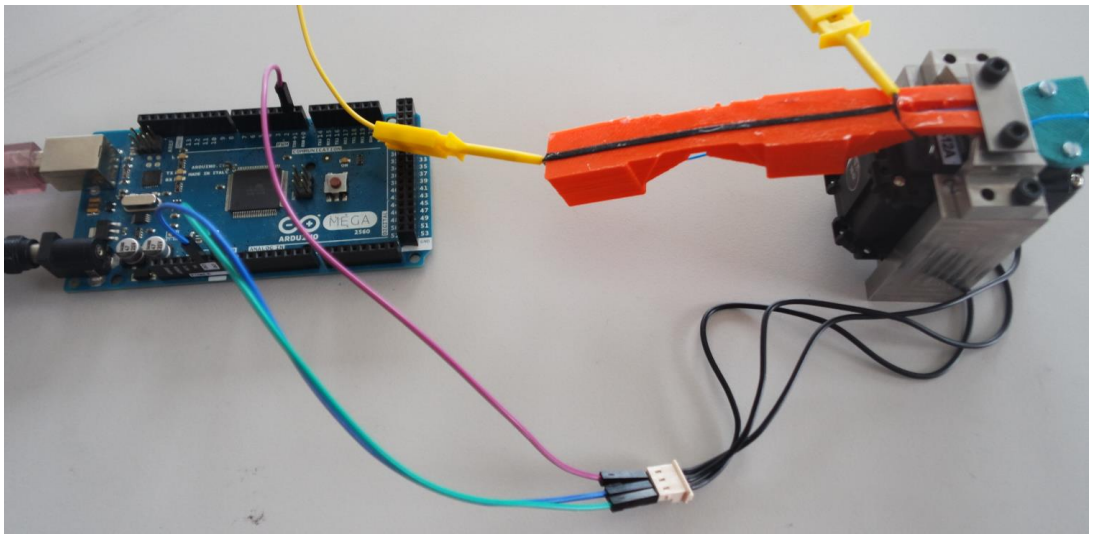
Workshop: Monitoring of 3D printed soft robotic hinges with flexible strain sensors using Arduino



The workshop combines theoretical background and practical training of sensor integrated soft robotic structure. The goal of this workshop is to get familiar with the assembling and controlling of sensor based soft robotic hinges (tendon-based actuators). Therefore, participants will assemble a tendon-based actuator and learn how to control the servomotor with an Arduino microcontroller. Later, a piezoresistive strain sensor, mounted on the tendon-based actuator, will be connected to an Arduino and sensor signal behavior will be investigated during deformation of the soft actuator-module.

Part A:

Presentation: Fused Deposition Modelling as a fabrication method for soft robots with integrated sensing elements.

Time: **20 min**

Video: The tendon-based actuators and sensor used in this study produced by additive manufacturing.)

Content: Background will be given about multi-material FDM 3D printed for soft robotic applications.

