Bioprinting as enabling technology for deep space missions

Prof. Carmelo De Maria

Biofabrication group at the University of Pisa

Centro E. Piaggio
bioengineering and robotics research center

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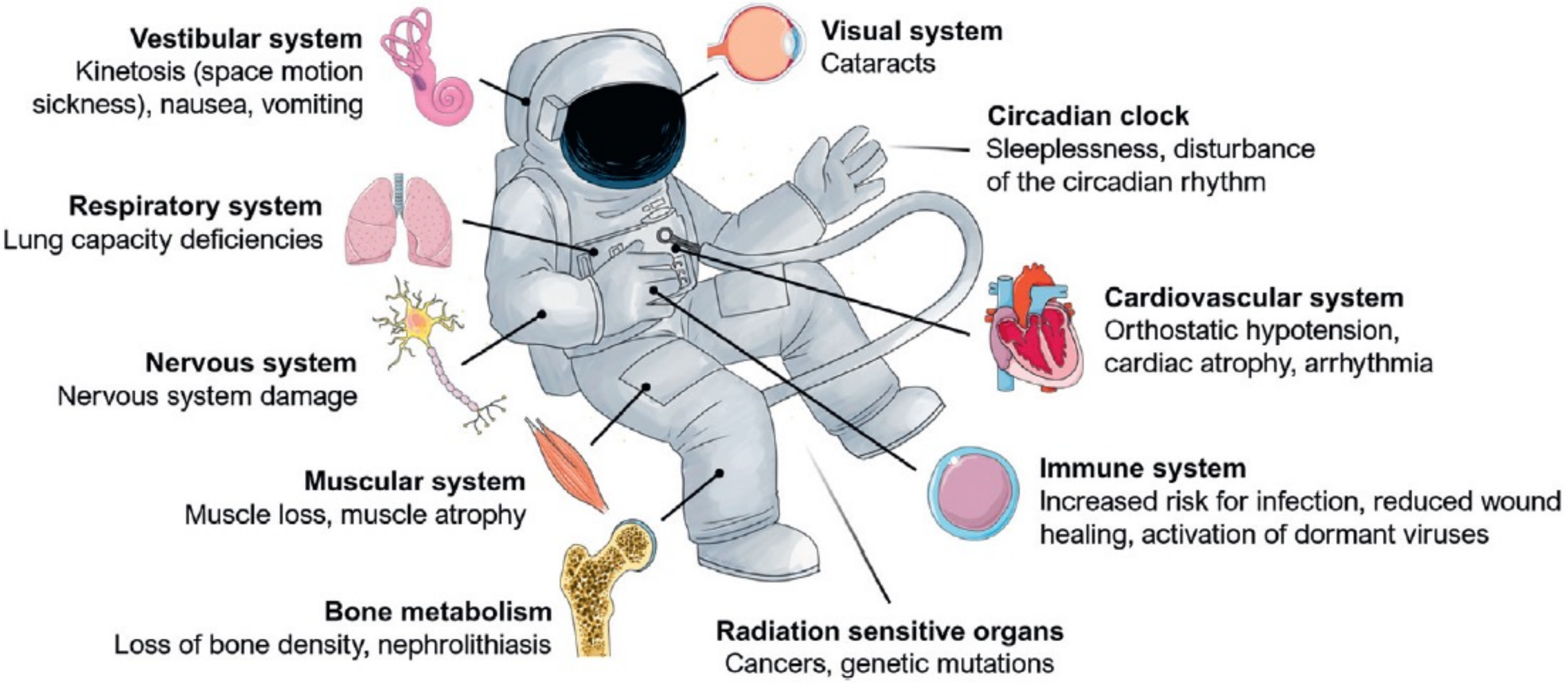
3D Bioprinting & Space Exploration

- What 3D bioprinting can do for space exploration?
- What space exploration can do for 3D bioprinting?

https://nebula.esa.int/content/3d-printing-living-tissues-space-exploration

3D Bioprinting & Space Exploration

- There are **several serious medical challenges** faced during **human space mission**



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- Cubo-Mateo, N., Podhajsky, S., Knickmann, D., Slenzka, K., Ghidini, T., & Gelinsky, M. (2020). Can 3D bioprinting be a key for exploratory missions and human settlements on the Moon and Mars?. Biofabrication, 12(4), 043001.

