Project ACTSOFTLY Workshop

8ª Edição IDI&CA

Concurso de Investigação, Desenvolvimento, Inovação e Criação Artística

Multifunctional Soft Actuators for Soft Robotics Applications: Soft Robotic Gripper

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Background, challenges and objectives

This project intends to study and create soft actuators for the application of soft robotics techniques in human interaction, a glove like the one in figure 1 [1] and a robotic gripper for handling sensitive products (figure 2-a). Thus, it is intended to study soft actuators, controlled by compressed air, using moulds and 3D printing techniques.

At this stage, the project has already studied the multifunctional actuators through simulation and experimental validation, creating soft Pneu-Net actuators using the 3D printed techniques and hyper elastic silicone (with moulds 3D printed with biodegradable materials), and validating the case study by making one of the two different prototypes – a soft robotic gripper, actuated by compressed air, duly instrumented (pressure sensor), valves and controlled using low-cost controller board – Arduino UNO.

Figure 1: Soft robotic glove (Elastosil M4601 A/B) [1].

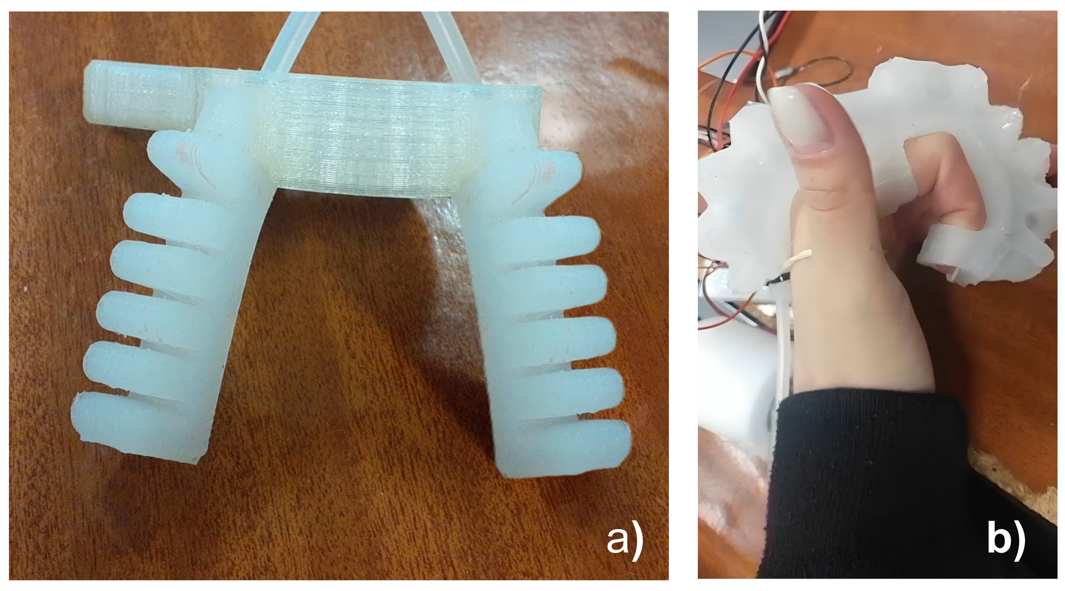

Figure 2: a) Gripper Made of DragonSkin Fast 10 silicone and b) Soft Pneu-Net exoskeleton actuator.

Keywords: soft robotics; soft Pneu-Net actuators; soft robotic gripper; glove for hand physiotherapy.

Soft robotic actuator and gripper

- A pneumatic network (Pneu-Net) bending actuator approach was used in this project.
- The 3D modelling was carried out in Solidworks Student®, figures 3-a) and b).
- The numerical simulation of the hyperelastic behaviour was carried out with the software ANSYS Workbench® - figures 3-c) and d).
- Materials used: Filament for 3D printing – Filaflex; silicones DragonSkin Fast 10 and Elastosil M4601 A/B for use with moulds.
- Material simulation model: hyperelastic model of Mooney-Rivlin and Yeoh model.

