderator. Fran Ávila | University of Zaragoza

17:00–17:45 **BIOPHOTONICS ENGINEERING**
Optical imaging techniques for scleral biomechanics
Lupe Villegas | Spanish National Research Council
Optical fiber sensors for the development of dynamo-smart shoe insoles
Sahar Safarloo | Carlos III University
In vivo multiphoton imaging of the human cornea and sclera
Rosa M. Martinez Ojeda | University of Murcia
Discussion
Moderator. Fran Ávila | University of Zaragoza

17:45-18:30 **CLINICAL APPLICATIONS**
European Young Eye (EYE)
Clara Lim | University Complutense Madrid
Chromatic assessment of intraocular lenses using an optical bench
Vicente Ferrando Martín | Polytechnic University of Valencia
Short-Term Follow-Up of Corneal Biomechanics in Silicon-Hydrogel Contact Lens Wearers
María Concepción Marcellán | University of Zaragoza
Discussion
Moderator. Mikel Aldaba | Polytechnic University of Catalunya

18:30-18:35 **CLOSING REMARKS**

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Welcome Visual Sciences Committee @SEDOPTICA

M Viñas-Peña | Harvard Medical School

The Visual Sciences Committee of the Spanish Optical Society (SEDOPTICA) aims to promote the Visual Sciences activities in Spain, stimulate the interactions between the different research groups of the topic, spread the knowledge in the field of vision by outreach and teaching events, to stablish a strong network with societies, organizations and industry of the Visual Sciences area, and finally, to promote the knowledge transfer in vision aiming for the general public benefit.
Among the activities organized by the Committee in the past, the Webinars series have been very well received for our scientific community, therefore we plan to continue organizing them. The new webinar of the series is this 2022 Young researchers biophotonics summer meeting, which we hope will be as well received as the previous ones.

The Board of the committee is currently formed by:

Chair	María Viñas	Harvard Medical School
Vice-Chair	Francisco Ávila	University of Zaragoza
Secretary	Mikel Aldaba	Polytechnic University of Catalunya

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KEYNOTE SPEAKER

Moderator. Fran Ávila | University of Zaragoza

A universal framework for adaptive optics microscopy

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Adaptive optics is widely used in high resolution microscopy to overcome the problems caused by specimen induced aberrations. This is particularly useful when focussing deep into biological specimens, due the the variations in refractive index throughout the volume of cells and tissues. Wavefront sensorless adaptive optics (AO) methods (or “sensorless” AO methods, for short) are common as their simple implementation does not include the extra hardware required for a wavefront sensor path. Furthermore, these methods are necessary in microscopes where wavefront sensing is not practical. These sensorless methods perform aberration correction through efficient optimisation of image quality. The wide range of such approaches that have been developed are tailored for different microscopes and applications. We have previously shown that all such methods can be fitted into the same framework, permitting side-by-side evaluation of effectiveness in different imaging scenarios. The parts of this framework include the aberration representation, the optimisation metric (or cost function), and the estimation algorithm. This approach to understanding sensorless AO shows that the seemingly differing methods have many common features. We use this framework to define new approaches that are applicable across a wide range of microscopes. In particular, we examine machine learning approaches to estimation that are independent of the wide range of specimen structures that might be encountered in general application of microscopes. We show how appropriate algorithms can be chosen to enhance the correction range of aberration magnitudes, processing efficiency or accuracy of the sensorless AO microscopes. Furthermore, we show how the methods can be translated across different microscopes. These tools will have broad application across a range of microscope modalities.

BIOPHOTONICS ENGINEERING

Moderator. Fran Ávila | University of Zaragoza

Optical imaging techniques for scleral biomechanics

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The sclera is an ocular tissue which constitutes the outer shell of the eye. It is a fibrous tissue composed of bundles of collagen fibres crossing each other in all directions making it opaque. Scleral behavior is studied for predicting response of eyes globes, as well as, change in biomechanical response of sclera are associated with ocular disorders such as myopia.