3D Bioprinting & Space Exploration

- 3D Bioprinting and the regenerative medicine approach are enabling technologies for long term and deep space missions since they can boost:
  - The development of **veritable human-like *in vitro* models** to study the effects of **space radiation** and **microgravity** on **human tissues and organs** (e.g., osteoporosis, lung capacity deficiencies and the effects on sensitive organs like thyroids and gonads).
  - **In situ biofabrication** of **custom-made tissue patches and substates** as emergency solutions **to treat astronaut injuries**.
  - In vitro **meat production** and **edible substance cultivation on** the **spaceships** and the **space stations, thus making the mission self-sustainable** and **self-sufficient foodwise**
- On the other hand, **space bioprinting in microgravity** conditions **advances** the **manufacturing (**e.g., **cell-laden hydrogel constructs with higher shape fidelity** than on Earth, reduced sedimentation, …)

- Ghidini, T. (2018). Regenerative medicine and 3D bioprinting for human space exploration and planet colonisation. Journal of thoracic disease, 10(Suppl 20), S2363.
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Bioprinting Technologies for space @UNIPI

European 3D Bioprinting Consortium

esa

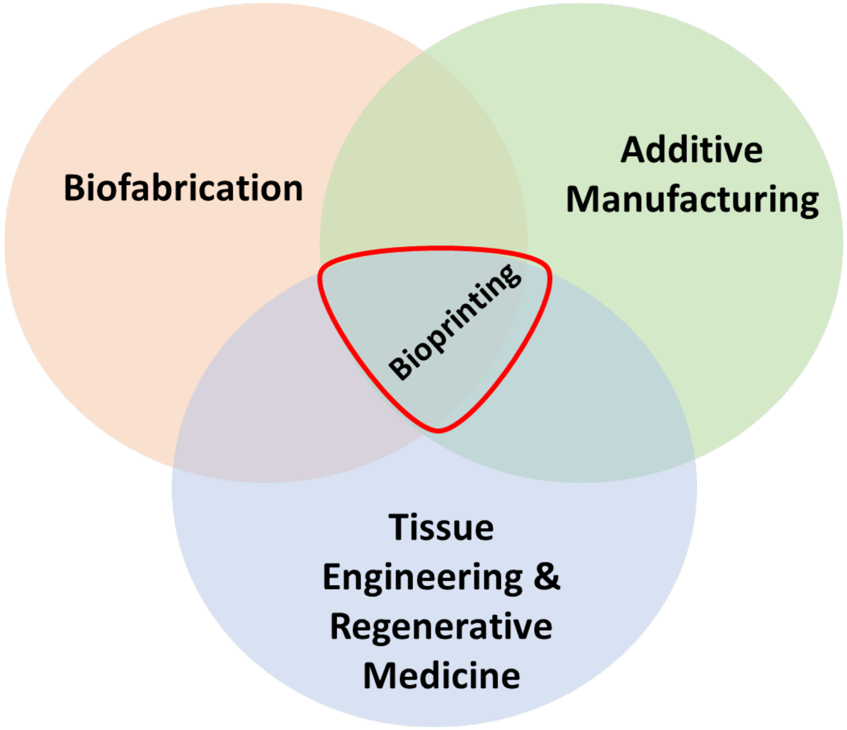
- ESA has installed a European 3D Bioprinting Consortium encompassing the following facilities:
    - 3D Bioprinting Lab, TU Dresden, DE [M. Gelinsky]
    - Henry Royce Institute – Bioprinting Technology Platform, University of Manchester, UK [M. Domingos]
    - Biofabrication Laboratory of Biomaterials Group, Warsaw University of Technology, PL [W. Swieszkowski]
    - Biofabrication Laboratory, University of Pisa, IT [G. Vozzi]
    - 3d FAB, Université de Lyon, FR [C. Marquette]

(AO-2022-3DBioprinting-Ground)

→ THE EUROPEAN SPACE AGENCY

Multiscale and Multimaterial Bioprinting

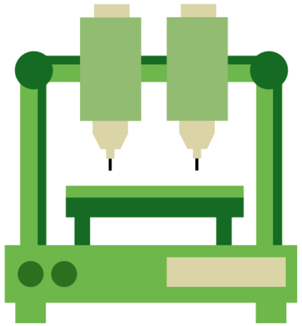
- **Design** and **development** of **advanced multiscale fabrication technologies**, including **3D bioprinting,** integrating **quality control,** for processing different biomaterials
- Manufacturing of **3D and 4D scaffolds** for **tissue engineering** applications, to **restore**, **maintain**, **improve** or **study** biological **tissue functions** or a **whole organ**
- **Green bioprinting:** Processing of **waste material** (e.g., Keratin from poultry feathers and **Pectin** apple and lemon peels) to get usable **biopolymers** with **added value**