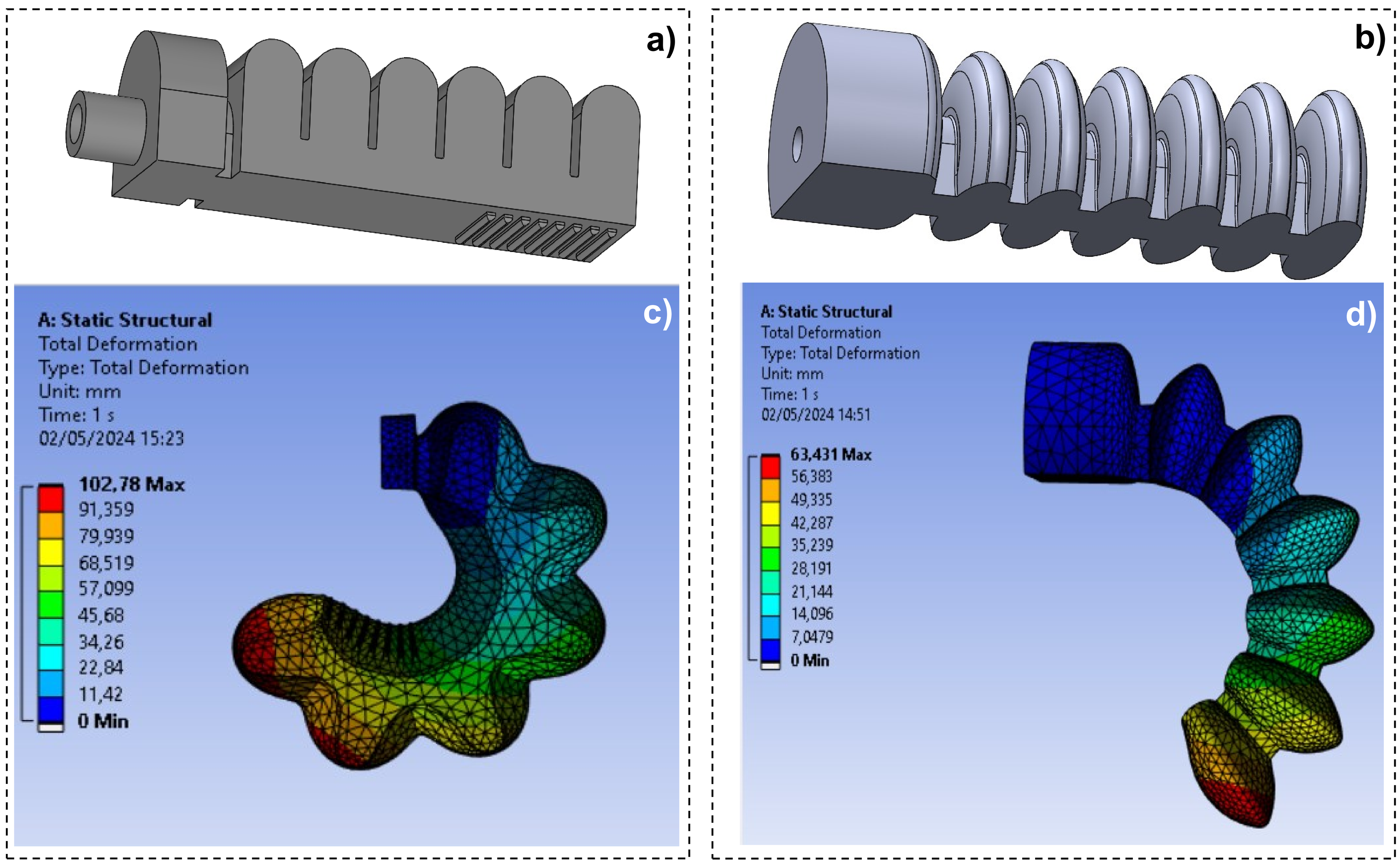

Figure 3: a) and b) Design of 2 different Pneu-Net actuators in Solidworks® (inspired by a) – [2]; b) – [3]) and c) and d) respective simulations in ANSYS®

a) and c) Elastosil M4601 A/B material - Pressure: 150 kPa (1.5 bar) - Mooney-Rivlin hyperelastic model.

b) and d) FilaFlex material - Pressure: 250 kPa (2.5 bar) - Yeoh Model hyperelastic model.

