Building a soft robot with omnidirectional bending capabilities: from fluidic artificial muscles manufacturing to the overall system characterization

ABSTRACT

The workshop aims at manufacturing and characterizing a soft robot with omnidirectional bending capabilities. To develop this system, the students will start from the fabrication of the single unit: the McKibben actuator. This class of actuators is known for being lightweight, easy to produce, and able to generate high forces despite their size.

During this workshop they will get familiar with the assembly of such a muscle, composed of three main elements: an elastomeric chamber, that inflates upon pressurization, an external braided sleeve, that depending on its angle guides the overall motion, and the end-fittings, responsible of sealing the main body and connecting it to the air supply. After manufacturing the McKibben muscle, they will be asked to characterize its motion and compare it with the theoretical model results.

Successively, the assembly of an omnidirectional soft robot will start, and multiple actuators will be connected onto two support plates. The omnidirectional bending behaviour of the soft robotic system, together with the stiffness variation will be quantitatively and qualitatively analysed.

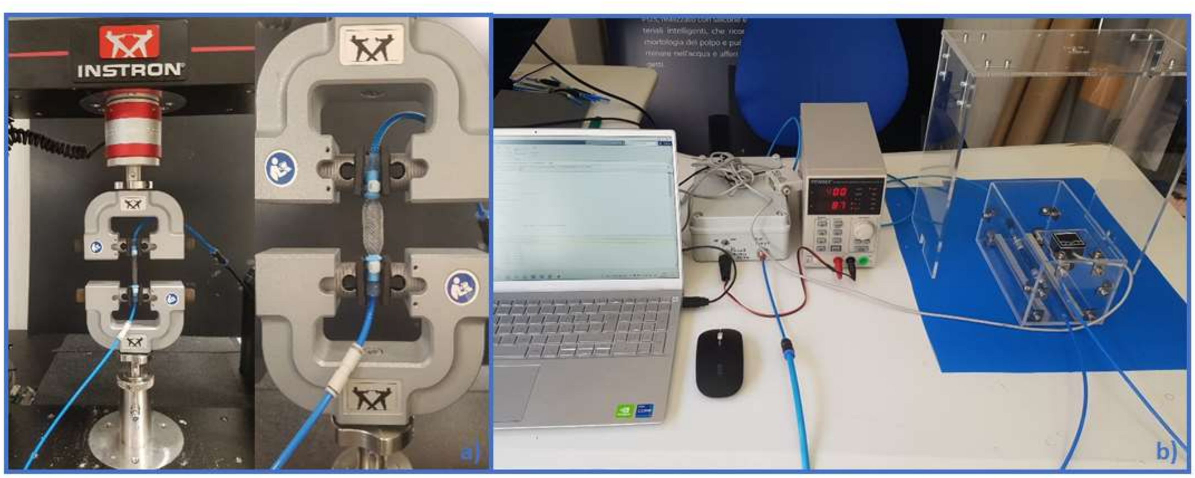
The ultimate goal of this seminar is thus to understand the main advantages and disadvantages of this typology of soft robotic muscles and systems and to be able to discuss critically their possible future developments and applications.

Keywords: Soft fluidic actuators, McKibben actuators, Characterization, Soft robots

PROGRAM

INTRODUCTION: The McKibben artificial muscle (15 min)

A brief presentation will introduce the fluidic artificial muscles and their applications. A short video tutorial will be shown to introduce the fabrication and typical characterization procedures.



PART 1: Muscle manufacturing (30 min)

The students will assemble at least one artificial muscle each. Procedures and dimensions will be provided.

After this procedure, they will be asked to answer some questions as:
i) what do you expect to be the reason or reasons of failure?
ii) which elements could be improved and how?
iii) how much force do you think it can produce?

PART 2: McKibben Muscle characterization (45 min)

Students will be working in groups. They will evaluate the initial braiding angle of their McKibben actuators and they will be asked to compute the maximum theoretical contraction ratio of each muscle. Successively, some actuators will be tested with an experimental setup, in order to characterize their behaviour, and correlate the input pressure with the axial contraction, and radial expansion.

Questions:
i) which is the maximum theoretical contraction ratio?
ii) draw the pressure displacement curve of your actuator (through 10 or 20 experimental points)
iii) draw the mean pressure-displacement behaviour (3 actuators at least)
iv) What happens if you attach a weight to your actuator while being pressurized? Test 3 different pressures and measure the length.

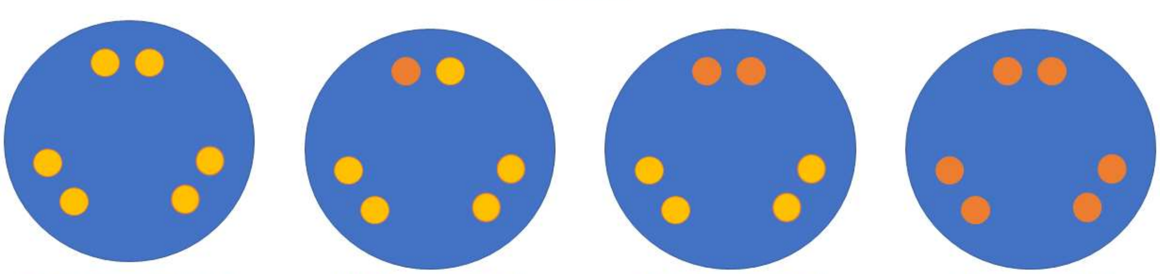
PART 3: Soft robot manufacturing (15 min)

Each group will build its own omnidirectional module following the instructions.

PART 4: Omnidirectional bending characterization (45 min)

The students will be asked to characterize qualitatively and quantitatively the behaviour of the robot.
Questions:
i) what happens if you activate one single muscle?
ii) what happens if you active one group of muscles?
ii) what happens if you activate all the muscles at the same time?
iii) Try to correlate the pressure of one group with the bending angle of the structure and draw a curve

TOP VIEW



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