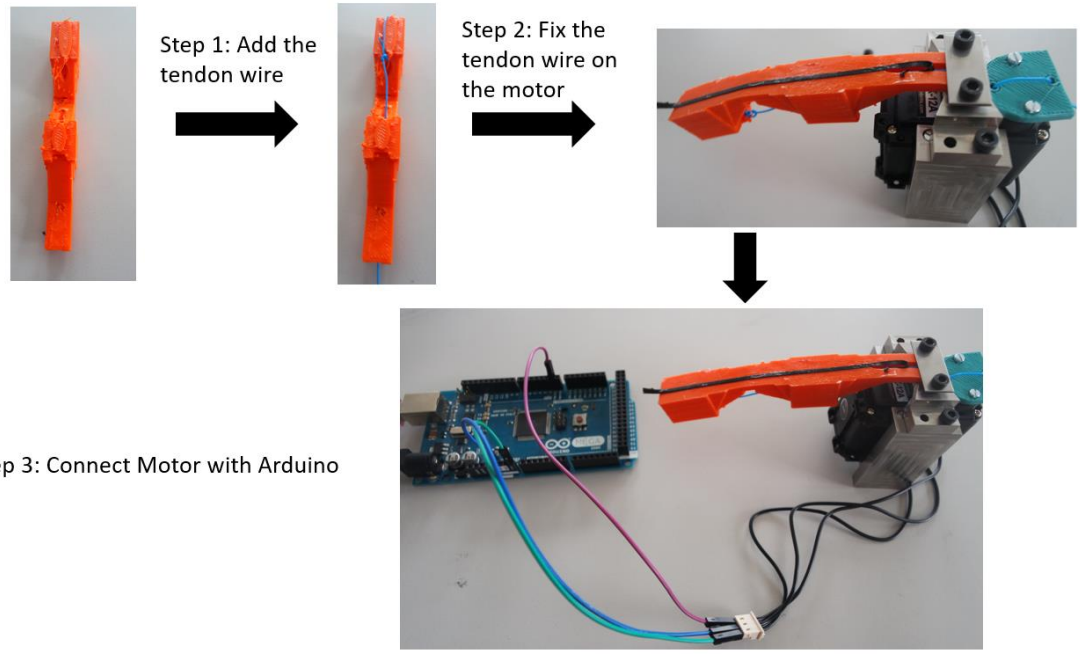
Part B:

Practical work: Assembling the tendon-based actuator hinge and controlling the Arduino.

Time: **30 min**

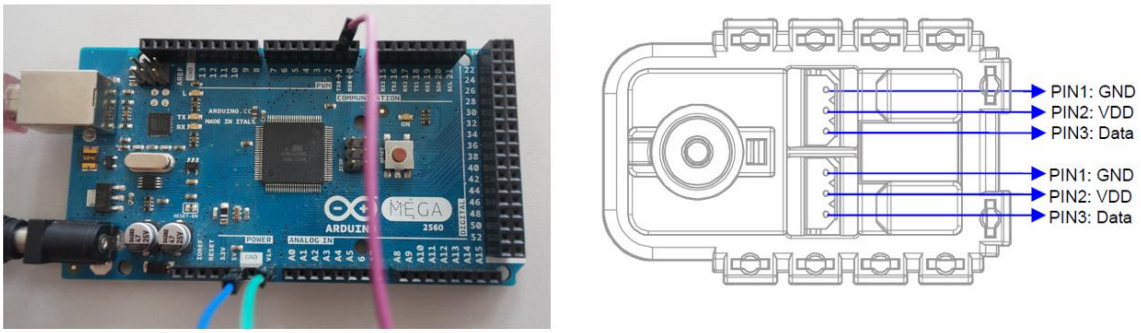
B.1: Assembling the robotic finger and connecting the tendon with the servomotor.

Time: **10min**



B.2: Connecting the servomotor with Arduino.

Time: **5min**



B.3. Programming the servomotor with Arduino.

Time: **10min**

Dynamixel_sensor | Arduino 1.8.13

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Dynamixel_sensor §

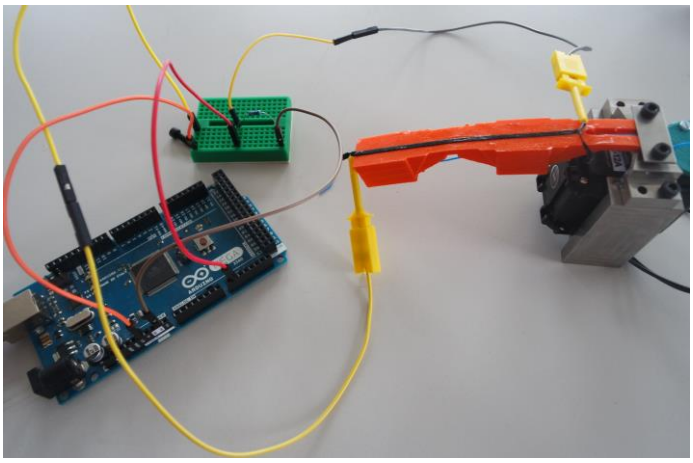
```
#include <DynamixelSerial.h>

void setup(){
Dynamixel.begin(1000000,2);  // Inicialize the servo at 1Mbps and Pin Control 2
}

void loop(){
Dynamixel.move(1,0);
delay(1000);
Dynamixel.move(1,500);
delay(1000);

}
```

B.4. Try different dwell times. (This step will be needed for the next part)

Time: **5min**

Part C: Characterizing the sensor response using Arduino-based Ohmmeter

Time: **45 min**



C1: Theoretical part about flexible sensors and the different aspects of the characterization of their behavior.