Green Bioprinting For Tissue Engineering applications

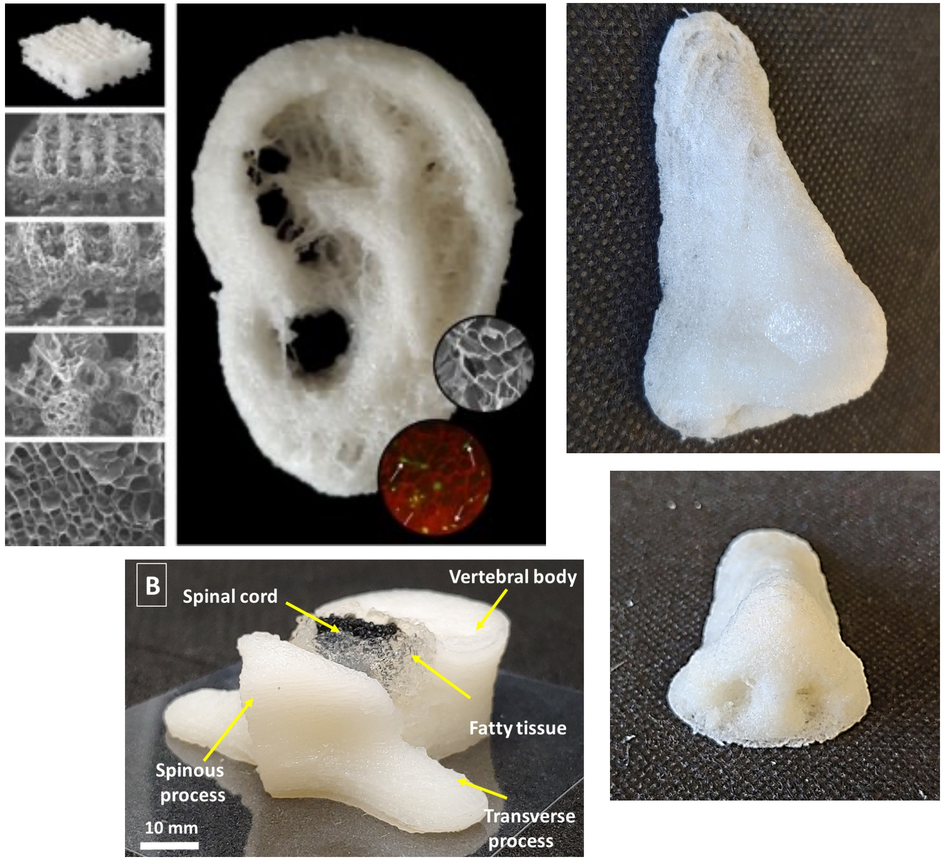
Citrus Industrial Processing

Poultry feathers



Green Biofabrication

Multiscale 3D anatomic scaffolds



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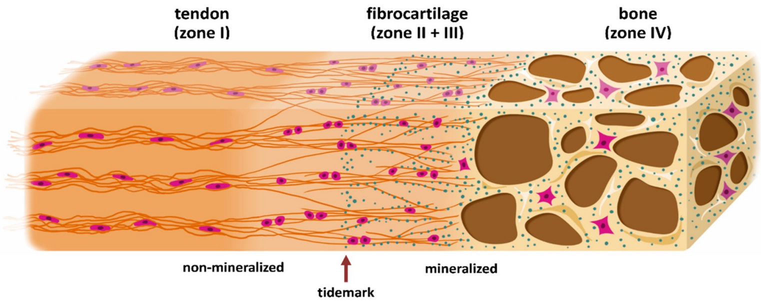
