Ph.D position offer - FEMTO-ST AS2M - 2021

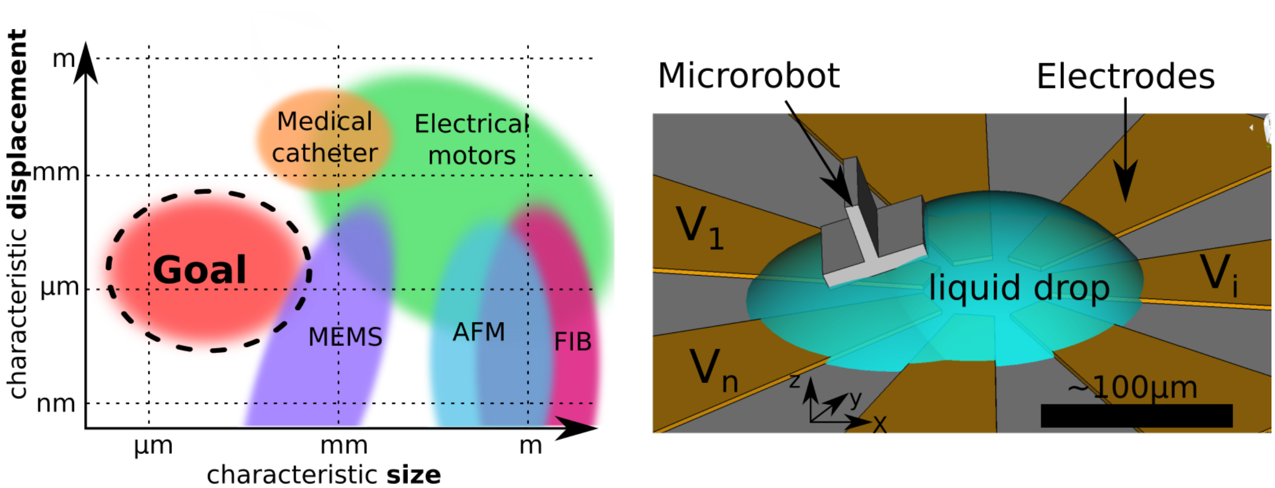
Surface Tension Forces for Compact Microrobotics

Thesis subject

Pushing the boundary of robot miniaturisation could answer the need for submillimetric surgical tools with less side effects. It would also allow innovative intervention as well as new treatment by manipulating cells in microfluidic environment (i.e. closed and submillimeter fluid networks used for research in biology). To make these applications possible, microactuators need to be compact with footprints inferior to a millimetre cube. However classical actuators lose their efficiency at small scale and different driving mechanisms have to be investigated. This thesis will answer this need by investigating the use of surface tensions forces, which becomes predominant at small scale, as a base of the actuation. This will allow the design and control of microactuators with better compactness while maintaining the high degree of freedom number required for complex tasks.

Contexte

The miniaturisation behind the millimetre cannot be achieved by a simple reduction in the dimensions of existing macroscopic components. Indeed, most physics effects such as gravity, magnetic force or friction have a different dependency with the dimension and therefore their relative importance depends on the system scale. Because of these scale effects, it is impossible to create efficient electric micromotors with a diameter of a hundred microns.



a) b)

Figure 1: a) Compacity of existing actuation means, b) Fluid joint schematic, the electrodes control the floating microrobot position and orientation by tuning the surface hydrophobicity and therefore the shape of the drop

Actuation at small scale is conventionally achieved with forces such as electrostatic [1] or piezoelectric forces [2]. Nevertheless, the compactness of these actuators (i.e. the ratio of their characteristic displacement to their characteristic dimension) remains low as illustrated in figure 1 a). Therefore to allow the development of robotic in confined environments of small dimensions, there is a need for micrometric actuators.

The use of surface tension forces at the interface between two fluids has enabled innovative approaches for micromanipulation applications. Surface tension forces evolve linearly with respect to the dimension, therefore they become largely predominant for microsystems. This advantage has made it possible to use capillary phenomena passively for self-assembly and origami like structure from millimetres to nanometres [3]. For example, the Robobulle [4] project which was developed at FEMTO-ST in collaboration with ULB has shown the ability to orient a millimetre platform placed on 3 drops by varying their volume. Electrowetting (a technology that allows the hydrophobicity of a surface to be changed with an electric potential) has been used to create millimetre motors driven by a matrix of microscopic drops [5] or to modify the surface of a simple drop allowing the rotation of an object floating on its surface [6] by succession of several equilibrium positions. Thus, the use of surface tension forces controlled by electrowetting techniques seems a particularly promising approach.

Thesis approach

This thesis will focus on designing a compact submillimetric actuator using a liquid joint to connect two objects by an interface between two immiscible fluids (for example water / air or water / oil) as illustrated by the diagram of the figure 1 b). Electrowetting will make it possible to control the wetted surface on the various electrodes, thus modifying the shape of the interface of the joint and therefore the position of free object floating on its surface to actuate it as a robot. The originality will be to consider the liquid joint as a 6 Degree of freedom platform by controlling the shape of the drop with a set of electrodes as shown in figure 1 b).

Goals

The thesis goals are the following

- Direct geometric model identification by defining by the function $f(V) = Q$ in order to allow the control of the floating microrobot in open loop. The impact of the geometry of the wetted surface and of the volume of the drop on the shape of f and in particular its linearity and its invertible character will be studied.
- Experimental electrowetting fluid joint device creation and characterisation with different geometries.
- Closed loop control with a visual feedback allowing precise control of the pose Q of the floating robot.

Environment

The thesis will take place in FEMTO-ST institute in Besançon, a leading multidisciplinary laboratory which gathers 750 people. The candidate will join the AS2M (Automatique System Micro-Mécatronique) department and will have access to micromanipulators, microscopes and microassembly station. He/she will also have full access to high level and state of the art resources in particular for microfabrication with the Mimento platform (800m2 dedicated to microfabrication). The necessary funding for buying equipment and attention national and international scientific conferences will also be available The gross salary will be of 1765.55 euros per month and starting date will be October 2021. The supervisors for the thesis will be Dr. Antoine Barbot and Dr. Aude Bolopion.

Requirement

We are looking for highly motivated candidates with the will to work in an interdisciplinary field and enthusiastic about stepping out of their comfort zone. Candidates should have an M2 degree or equivalent in at least one of the following topics : Robotic, Physic, Electronic, mechanical engineering or chemistry. Strong analytical skill is required, previous experience in scientific experimental setup and finite element simulation will be a strong asset but is not mandatory.

How to apply

To apply, please send a CV and motivation letter to Antoine Barbot and Aude Bolopion at : **antoine.barbot@femto-st.fr** and **aude.bolopion@femto-st.fr**

References

[1] M. González, P. Zheng, E. Garcell, Y. Lee, and H. B. Chan, "Comb-drive micro-electro-mechanical systems oscillators for low temperature experiments," *Review of Scientific Instruments*, vol. 84, no. 2, p. 025003, 2013.

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