Ocular mechanical properties have been quantified by different macroscopic techniques which in general involves excitation sources and optical coherence tomography (OCT), and by microscopic techniques.

We have mapping the sclera using swept source optical coherence tomography air-puff deformation imaging, wave-based Optical Coherence Elastography and Second-harmonic imaging microscopy. We can obtain ocular deformation behavior of ex vivo animal models and determine changes in collagen organization along the depth using the Order coefficient.

Optical fiber sensors for the development of dynamo-smart shoe insoles

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Gait is a crucial part of human life because it has a significant impact on a variety of everyday activities. Plantar foot pressure can be used to diagnose a variety of illnesses, as well as to recommend therapy improvements, rehabilitation tasks, patient monitoring, orthopedic device development, and other purposes. As a result, accurate plantar pressure monitoring during gait is crucial. Footwear-embedded sensors are one of the best technologies among others for this purpose since they have no boundary limitations that limit participant motions and can be used to obtain natural gait patterns while walking or running. Recent advancements in the quality of plastic optical fibers (POF) have made them possible to manufacture a low-cost bending sensor with a novel design for use in plantar pressure monitoring. An intensity-based POF bend sensor is not only lightweight, non-invasive, and easy to construct, but it also produces a signal that requires almost no processing.

In this work, we have designed, fabricated, and characterized a novel intensity variation POF sensor to detect the force applied by the human foot and measure the gait pattern. The sensors were put through a series of Dynamic and static tests to characterize their measurement range, sensitivity, and linearity, and their results were compared to that of commercial force sensors, including piezo resistive sensors and a clinical force platform. After characterization, a participant was asked to walk with the instrumented insole, and the typical M-shaped pattern of walking was produced by the sensors. The results suggest that the POF bend sensor has a great potential to be used in a wide range of applications, given its low cost and non-invasive nature. Feedback walking monitoring for ulcer prevention or sports performance could be just one of those applications.

In vivo multiphoton imaging of the human cornea and sclera

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Multiphoton (MP) microscopy has become a powerful tool for ex vivo assessment of the cornea and the sclera in both healthy and pathologic conditions [1,2]. However, MP microscopy of living tissues has been a challenge for the past decades, with a few attempts performed in animal models [3,4]. The presence of aberrations and scattering reduce the capacity when imaging biological tissues. It gets worse for in vivo imaging due to the exposure time (ExT) constrains to stay below the maximum permissible exposure (MPE) and to avoid involuntary movements [5]. In this sense, the aim of this work is to assess and evaluate the combination of registration parameters of a compact MP microscope for optimal imaging of the cornea and sclera in both conditions, ex vivo and in vivo [6].
A femtosecond infrared Ti:Sapphire laser was used as illumination source for a research compact MP microscope with dimensions ~30x30x45 cm^2. This was divided into two levels: a superior level holding all the optical elements, and a lower level incorporating the electronic components. The whole system was controlled by a custom software developed in C++ that allows to freely modify each acquisition parameter, including the detector sampling frequency (MHz), pixel integration (samples/px), image resolution (µm/px) and scanned area (μm^2). An exhaustive study of the quality of the acquired images allows evaluating the parameters to acquire an optimal image.
Results show an important relationship on the distortion of the image (i.e., non-useful area to extract tissue information) and the experimental acquisition parameters which turn to have a strong dependence on the ExT. However, we are able to record optimum MP images of the human cornea and sclera to extract structural information parameters with an 88% of useful image and an ExT of 0.90 s which is below the human eye safety limits to protect cornea, lens and retina. Although this ExT might go down to 0.42 s to increase the image stability, the presence of noise will require additional image processing.

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[6] F. J. Ávila, A. Gambín, P. Artal, and J. M. Bueno, “In vivo two-photon microscopy of the human eye,” *Sci. Rep.* 9, 1-10 (2019).

