

Collective motion based on deep reinforcement learning

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. 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]. At IRPHE, researchers use deep reinforcement learning to allow the agent to infer the underlying structure of its environment. Through simulated trial and error, the agent learns an optimal strategy to adapt its trajectory and reach its target despite extremely limited visibility.

This internship aims at implementing this approach on physical robots in order to evaluate these behaviors under real-world conditions. The candidate will learn to program the robotic platform (Fig. 1) and conduct a series of experiments to evaluate its performance. The student will join an ongoing project involving PhD students and PIs and combining experimental, numerical and theoretical approaches. 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.

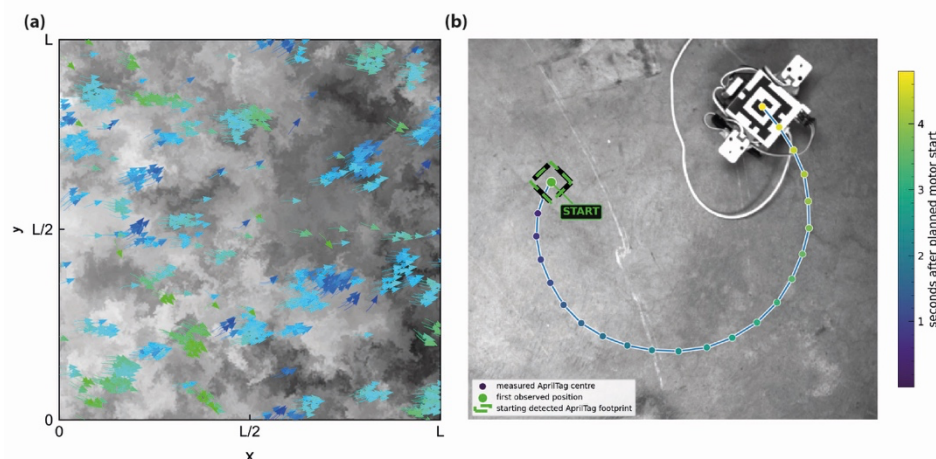


Fig. 1: **(a)** A numerical simulation of a swarm of elemental robots [2]. **(b)** Picture of a robot navigating via phototaxis.

Internship informations:

Duration : 5-6 months

Grant : 600 euros per month

Degree : from L3 to M2 Starting from February 2026.

Location : IRPHE, 49 Rue F. Joliot Curie 13013 Marseille

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References:

- [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.