Prototypes and results

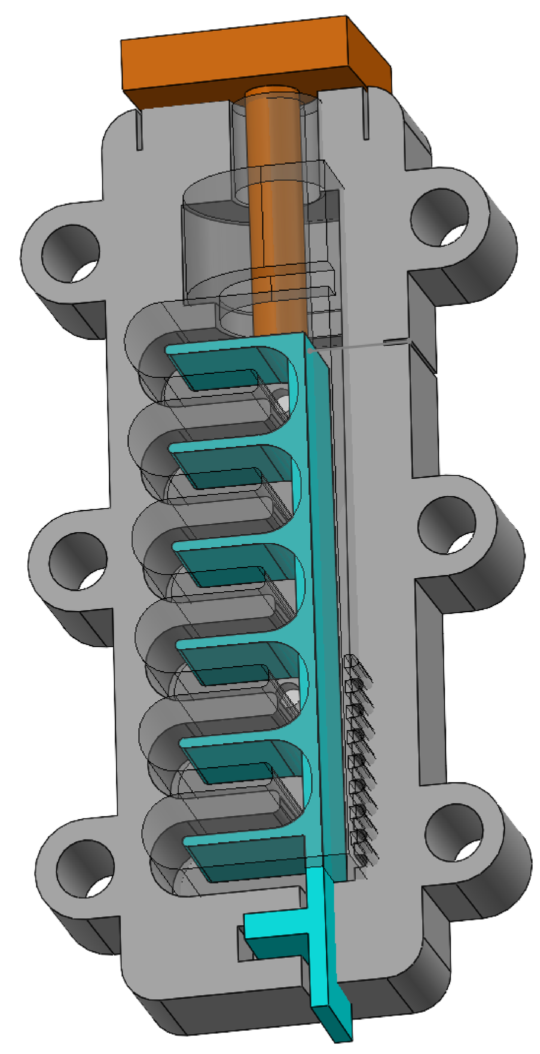

Figure 4: Solidworks® mould modeling.

