Collective motion in complex flows

When a system of many individuals is under stress, whether seeking resources or avoiding threats, its survival depends on its ability to collectively move towards a specific objective. In many cases, either the objective itself or the environment in which this locomotion occurs is fluid, examples include large systems like human populations migrating in response to climate change, or microscopic systems like viruses navigating through the body to infect host cells. These complex events are often difficult to study directly due to their infrequency, experimental complexity, or the many scales involved. A large scientific community is currently working on solutions to better model and predict these collective motions [1].

This project aims at understanding how cooperation between many individuals enables efficient locomotion towards an objective in a complex flow. The student will join an ongoing project involving PhD students and PIs and combining experimental, numerical and theoretical approaches. He/She will perform experiments with minimal robots (Fig. 1) programmed to follow streamlines of a flow. He/She will use tracking algorithms to characterise how collective interactions within a flow enable efficient transport towards an objective. He/She will develop models that integrate fluid mechanics and chemotaxis theories, and, from there, open the way for improved predictions of large-scale population movements.

The internship could progress into a PhD aiming at developing a complete understanding of collective motion in complex flows, pending successful grant approval from the doctoral school.

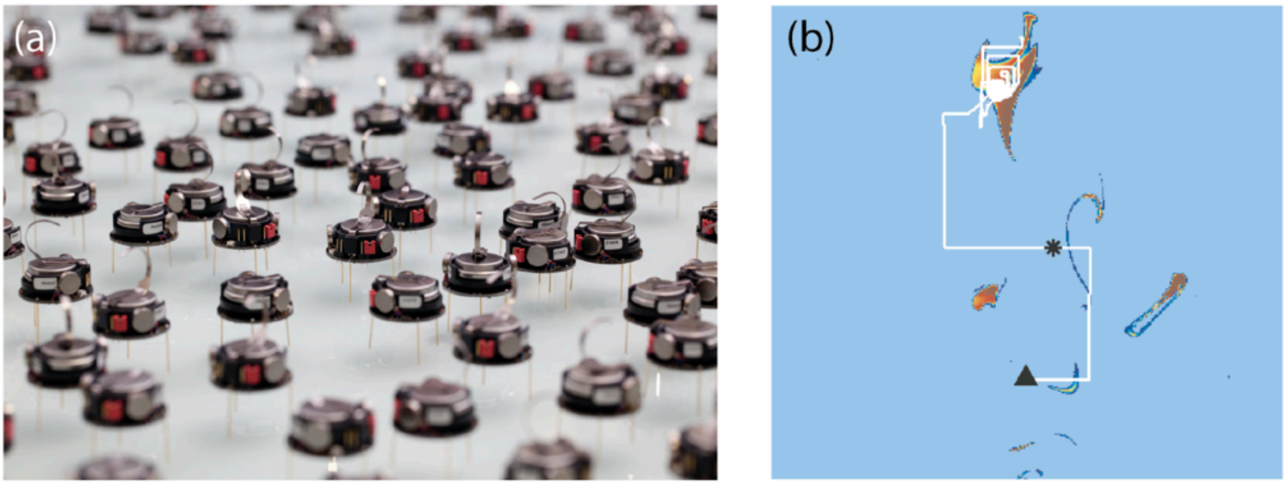

Fig. 1: (a) A swarm of elemental robots [2]. (b) Numerical simulations of the displacement of one unit towards information (depicted by the color gradient) [3].

<u>Internship informations:</u>
Duration : 5-6 months
Grant : 600 euros per month
Degree : from L3 to M2 Starting from February 2025.
Location : IRPHE, 49 Rue F. Joliot Curie 13013 Marseille
Contact: Martin Brandenbourger (martin.brandenbourger@univ-amu.fr), Emmanuel Villermaux (emmanuel.villermaux@univ-amu.fr)

<u>References:</u>

[1] Shaebani, M. R., Wysocki, A., Winkler, R. G., Gompper, G., & Rieger, H. (2020). Computational models for active matter. Nature Reviews Physics, 2(4), 181-199.
[2] Rubenstein, M., Cornejo, A., & Nagpal, R. (2014). Programmable self-assembly in a thousand-robot swarm. *Science*, *345*(6198), 795-799.
[3] Vergassola, M., Villermaux, E., & Shraiman, B. I. (2007). ‘Infotaxis’ as a strategy for searching without gradients. *Nature*, *445*(7126), 406-409.