A 1-year post-doctoral position is open in robotics and control at the "Institut des Systèmes Intelligents et de Robotique (ISIR)", Sorbonne University. The aim is to design and control a novel technology of compact fast nano-positioners for video rate AFM in correlative microscopy. The selected candidate will join the group “multi-scale interaction”.

The research work is related to the design and the control of flexure-based structures for fast multi-DOF nanoscale positioning.

1- Context

There is a specific need for microscopy methods able to reveal intracellular structures details and quantitative information with a high resolution [Usukura et al. 2016]. Such methods contribute to the flourishing field of cell mechanics. Several microscopy technics are well mature nowadays to address this specific need but each of them have advantages and drawbacks. Correlative microscopy [de Boer et al. 2015] showed itself to be an alternative to merge the best capabilities of two or more microscopy technics toward new ways of nano-structures observation. For instance, nowadays, the reference tool in the biology field is the CLEM\(^1\) microscope that combines a Fluorescence Microscope (FM) to highlight regions of interest on specimens and an Electron Microscope (EM) that gives a more detailed image with a much better resolution of these regions. To obtain additional data such as topography or biomechanical quantitative informations, the Atomic Force Microscope (AFM) is the must-have tool to be involved with a super resolution Light Microscope (LM) or with an EM [Janel et al. 2017].

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\(^{1}\) CLEM : Correlative Light-Electron Microscopy.
Correlative EM/AFM or LM/AFM has sparked a significant attention of the community due to the tremendous fields of applications and particularly for the observation of intracellular structures. This has been possible thanks to recently developed unroofing techniques of cells that have provided a unique way to view plenty of structures inside the cell (Fig.1) with an EM or with an AFM [Vassilopoulos et al. 2014] [Usukura et al. 2016]. The unroofing refers to breaking the cell membrane.

2- Objectives of the postdoctoral research

A Classical AFM as it was first invented [Binnig et al. 1986] consists in using a cantilever (Fig.2), imbedded at one end, and with a sharp vertical tip at the other one. The basic working principle of such a microscope consists in keeping the cantilever tip sample distance constant while scanning the surface. This initial setup also allowed some degrees of observation under an optical microscope.

Nano-positioners can either move the AFM tip or move the sample holder in X, Y and Z directions [Yong et al. 2012]. When a change in force is detected on the AFM tip, a Z axis displacement is required in order to keep the force at a constant value and therefore keeping
the tip-sample distance constant. The total controlled Z displacement signal is extracted and used to define the topography of the scanned sample.

One of the major downsides of correlative microscopy involving AFM is that it does not use the full potential that an AFM may offer mainly in terms of working range, scanning speed and degree of freedom. Robine project aims at proposing a breaking approach in correlative microscopy involving AFM based on high-speed poly-articulated micro-robotics operating in correlation with Electron Microscopes (EM) and Light Microscopes (LM).

![Fig.3 Example of a XY flexure-guided nano-stage developed in ISIR [Bazaei et al.2019].](image)

The first objective of the postdoctoral research is to design a novel technology of multi-dof fast nano-positioners for high-speed video rate AFM in correlative microscopy. The design must fill specifications to be compatible with electron microscopy. Structures based on flexure-guided nano-positioners actuated by piezoelectric actuators [Bazaei et al.2019] (Fig.3) and/or actuated by electrostatic actuators with MEMS² technology [Maroufi et al. 2017] can be investigated. The second objective depending on the skills of the candidate is to control the designed positioners in closed loop for video rate AFM.

The reader can refer to the following publications to see some works in this field at ISIR [Bazaei et al.2019] [Cailliez et al. 2019] [Liang et al. 2019] [Boudaoud et al. 2018] [Abrahamians et al. 2013] [Acosta et al. 2013] [Xie et al. 2012].

3- Applications to biology

The selected candidate will have an access to muscular cells with a specific preparation for EM and AFM observations (Fig.1). The cells preparation will be made by researchers at the institute of Myology inside la Pitié-Salpêtrière hospital, Paris.

4- Partners of the project

The project is deeply related to flexible robotics design and control. It will be performed at the "Institut des Systèmes Intelligents et de Robotique (ISIR) UMR 7222". The selected candidate will also collaborate with researchers and engineers from the “Centre de recherche en Myologie (UMRS 974)” whose main skills are in the analysis of myopathy muscular disease and in the unroofing technique for cells preparation.

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5- Environment

The Institute for Intelligent Systems and Robotics (ISIR) is a multidisciplinary research laboratory that brings together researchers and academics from different disciplines of engineering sciences, information and life sciences. The ISIR is a joint research laboratory (UMR7222) which belongs to Sorbonne University and the Centre National de la Recherche Scientifique (CNRS). The "multiscale interactions" team in ISIR has a profound experience in microrobotics including among others multiphysics modeling, Atomic Force Microscopy (AFM) based nanorobotics, control of robots at the small scales and haptics. Research activities of this team have been published in several well-known international conferences and selected journals and have been rewarded many times. The division was involved in several research projects such as the European Research Council (ERC) PoC "RELAX".

ISIR is located in the center of Paris (Quartier Saint-Victor, the 5th district of Paris), in the Pierre et Marie Curie Campus of Sorbonne University. At the Place Jussieu, the Pierre and Marie Curie campus houses the majority of the laboratories and classrooms used by the Faculty of Sciences, in addition to libraries and student dedicated spaces. With the 90-meter-high Zamansky Tower at its heart, this campus alone covers an area of 400,000 square meters. The roots of Sorbonne University trace back to the medieval University of Paris. Founded in the mid-12th century, it quickly achieved the stature and prestige that have remained undiminished ever since. The Collège de la Sorbonne, officially founded in 1257, underwent a substantial overhaul in 1885, and then the May 1968 protests brought about the decision to divide the institution into 13 autonomous universities. Among these are Université Paris-Sorbonne and Université Pierre et Marie Curie, now reunited.
6- **Required skills**

We are seeking a highly motivated candidate with skills in CAD mechanical design, control and robotics and with a particular affinity to experimentations. An experience in micro-robotics and AFM will be highly appreciated.

**Applications should include a detailed CV, a motivation letter, a link to the Ph.D. thesis and two referees (name, institution, email address). The documents must be sent in a zipped format to mokrane.boudaoud@sorbonne-universite.fr**

7- **References**


