phD Thesis offer
Microswimmer from theory to experiments

Keywords : Control and optimal control for finite dimensional system, Micro-swimming, Predictive control, Experiments.

Subject: The aim of the phD thesis is to study the maneuverability of micro-robot in water with its optimal aspect. The originality of this thesis consists in the fact that The phD student will work at the edge between the theoretical aspect of the microswimming by using the control theory and the experimental one.

At this length scale, locomotion presents a different set of challenges compared with those encountered by macroscopic robots. Most microorganisms live in fluid environments where they experience a viscous force that is many orders of magnitude stronger than inertial forces. This is known as the low Reynolds number regime characterized by instantaneous and time-reversible flows that are described by the time-independent Stokes equation.

A recent promising technique resides in using an external magnetic fields to act on a magnetized micro-object by creating an external force or torque. The robot experiences a deformation and then moves without requirement for chemical fuel or motor.The internship focuses on a model which consists in a head and a flexible magnetized filament (see [1, 2, 4]). A recent study [3] shows that a simplified model parametrized by one shape variable is controllable by using an external magnetic fields.

One of the main objectives is to confirm this controllability theoretical result by proposing experiments which are in good agreement with these predictive result.

An other purpose is to study the optimal command which allow the micro robot to move as far as possible. This latter aspect contains a significant numerical analysis with the using of several tools as Matlab, and other open softwares developed by INRIA as Bocop and Hampath and still an important experimental part.

Contacts:

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Practical aspects: The phD takes place between INRIA, Sophia-Antipolis within the team McTAO and ISIR, UPMC, Paris.

Eligibility criteria: He/she should have a background in applied mathematics (Control theory, PDE, Numerical method in optimal control). Candidates should be interested in interactions between mathematics and automatics will be especially examined.

Work conditions: A post-doctoral fellow will receive a brut salary of €1600 per month and benefit from health insurance and social coverage. He/She will participate to the scientific activities of the project (seminars, workshops). Some funding will also be available to participate in scientific events related to the topic.

Application process: Applicants should comprise:

1. a personal letter of application,
2. a detailed curriculum vitae
3. Names, affiliations and contact details of two persons who will write reference letters.

Applications should be sent to Stéphane Régnier,Laetitia Giraldi Jean-Baptiste Pomet

Deadline for applications: Deadline for applications: June 31th. It is encourage to candidate as soon as possible. For any further query, please send a message to one of the above addresses.

References :

[1] F. Alouges, A. DeSimone, L. Giraldi, M. Zoppello. Can magnetic multilayers propel artificial micro-swimmers mimicking sperm cells ? *Soft Robotics*, 2(3): 117-128, 2015.

[2] R. Dreyfus, J. Baudry, M. L. Roper, M. Fermigier, H. A. Stone, and J. Bibette. Microscopic artificial swimmers. *Nature*, 437: 862–865, 2005.

[3] L. Giraldi, J.- B. Pomet. Local controllability of the two-link magneto-elastic swimmer. Accepted in *IEEE: Trans. Autom. Control.* , 2017.

[4] Ye, Zhou and Régnier, Stéphane and Sitti, Metin Rotating magnetic miniature swimming robots with multiple flexible flagella. *IEEE Trans. Robotics* , 2014.