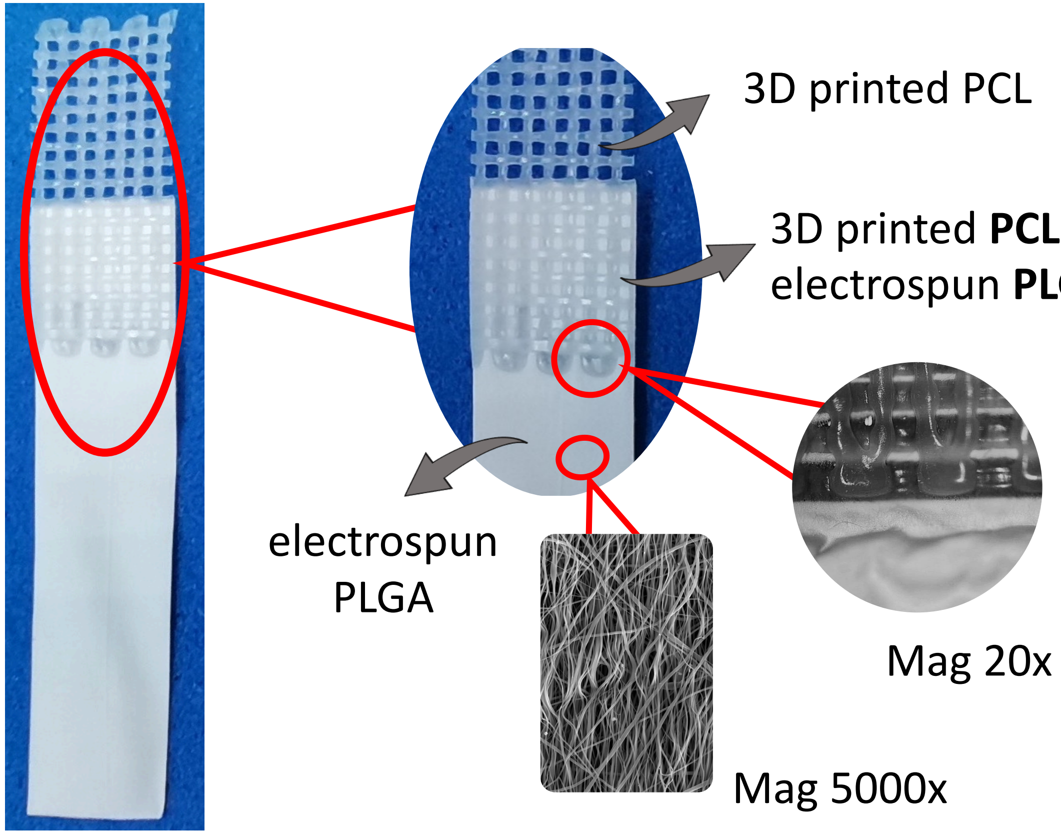
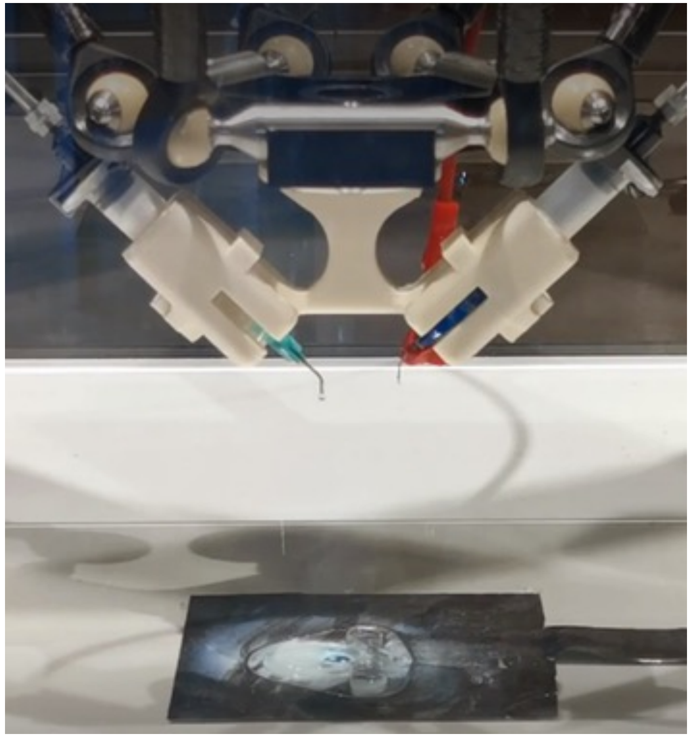
Bioprinting of 3D constructs for human tissue regeneration

Case of study: 3D multi-scale scaffolds to mimic the anisotropy of the ligament/bone interfaces





