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Carlos III International School

New Research and Developments in Engineering for Biomedical Applications

21th to 24th May, 2024

Abstract:

This course will focus on the new challenges that today's society demands in biomedicine.

Two different approaches will be proposed.

The first approach will deal with new research in biomedical fields, always from the engineering point of view.

The second will try to stabilize the new developments in robotics and electronic devices that are being implemented for medical issues.

Dates	Speaker	Topic
21/05	Maria Victoria Gomez Gaviro	Advanced Optical Techniques in Biomedical Research
21/05	Alicia Pose	Augmented Reality for Clinical Application
22/05	Sara Guerrero Aspizua	Advances in skin tissue engineering: Technological and clinical challenges
22/05	Diego Velasco	3D skin bioprinting/ skin-on-a chip: enabling technologies, applications and future
23/05	Caterina Fuster-Barceló	Deep Learning in Biomedical Imaging: From Theory to Practice
23/05	Monica Garcia	Surgical navigation for clinical applications
24/05	Dorin Sabin Copaci	Exoskeletons and exosuits for rehabilitation or human movement assistance
24/05	Edwin Daniel Oña	Development of serious games for rehabilitation and assessment of the upper limb

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Date: 21/05	9:00-11:00
Department: Biomedical engineering **Speaker: Maria Victoria Gomez Gaviro**	

Title:
Advanced Optical Techniques in Biomedical Research

Abstract:
Three-dimensional optical imaging of large biological tissue in high resolution is a key technique in several research fields such as cancer treatment, neurology, developmental biology, pathology, plant development, among others. There are several techniques that can create high resolution 3D images for this kind of samples, like confocal microscopy, two-photon microscopy, light sheet microscopy, etc., most of them based on fluorescence microscopy. Independently of the optical method used, prior to the imaging process, it is always necessary a sample preparation step, consisting of making the tissue sample transparent so light can pass through it. This is called optical clearing of the sample and includes two steps, a de-lipidation step followed by a refractive index matching step. There are many commercial and academic clearing methods published already but all of them are still performed manually by the user. Many times, between the two clearing steps, it is necessary to perform an immunostaining process with the sample so the desired areas of interest can be tagged with specific fluorescence dyes.

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Date: 21/05	11:30-13:30
Department: Biomedical engineering **Speaker: Alicia Pose**	

Title:
Augmented Reality for Clinical Applications

Abstract:
In this presentation, we will delve into Augmented Reality (AR), covering its foundational principles, types, compatible devices, and registration. We'll utilize real-life examples of AR in everyday scenarios to enhance understanding. Next, we'll explore AR applications in clinical settings, focusing on UC3M's established workflow for hospital integration. Accompanying our discussion will be videos showcasing real cases from collaborations with Madrid's hospitals, including Hospital General Universitario Gregorio Marañón de Madrid, Hospital Universitario La Paz, and Clínica Universidad de Navarra. Following the talk, attendees will participate in a practical session to develop their own AR application using Unity, which will be compatible with Android devices.

Visit to labs: Alicia Pose

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Date: 22/05	9:00-11:00

Department: Biomedical engineering
Speaker: Sara Guerrero Aspizua

Title:
Advances in skin tissue engineering: Technological and clinical challenges

Abstract:
Tissue Bioengineering and regenerative medicine are fields crucial for the development of personalized medicine. This talk will deepen in the main challenges of skin tissue engineering and will discuss some of the recent applications in these fields. We will talk about the principles of skin tissue engineering, and its use for diseases modeling and clinical applications.
Bioengineered skin, developed in our laboratory, has been used in a preclinical context in order to model different genodermatoses, allowing the deeper understanding of different rare skin diseases and providing an *in vivo* platform that faithfully recapitulates the structure and function of the human skin, that allows the testing of new therapeutic agents, that cure or improve the quality of life of patients with no other therapeutic alternative.
In addition, these skin substitutes have demonstrated its clinical applications in the treatment of patients with different pathologies. In that context, our group has a clear translational orientation by which, the results of research done in the laboratory are directly used to develop new ways to treat patients. We will review the main leading research projects on this field from Tissue engineering and regenerative medicine group (TERMEG) at Universidad Carlos III de Madrid.

