UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Additive manufacturing on non-planar surfaces: operating workflow from surface scanning to 3D printing"

Dr. Gabriele Maria Fortunato

Department of Information Engineering, University of Pisa - Italy

E-mail address: gabriele.fortunato@unipi.it

Short Abstract: Additive manufacturing (AM) is a series of technologies that aims at fabricating solid objects starting from the three-dimensional (3D) model, through the deposition of thin layers of material [1]. The ability to print objects of any shape and size on any type of substrate is an extremely important feature for applications where high in-situ precision is required, such as the fabrication of electronic [2] and microfluidic components [3] or the fabrication of biological tissues in *in-situ* bioprinting techniques [4]. Thanks to the generation of geometries directly on the required site, the almost total absence of dimensional mismatch between the receiving substrate, and the object to be printed, can be achieved. To correctly plan the printing trajectory onto a non-planar and complex surface a specific operating workflow can be followed starting from the acquisition of the geometry of the printing substrate [5]. Different technologies can be used for this step, obtaining the reconstructed surface where the printing path can be planned. Once the trajectory has been computed, it has to be registered in the operating workspace for proceeding with the material deposition through the desired AM technology [6]. The ability to print onto non-planar surfaces following the curvature of the geometry not only allows to obtain a perfect adhesion on the substrate but also to enhance the mechanical and electrical properties of the printed structure thanks to the deposition of a continuous filament as well as a better aesthetic result.

Course Contents in brief:

- Introduction on additive manufacturing
- Overview of slicing algorithms
- Scanning approaches and algorithms for surface reconstruction
- Path planning for 3D printing onto non planar surfaces
- Registration/localization in the operating workspace
- Applications of the additive manufacturing operating workflow

Total # of hours of lecture: 24

References:

[1] Zhang, Z., *et al.* "An improved slicing algorithm with efficient contour construction using STL files." The International Journal of Advanced Manufacturing Technology 80 (2015): 1347-1362.

[2] Lu, B., *et al.* "Additive manufacturing frontier: 3D printing electronics." Opto-Electronic Advances 1.1 (2018): 170004.

[3] Hwang, Y., *et al.* "3D printed molds for non-planar PDMS microfluidic channels." Sensors and Actuators A: Physical 226 (2015): 137-142.

[4] Singh, S., *et al.* "In situ bioprinting–Bioprinting from benchside to bedside?." Acta biomaterialia 101 (2020): 14-25.

[5] Fortunato, G. M., *et al.* "A fully automatic non-planar slicing algorithm for the additive manufacturing of complex geometries." Additive Manufacturing 69 (2023): 103541.

[6] Fortunato, G. M., *et al.* "Analysis of the Robotic-Based In Situ Bioprinting Workflow for the Regeneration of Damaged Tissues through a Case Study." Bioengineering 10.5 (2023): 560.

CV of the Teacher

Gabriele Maria Fortunato is an Assistant Professor at the Department of Information Engineering and fellow of the Research Center "E. Piaggio", University of Pisa. He received his PhD in Information Engineering at the University of Pisa in 2022, working on the development of a robotic biofabrication platform for *in situ* bioprinting applications. In particular, he analysed the advantages and limitations of this innovative technology against traditional tissue engineering approaches, developing a standardised *in situ* bioprinting workflow. The proposed approach was tested on different patient-specific phantoms, purposely designed.

At the present, he is still investigating the potential of the robotic-based *in situ* bioprinting technology. Another main topic of his research is additive manufacturing techniques and their combination (extrusion-based 3D printing, ink-jet printing, electrospinning) to fabricate multiscale and multimaterial scaffolds for tissue engineering applications. He is also involved in the design and development of bioreactors and open-source medical devices.

Final Exam: Presentation and discussion of a research paper

Room and Schedule

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

Schedule:

Day1 – 23 January 2024 – 14:00-18:00 (4 hours)

Day2 – 25 January 2023 – 14:00-18:00 (4 hours)

Day3 – 30 January 2023 – 14:00-18:00 (4 hours)

Day4 – 6 February 2023 – 14:00-18:00 (4 hours)

Day5 – 12 February 2023 – 14:00-18:00 (4 hours)

Day6 – 19 February 2023 – 14:00-18:00 (4 hours)