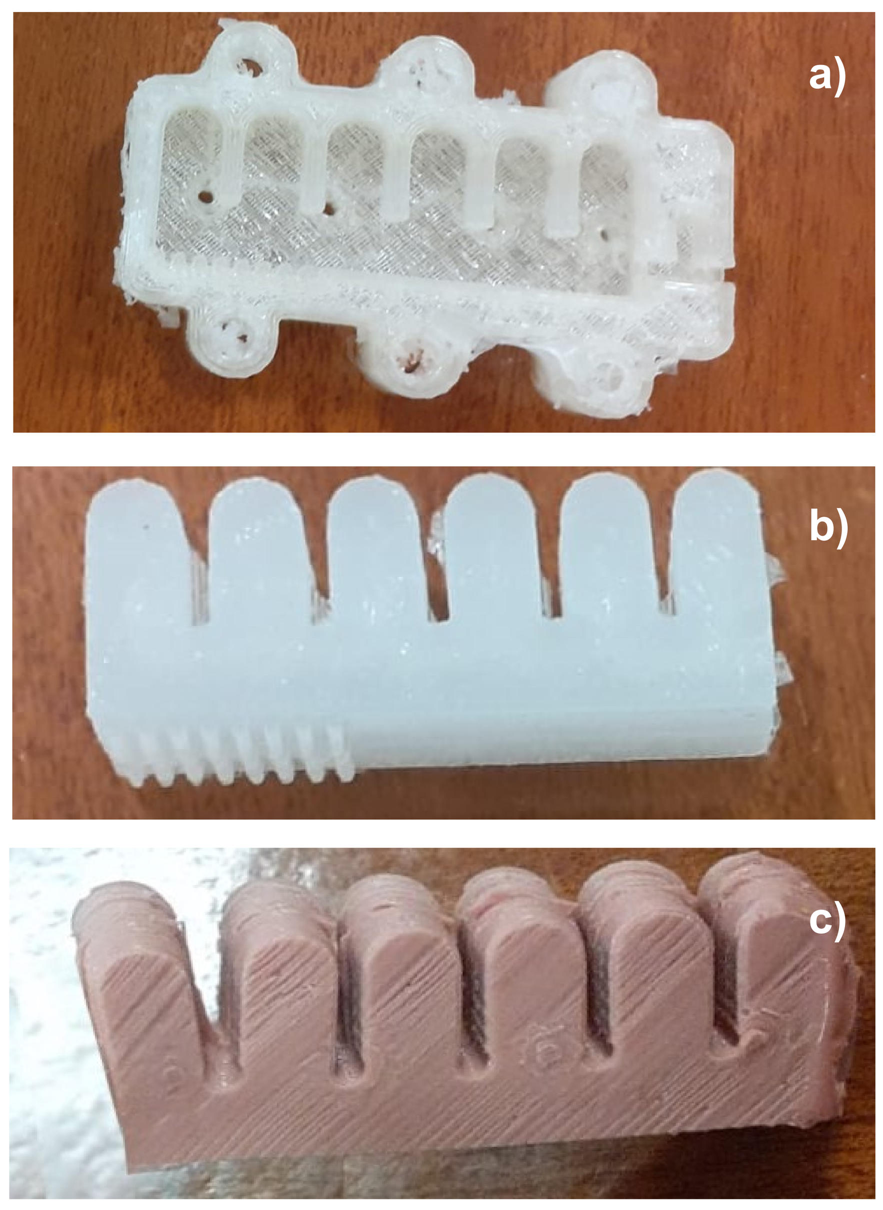

Figure 5:
a) Pneu-Net actuator mould printed in PLA,
b) Actuator made of DragonSkin Fast 10 silicone
c) Actuator made of Elastosil M4601 A/B silicone.

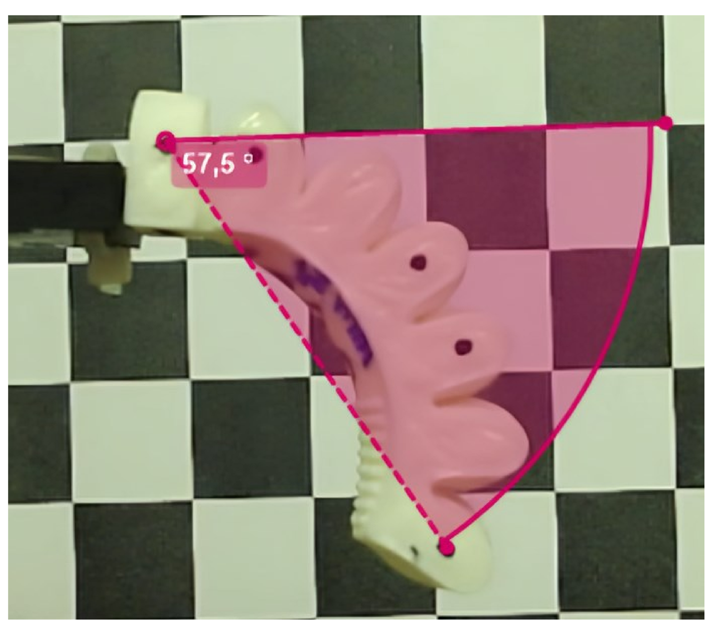

Figure 6: Pressure vs. Displacement (at maximum pressure of 2.5 bar) of the Pneu-Net actuator (figure 3-a) type, in FilaFlex).