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Date: 22/05	11:30-13:30

Department: Biomedical engineering Diego Velasco
Speaker: Diego Velasco

Title:
3D skin bioprinting/ skin-on-a chip: enabling technologies, applications and future

Abstract:
Based on the 3D printing technologies and the concepts developed in tissue engineering during the last decades, 3D bioprinting is emerging as the most innovative and promising technology for the generation of human tissues and organs. In the case of skin bioprinting, thanks to the research process carried out during the last years, complex skin has been printed with a structural and functional quality that paves the way for clinical and industrial applications.
On the other hand, skin-on-a-chip microfluidic platforms are currently on the forefront of developing technologies. These platforms have been widely described in the literature as good candidates for skin modeling, as they enable a more physiological transport of nutrients and permit a high-throughput and less expensive evaluation of drug candidates in terms of toxicity, efficacy, and delivery.
This talk addresses the main challenges of 3D skin bioprinting and skin-on-a-chip technologies and discuss some of the recent applications in these fields. Tissue Engineering and regenerative medicine group (TERMEG) projects of the Carlos III University of Madrid will be taken as the background for this talk.

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Date: 23/05	9:00-11:00
Department: Biomedical engineering **Speaker: Caterina Fuster-Barceló**	

Title:

Deep Learning in Biomedical Imaging: From Theory to Practice

Abstract:

This talk unravels the transformative role of deep learning in the field of biomedical engineering. The talk begins with an overview of the essentials of deep learning, emphasizing convolutional neural networks and their efficacy in interpreting complex biomedical images. From theoretical foundations to practical applications, the narrative transitions to explore how deep learning is applied to a wide range of biomedical images, from CT scans to the developmental imaging of beetle embryos. Participants will gain insights into how deep learning technologies are enhancing diagnostics, accelerating research, and shaping the future of medical technology.

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Date: 23/05	11:30-13:30
Department: Biomedical engineering **Speaker: Monica Garcia**	

Title:
Surgical navigation for clinical applications

Abstract:
This talk centers on surgical navigation and its application across various clinical scenarios. We will explore the underlying technology, specifically the tracking systems, weighing the pros and cons of each. Additionally, we will understand the registration process, crucial for aligning medical imaging with the patient in the surgical room. Lastly, practical applications will be illustrated through examples, demonstrating how surgical navigation enhances precision in complex surgical situations and can provide data for the analysis of surgical outcomes or skills.

Visit to labs: Monica Garcia

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Date: 24/05	09:00-11:00

Department: Systems Engineering and Automation
Speaker: Dorin Sabin Copaci

Title:
Exoskeletons and exosuits for rehabilitation or human movement assistance

Abstract:
The movement of the human body encompasses various degrees of freedom, facilitating the execution of dynamic tasks with efficiency while enabling robust interaction with the environment in a compliant and continuous manner. However, when confronted with pathologies such as stroke, motor function deficits ensue, significantly impacting patients' mobility, curtailing their engagement in daily activities, impeding his participation in society, and diminishing prospects for returning to professional activities. These factors collectively contribute to a low quality of life for affected individuals. Rehabilitation training stands out as one of the most effective strategies for mitigating motor impairments resulting from such conditions. Over the past decade, a variety of rehabilitation devices, including exoskeletons and exosuits, have been developed to aid in the physical rehabilitation of individuals afflicted with neurological or musculoskeletal injuries, or those grappling with motor disabilities. While these devices hold promise in potentially improving post-rehabilitation outcomes, definitive evidence of their therapeutic superiority over conventional therapy remains elusive. Rigid exoskeletons offer the advantage of precision in movement control, but their rigid constraints restrict natural user movements, impeding interaction with the environment in a natural manner. Consequently, there exists a need to develop soft exosuits which can permit the natural human movement by eliminating constraints on joints through external rigid structures and reducing overall device weight for enhanced user comfort. Constructed from lightweight and flexible materials, these soft exosuits afford patients natural and transparent control, while mitigating issues associated with joint alignment owing to increased compliance. This presentation provides an overview of these two technologies, highlighting their respective benefits and potential contributions to rehabilitation tasks.

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Date: 24/05	11:30-13:30
Department: Systems Engineering and Automation **Speaker: Edwin Daniel Oña**	

Title:

Development of serious games for rehabilitation and assessment of the upper limb

Abstract:

This talk describes the use of new technologies such as virtual reality as a tool for rehabilitation and evaluation of motor function in patients with neurological impairments (Parkinson's, Multiple Sclerosis, Stroke, etc.).

A relevant feature of this technology is data acquisition through non-invasive movement tracking sensors (Kinect, Leap Motion Controller, etc), that allows reliable monitoring of the patient's movements, being a powerful tool for biomechanical analysis.

We have developed several environments that explores different game modalities such as 2D vs VR-based systems (desktop vs immersive), gamification versus virtualization, sensor-based versus natural interaction to promote the patient's adherence. The design of the video games is based on Unity game engine, an Open Source program to create virtual environments. This technology is a low-cost alternative to high-level Vicon-type systems.