Scaffold dimensions
- ✓ Thickness: 0.4 mm
- ✓ Width: 5 mm
- ✓ Length: 30 mm



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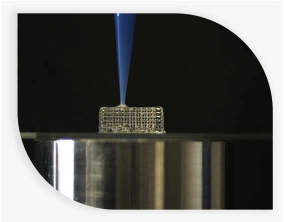
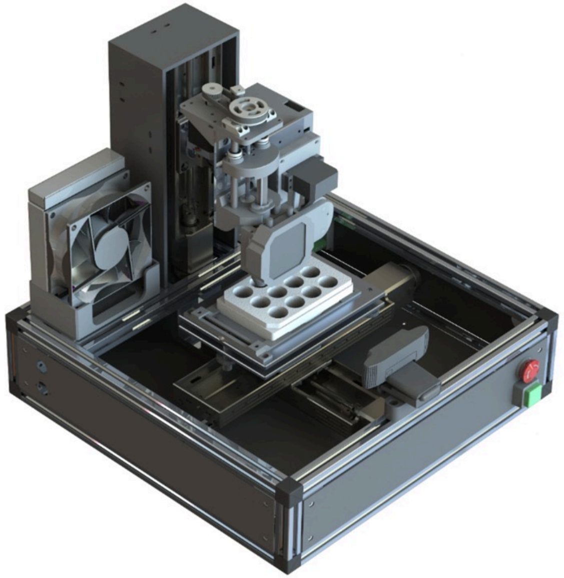
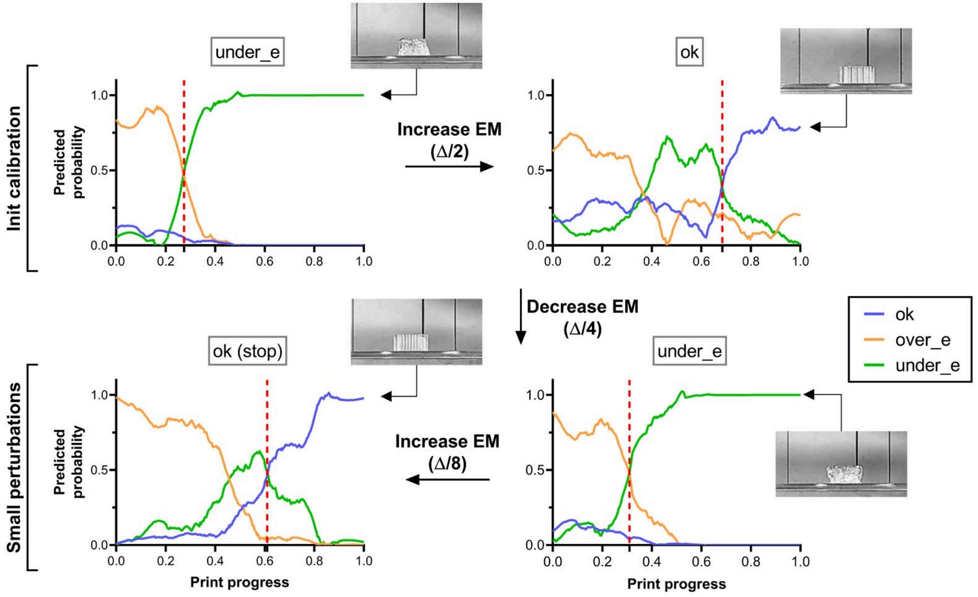
4D printing of self-actuated devices with AI-empowered quality control