Time: **10min**

C2: Practical work: Building up an Ohmmeter with Arduino and testing a resistor with a given resistivity value.

Time: **10min**

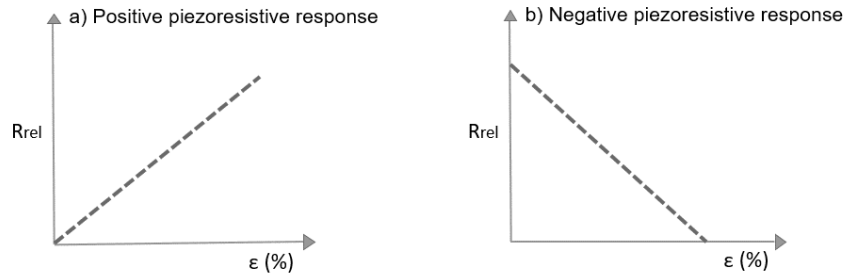
C3: Practical work: Dynamic testing (short delay time).

Time: **15min**

In this test, the sensor signal is recorded while the servomotor operates with short delay time.

Questions for the students

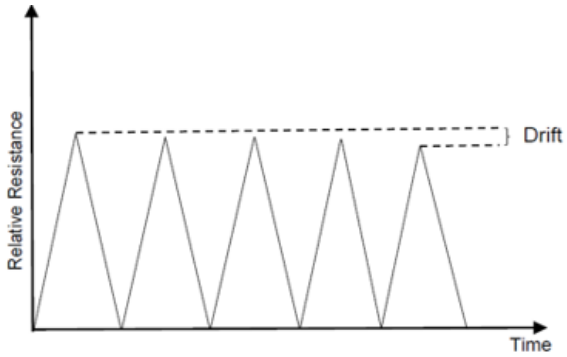
i) Do you observe a positive or negative piezoresistive response?



ii) Can you calculate the gauge factor GF for one cycle of the sensor signal?

$$GF = \frac{\Delta R_{rel}}{\Delta \varepsilon}$$

iii) Is there a drift in the sensor response? Can you calculate the drift between cycle 10 and cycle 20?



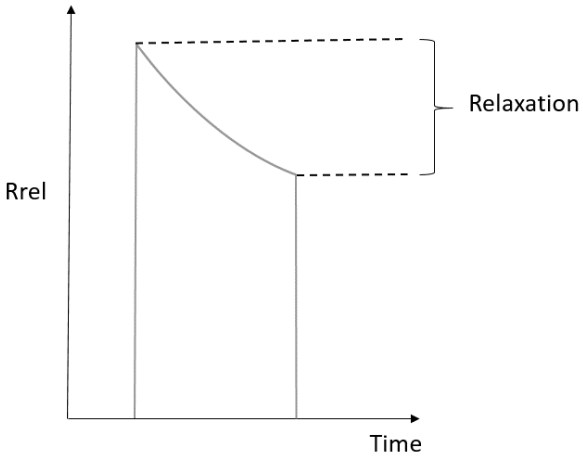
C4) <u>Practical work:</u> Quasi-static testing (long delay time).

Time: **10min**

In this test, the robotic finger will remain in the same position over a swell time.

Questions for the students:

i) Do you observe a relaxation of the sensor signal during the dwell time?



ii) Can you calculate the relaxation and compare for the two positions of the hinge (open and close)?

iii) Can the sensor be used for the monitoring of the position of the soft robotic hinge?