UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Biofabrication technologies for engineering functional living tissues"

Asst. Prof. Riccardo Levato
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Short Abstract: The function of living tissues is intimately linked to their complex architectures. Biofabrication technologies are rapidly advancing as powerful tools capable to capture salient features of tissue composition and thus guide the maturation of engineered construct into mimicking functionalities of native organs. In biofabrication, multiple cell types and biomaterials are patterned in three dimension through automated processes, either via bioprinting or bioassembly. The current paradigm in bioprinting relies on the additive layer-by-layer deposition and assembly of repetitive building blocks, typically cell-laden hydrogel fibers or voxels, single cells, or cellular aggregates. Since its initial conception and its first implementations through inkjet printing technologies, bioprinting rapidly introduced a new toolset for bioengineers and material scientists to produce new strategies to restore the function of impaired tissues. In this course, both currently available and innovative bioprinting approaches will be reviewed, with a particular focus on how these techniques can be combined to mimic the multi-material hierarchical composition of living tissues. Key concepts underlying extrusion, laser and light-based technologies will be discussed, together with the recent emergence of layerless volumetric and field-based printing methods. Finally, technological advances and challenges towards the biofabrication of both in advanced in vitro models for biomedical and pharmaceutical research, as well as the production of clinically-relevant multi-tissue constructs for regenerative medicine via will be discussed, in light of specific, state-of-the-art examples of biofabricated tissues.

Course Contents in brief:

- Introduction to additive manufacturing
- Fundamentals of biofabrication: enable cell processing via bioprinting and bioassembly technologies
- Hydrogels, bioinks and biomaterial inks
- Extrusion-based bioprinting
- Sacrificial templates and suspended printing
- Light-driven bioprinting
- Layer-by-layer and layerless 3D biofabrication
- Field-based fabrication strategies (magnetic, sound and light fields)

- Printability, shape fidelity and automation in biofabrication processes
- Smart and stimuli-responsive prints
- Addressing specific challenges in tissue engineering: examples of applications in regenerative medicine and *in vitro* models

Total # of hours of lecture: 16

References:

[1]Levato et al., Adv Mater 2020 (32) 1906423

CV of the Teacher

Dr. Levato is currently Assistant Professor of Biofabrication and Regenerative Medicine at the Department of Orthopedics, University Medical Center Utrecht (UMCU) and at the Regenerative Medicine Center Utrecht. His research focuses on the development of novel biofabrication strategies to create bioprinted, lab-made tissue models and transplantable engineered grafts, particularly for the regeneration of the musculoskeletal system. At UMCU his work integrates expertise in engineering, stem cell biology, as well as cartilage and bone pathophysiology, to translate biofabricated structures towards novel treatments for the regeneration of damaged articulating joints. For his work on biofabrication, Dr. Levato was conferred several awards, including the 2018 Orthoregeneration Network Fellowship by the International Cartilage Repair Society, the 2016 Wake Forest Institute for Regenerative Medicine Young Investigator Award and the 2015 Julia Polak award by the European Society for Biomaterials. Prior to his appointment at UMCU, he also worked in several research groups in the field of Biomaterials and Regenerative Medicine: 3Bs, University of Minho, (Portugal); BioMatLab, Technical University of Milan (Italy), Institute for Bioengineering of Catalonia (IBEC, Spain), and he hold a *cum laude* PhD in Biomedical Engineering from the Technical University of Catalonia (Barcelona, Spain). Since 2015, Dr. Levato lectures at the Master degree program in Biofabrication, offered at Utrecht University, and since 2017 he is coordinator of the Utrecht Summer School in 3D printing and Biofabrication.

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

Day1

Introduction to additive manufacturing (1hr)

Fundamentals of biofabrication (1hr)

Hydrogels, bioinks and biomaterial inks (2 hrs)

Day2 – time

Extrusion-based bioprinting (1:30 hr)
Sacrificial templates and suspended printing (1hr)
Light-driven bioprinting (1:30 hr)

Day3

Layer-by-layer and layerless 3D biofabrication (1hr)
Field-based fabrication strategies (magnetic, sound and light fields) (1 hr)
Printability, shape fidelity and automation in biofabrication processes (1 hr)
Smart and stimuli-responsive prints (1hr)

Day 4

Addressing specific challenges in tissue engineering: examples of applications in regenerative medicine and *in vitro* models

Musculoskeletal tissue engineering (1hr)

Liver repair (1hr)

Cardiovascular and neural applications (1hr)

In vitro models and biofabrication for organ-on-chip applications (1hr)