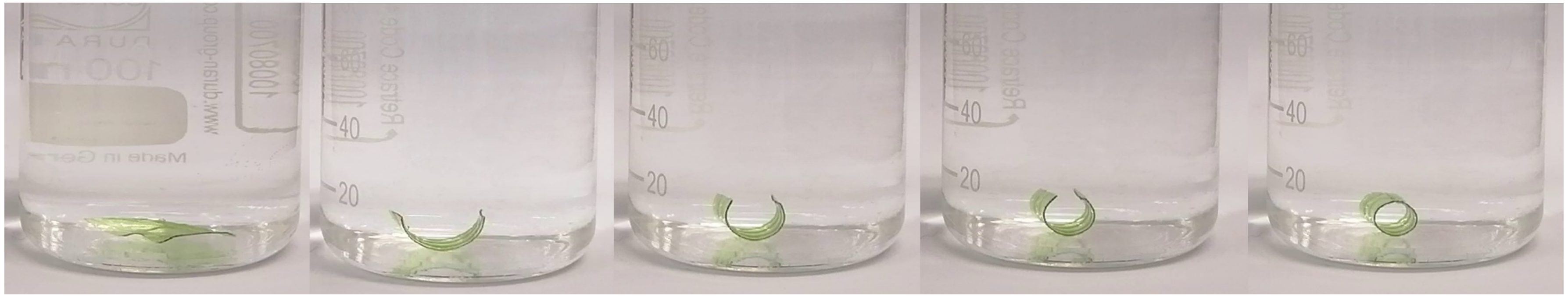


Advanced **multi-material and multi-scale** bioprinting **ecosystem** exploiting **AI for controlling the quality** of the printed product





Fabrication of **high-quality actuators** without the need of electrical power **by 4D printing**



