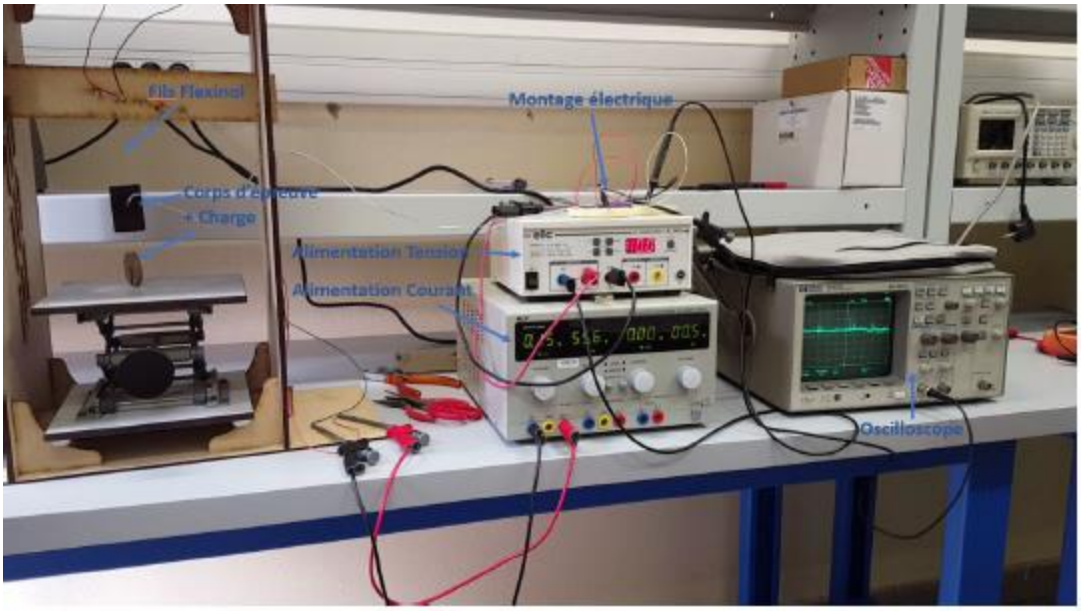
Proposal of thesis topic:

Design and Control of a Micro-Robot Actuated by Shape-memory Alloy Artificial Muscles

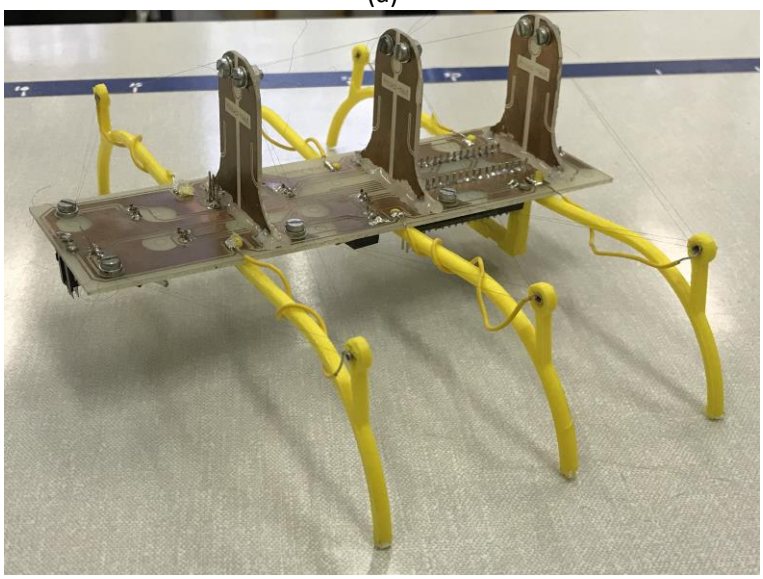
Shape-memory alloys are materials able to contract/extend when a variation of temperature is applied to them. The so-called NiTinol alloy is particularly interesting for micro-robotics because it can be used under the form of thin wires whose contraction is obtained by means of a current variation inside the wire. The axial resulting shape change gives to the NiTinol wire the characteristics of a true artificial muscle fiber. Although this material, whose commercial name is Flexinol, has already be used for applications in micro-surgery and micro-robotics, we think that work has still to be made in order to better specify its static and dynamic characteristics as an artificial muscle and to highlight its possible use according to an antagonist principle in order to get a revolute actuator on the model of the biceps/triceps system driving the elbow-joint.

In a first part of the thesis, the work will consist in developing an experimental set-up in order to characterize the contraction of different size NiTinol wires both in static and dynamic conditions. Static characteristics will be realized according to the so-called isometric experimental protocol peculiar to the physiology of skeletal muscle and dynamic characteristics will be realized according to the so-called isotonic experimental protocol also used in human physiology. The aim of this first stage is to specify the ability of the NiTinol wire to mimic both static and dynamic behavior of artificial muscle fiber. The ability of the NiTinol wire to behave according to the so-called Hill's curve will be especially analyzed. Figure 1.a shows the current state of the experimental set-up to be used and improved by the student.

In a second part of the thesis, the NiTinol wire will be used as an actuator of a micro hexapod robot. We already developed at the laboratory an autonomous version of the so-called Stiquito robot in which each leg is moved by a single wire set in antagonism with a passive flexible wire. During the thesis, it is expected that a true active antagonism can be performed for each leg, with two degrees of freedom per leg, in order that the micro-robot can move with a movement mimicking the walk of a real insect. The goal of this hexapod-prototype is not to be the smallest possible but, at the contrary, to show until which large scale it can be designed while embedding its battery and its controller. A control will be proposed in order to guide the robot in a constrained environment. This control will benefit from other works we realized in the laboratory on robots actuated by antagonist pneumatic artificial muscles. Figure 1.b shows the current state of the hexapod robot to be improved by the student.



(a)



(b)

Figure 1. Current state of the experimental set-up for characterizing the contraction of the NiTinol filament: a load is hang at the filament and its contraction is studied by means of an embedded laboratory-made strain gauge (a), Current state of the hexapod: each leg is actuated by a couple of filament responsible for an abduction-adduction movement and a flexion-extension movement – the electric battery is not embedded in this actual version of the robot (b).