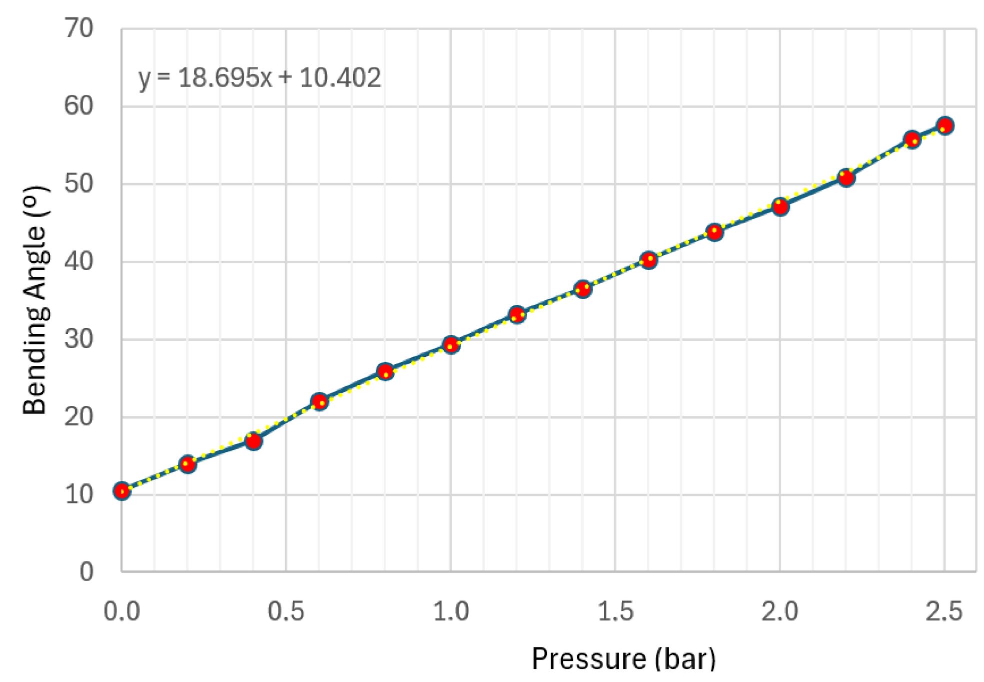

Figure 7: Bending angle vs. Pressure – Pneu-Net actuator of figure 6 (FilaFlex).

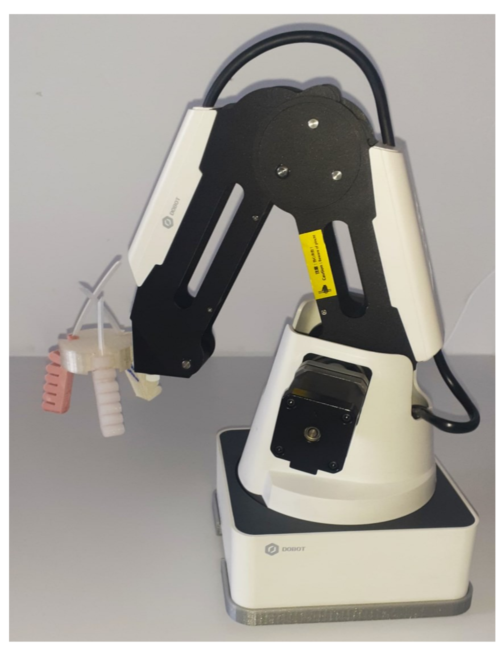

Figure 8: Dobot with Grippers made of FilaFlex and Elastosil M4601 A/B, DragonSkin Fast 10 silicones.

- Two different models of actuators were built, of the Pneu-Net type (figures 3-a and b), with three different materials: FilaFlex (3D printed), Elastosil M4601 and Dragonskin Fast 10 silicones (with moulds - Figures 4 and 5-a), b) and c).
- Videos of how the actuators worked were made and software was used: Kinovea® and OBS studio video editor (one example at figure 6) to obtain experimental data on displacement and bending angle with the pressure.
- Figure 7 shows the experimental linearity obtained (pressure vs bending angle) with the soft actuator of figure 6.

Conclusions and future work

- The work carried out so far has made it possible to study, design and obtain two different models of multifunctional soft actuators of the Pneu-Net type.
- With the soft actuators obtained (in three different materials), it was possible to build three functional soft grippers for the Dobot robot (figures 2-a) and 8).
- Work is underway on the development of the pneumatic control system, with an arduino uno board, a pressure sensor, a 2/2 valve, a compressor, etc.
- The study and development of the 2nd prototype - an exoskeleton to help with physiotherapy and hand rehabilitation - is already underway (figure 2-b).

References

[1] M. Mendes, "Projeto de luva pneumática para ajuda na reabilitação da mão", Master dissertation in Biomedical Engineering. Instituto Superior de Engenharia de Lisboa/Escola Superior de Tecnologia da Saúde de Lisboa, 2nd December 2022.

[2] H.K.Yap, H.Y.Ng & C.H.Yeow, "High-Force Soft Printable Pneumatics for Soft Robotic Applications", In Soft Robotics, Vol. 3, Number 3, 2016. DOI: 10.1089/soro.2016.0030

[3] D.K. Patel, A.H. Sakhaei, M. Layani, B. Zhang, Q. Ge & S. Magdassi, "Highly stretchable and UV curable elastomers for digital light processing based 3D printing", In Advanced Materials, Vol. 29, Number 15, 2017. DOI: 10.1002/adma.201606000

This project was funded within the IPL/IDI&CA2023/ACTSOFTLY_ISEL.

10th May 2024