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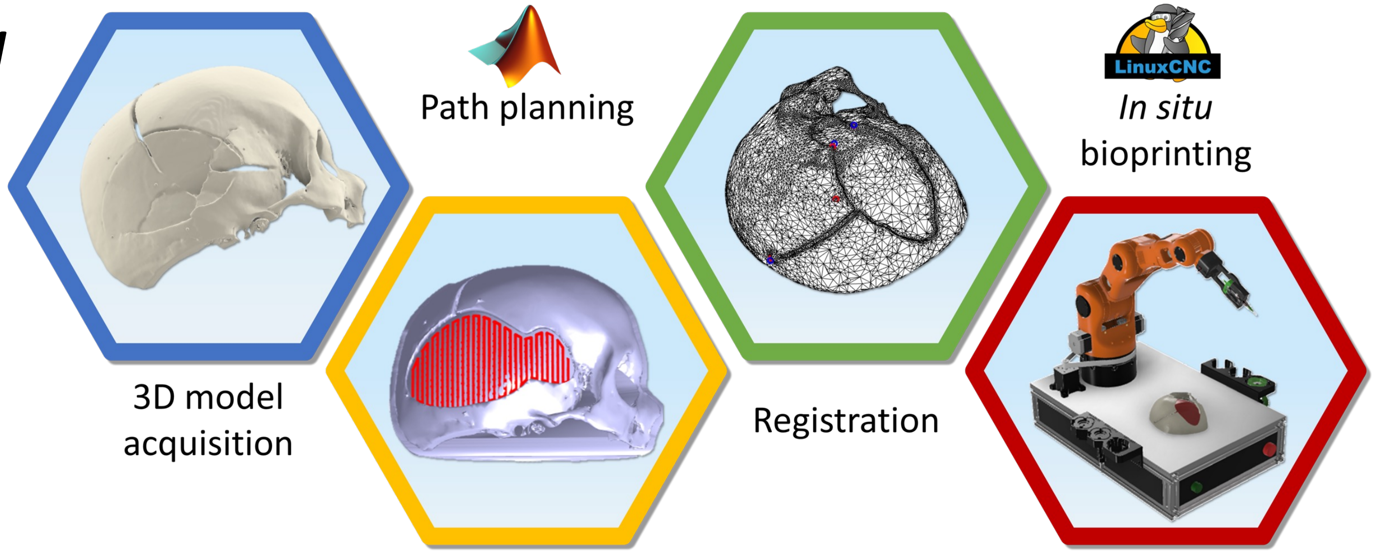
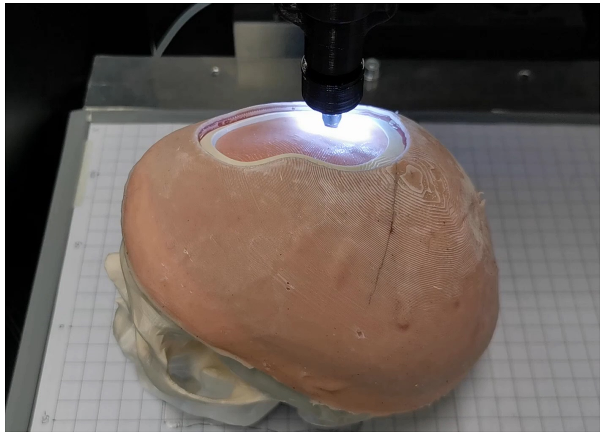
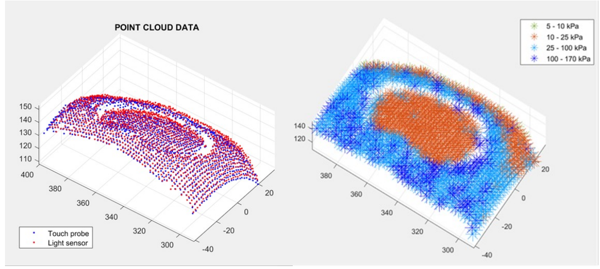
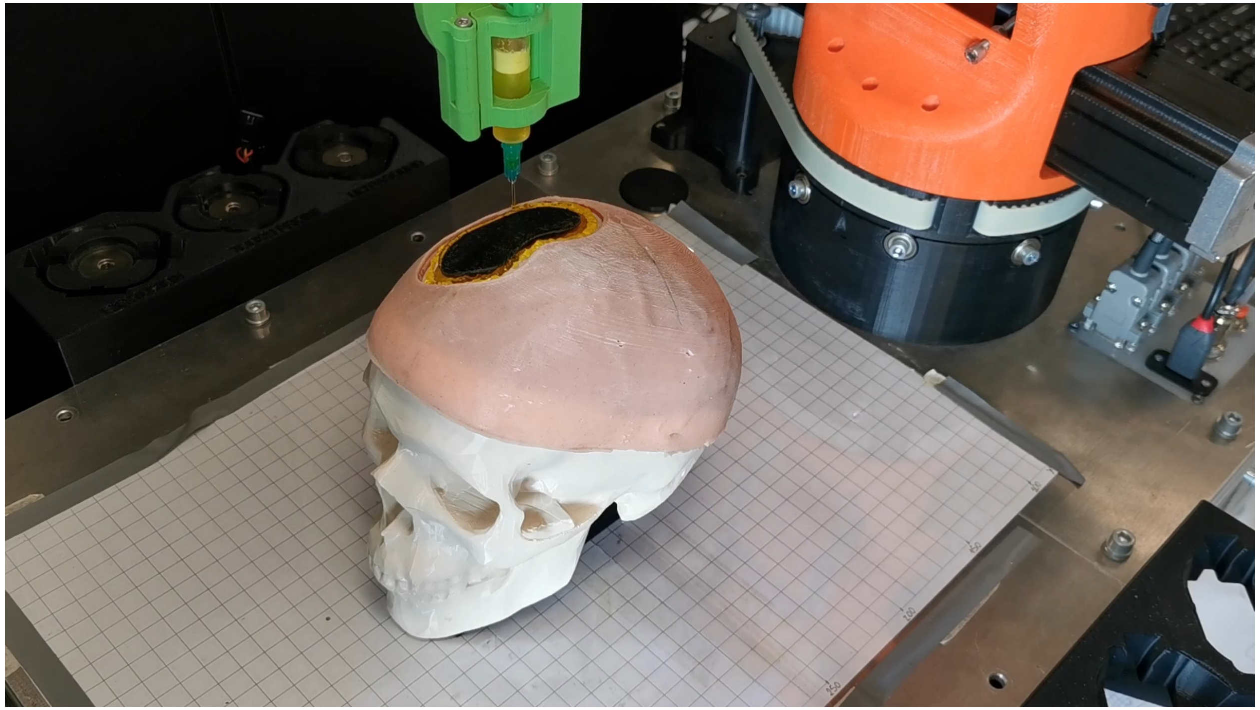
Robotic-based *in situ* bioprinting



- Direct biomaterial deposition onto/into the anatomical defect. The human body itself acts as a bioreactor.
- Use of a robotic platform for scanning, registering and regenerating the patient defect.







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Thanks for your attention!

Questions?

carmelo.demaria@unipi.it

Biofabrication Group, University of Pisa

Prof. Giovanni Vozzi, Ph.D
Prof. Carmelo De Maria, Ph.D
Francesca Montemurro, Ph.D
Aurora De Acutis, Ph.D
Gabriele Maria Fortunato, Ph.D
Amedeo Franco Bonatti, Ph.D
Irene Chiesa, Ph.D
Simone Micalizzi, M.Sc
Florinda Coro, M.Sc
Elisa Batoni, M.Sc
Costanza Daddi, M.Sc
Alessio Esposito, M.Sc
Ginevra Pegollo, M.Sc

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