Design and manufacturing of a flexible gripper for dexterous manipulation

ANR Project : ANR-20-CE33-0005 MANIMAT

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Context

MANIMAT Project

- Dexterous *MANI*pulation with **active** and **soft** *MAT*erials
- Adaptability to the versatility of object grasping
- Modification of the object configuration from inside the soft hand

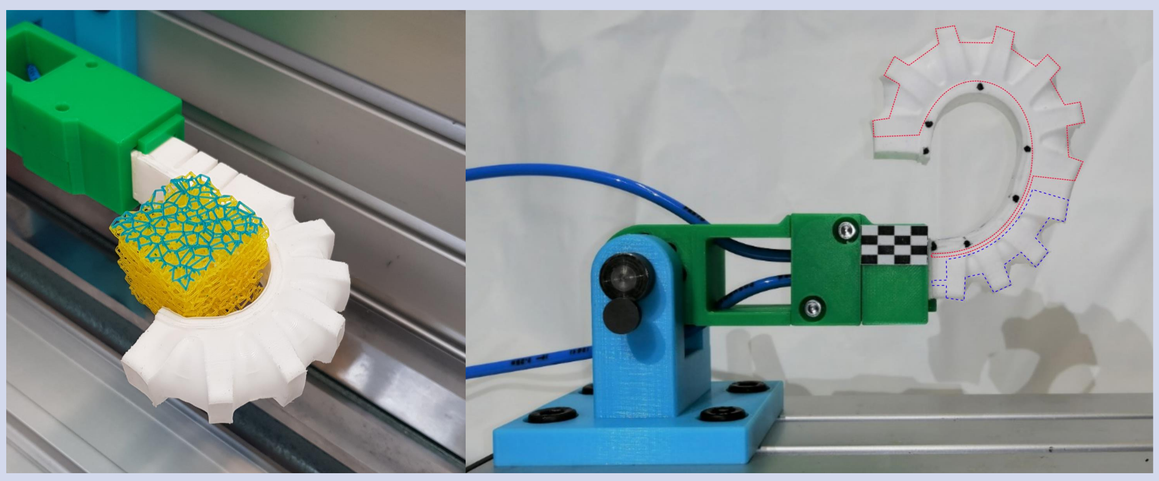
Main research axes of the thesis

- Characterization of soft materials (mostly silicones) and active elements for simulation-driven design
- Multi-material fabrication with a focus on manufacturing repeatability

Preliminary work

Soft finger design, simulation and manufacturing

- Design and fabrication of a pneumatic finger (*PneuNet* geometry [1]) with two independent air chambers (centralized air supply on the fixed part of the finger)
  - Material characterization (molded silicones)
  - Simulation-driven design of the finger
  - Study of the relationships between process parameters and product properties



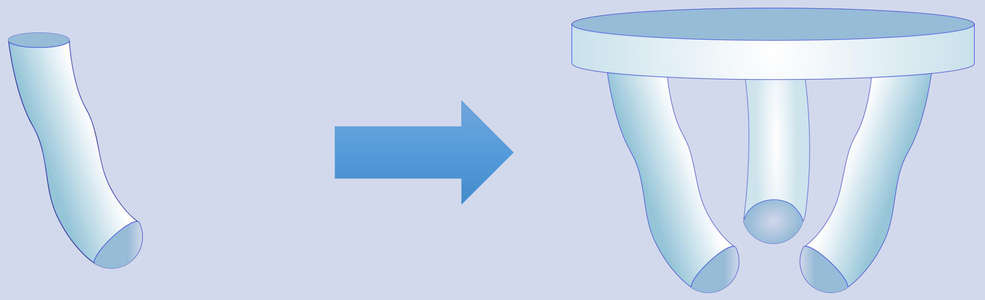
Dexterity challenge

In-hand manipulation

- Spatial manipulation of an object in an arbitrary way between two stable gripping positions [2]
- Requirements for the fingers:
  - Minimum two independent bending zones: bending close to 90°
  - Possibility to make a S-shape with the finger for thin objects gripping

Intended architecture

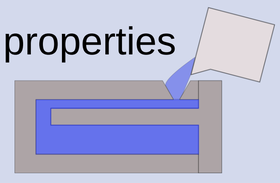
- Multi-finger hand: design of a finger and building of the hand by a finger combination



Soft hand with active materials

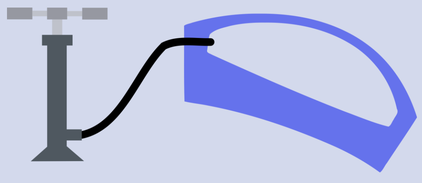
Manufacturing method

- Molding technologies
  - Wide variety of materials and elements that can be integrated into the soft matrix
  - Quality of product properties



Actuation

- Pneumatic energy as major source [3]
  - High force generation
  - Large stroke



Additional functions

- Tunable rigidification: increased hand gripping ability (SMA or other active materials)
- Sensing: precise hand control for dexterous manipulation

Ongoing work

Material characterization

- SMA wire experimentations
- Study of representative geometries and parameters for the simulation of soft and active materials

Fabrication repeatability in soft robots

- Testing of functional element integration methods
- Determination of process properties
- Characterization and improvement of manufacturing repeatability [4]

[1] B. Mosadegh *et al.*, “Pneumatic Networks for Soft Robotics that Actuate Rapidly,” *Advanced Functional Materials*, 2014.

[2] S. Abondance, C. B. Teeple, and R. J. Wood, “A Dexterous Soft Robotic Hand for Delicate In-Hand Manipulation,” IEEE Robotics and Automation Letters, Oct. 2020.

[3] A. Pagoli *et al.*, “Review of soft fluidic actuators: classification and materials modeling analysis,” Smart Mater. Struct., Dec. 2021.

[4] F. Kaasik et al., “Scalable fabrication of ionic and capacitive laminate actuators for soft robotics,” Sensors and Actuators B: Chemical, Jul. 2017.