CLINICAL APPLICATIONS

Moderator. Mikel Aldaba | Polytechnic University of Catalunya

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European Young Eye (EYE)

Clara Lim, Alicia Lopez-Raso, Elsa Albero-Ros, Darshan Ramasubramanian, Youssef Marrakchi
Universidad Complutense de Madrid, mark'ennovy and Alain Afflelou
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Presbyopia is an age-related eye condition that affects the near visual distance performance, as the lens of the eye becomes increasingly inflexible over time. Being it the most common physiological change occurring in the adult eye after age 40 the most popular non-invasive treatment option has become wearing corrective eyeglasses. EU-funded EYE project will strive to advance scientific knowledge in order to develop better therapeutic solutions. The purpose of this project is to improve the current knowledge about the condition of presbyopia, with the aim of developing more satisfactory therapeutic solution and new technology that will improve the patient's condition. Along with 5 junior researchers training in this field and boost the impact and international visibility of European research and EU funding.

In order to achieve the objective, the project comprises three Beneficiaries: Universidad Complutense de Madrid, the CL manufacturer, mark'ennovy, and optical centers group, Alain Afflelou. Therefor a team of optometrists, chemists, biochemists, physicists and computer engineers is conformed. Five research lines have been created, one per junior researcher. 1. New optical designs of presbyopic contact lenses. 2. New Contact Lens Materials 3. Development and validation of the presbyopic contact lens Patient Reported Outcomes instrument (PRO instrument) 4. Computer modelling of eye response and adaptation to new contact lenses. 5. Computer modelling of eye response and adaptation to new contact lenses. Each junior researcher will be focused on one, assuring the project is research progress.

In this talk, the progress on the project will be presented.

Chromatic assessment of intraocular lenses using an optical bench

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The chromatic behaviour is becoming more important in the design of intraocular lenses not only in terms of avoiding the chromatic aberration, but nowadays manufacturers use different mechanisms to design the behaviour of their lenses under polychromatic illumination. On the other hand, the characterization of intraocular lenses using polychromatic light is not always able to demonstrate the behaviour provided by the different design mechanisms. In order to perform a complete study of the chromatic properties of intraocular lenses we have developed an optical bench based on the ISO 11979-2 standard from which we obtain the images formed by the artificial eye with the intraocular lens. By using a set of objects, we can analyse the behaviour of the intraocular lens under a set of metrics. Among these metrics we can obtain the image forming of the USAF test, the Point Spread Function (PSF) given by a pin-hole, and the Through the Focus Modulation Transfer Function (TF-MTF) provided by a binary grating of a selected frequency. All these measurements can be performed under monochromatic illumination with different wavelengths or white light illumination, providing a complete chromatic behaviour test of an intraocular lens.

Short-Term Follow-Up of Corneal Biomechanics in Silicon-Hydrogel Contact Lens Wearers

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The aim of this work is to determinate the effects in the physical parameters in terms of intraocular pressure (IOP) and central corneal thickness (CCT) and corneal biomechanics in terms of corneal resistance factor (CRF) and corneal hysteresis (CH) of wearing silicone-hydrogel soft contact lenses (SiH-CLs) in young adult subjects during a short-term follow-up.
40 eyes of 20 healthy patients with a mean age of 22.87±4.14 were involved in this study. Subjects with corneal diseases, dry eye, irregular astigmatism or who have been previous contact lens wearers were excluded. The Ocular Response Analyzer (Reichert Ophthalmic Instruments) was used to measure CH, CRF and IOP and Scheimpflug imaging (Galilei Dual Scheimpflug camera analyzer, Pentacam) was used to measure CCT before and 10 days (Group 1) and 20 days (Group 2) after using the SiH-CLs.
IOP was decreased significantly 10 days after using the SiH-CLs (p=0.009). Within the 20 days' period, Group 2 revealed an even more pronounced decrease in IOP (p=.003) and CH increased significantly (p=.04). CCT and CRF did not show a significant change during the period of SiH-CLs use. Our finding allowed obtaining an analytical expression that relates IOP, CCT, CRF and CH within a biomechanical compensation experimental model.
Corneal biomechanical parameters and physical properties of the cornea may alter with SiH-CLs use. Our finding could have an impact on the management of glaucoma progression and ocular hypertension.