This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 101035813

Nature-mimicking intelligent micro/nanorobots

Mario Urso[1]

[1] *Department of Physics and Astronomy "Ettore Majorana", University of Catania, and IMM-CNR, via S. Sofia 64, 95123 Catania, Italy*

Nature provides a plethora of stimuli-responsive and self-organization phenomena, where biological systems manifest adaptive reactions and global patterns resulting from the interactions between its constituents and the surrounding environment. These intricate behaviours serve as a source of inspiration for the development of nature-mimicking micro/nanorobot swarms to solve specific challenges beyond individuals' capabilities. Micro/nanorobots are obtained starting from micro/nanomaterials by introducing the motion feature and increasing intelligence in terms of programmable functions, tactic and collective behaviours.[1] Inspired by the diel vertical migration of crustaceans, photogravitactic MXene-derived layered microrobots capable of light-driven self-propulsion in the three-dimensional (3D) space can rapidly capture suspended nanoplastic pollutants in water by programmable electrostatic interactions, and be magnetically transferred to miniaturized electrodes to detect and quantify nanoplastic particles, offering a practical strategy for on-site screening of nanoplastic-polluted waters.[2] Cooperative actions of animal groups, such as the self-organization of fire ants into "living" bridges to march across gaps or floating rafts to survive floods, inspired the reconfigurable, reversible, and active self-assemblies of photocatalytic magnetic Fe_2O_3-based microrobots into planar or linear structures, triggered by light-induced attractive phoretic or magnetic interactions between microrobots, enabling advanced methods in biological cargo transport and water purification.[3] Mimicking the synchronized motion of fish schools and bird flocks, metamachines of magnetic microrobots are magnetically navigated as a synchronized group of microrobots in narrow microfluidic channels, emulating blood vessels, and disperse "on-demand" to maximize the volume of operation, opening new possibilities in biomedicine. These insights pave the way for transformative approaches in diverse applications, promising profound societal and environmental impact.

[1] M. Urso, M. Ussia, M. Pumera, *Nature Reviews Bioengineering* **2023**, *1*, 236–251.
[2] M. Urso, M. Ussia, F. Novotny, M. Pumera, *Nature Communications* **2022**, *13*, 3573
[3] M. Urso, M. Ussia, X. Peng, C. M. Oral, M. Pumera, *Nature Communications* **2023**, *14*, 6969