LadHyX Seminar – June 12th, 11:00

Alexandros Anastasiadis
(EPFL, Switzerland)

Role of kinematics, vorticity and sensing for single and collaborative undulatory swimming

Undulatory swimmers, such as eels, achieve efficient propulsion through complex body motions and fluid interactions. In this talk, I explore how kinematics, flow structures, and sensory feedback shape performance, measured in terms of speed and cost of transport, in both single and collective swimming using our bio-inspired robot, 1-guilla. First, we characterise the role of body kinematics under free-swimming conditions. Waveform parameters such as amplitude, wavelength, and frequency are varied to identify a trade-off between speed and efficiency. We highlight a key metric, the specific tail amplitude, that describes optimal stride length, and we quantify how travelling wave-like kinematics favour efficiency. Second, we examine how tail stiffness influences performance and flow structures. Particle image velocimetry is used to analyse flow structures around the body and in the wake. We characterise the flow patterns of vorticity and show how the tail rigidity and body undulations must co-adapt for efficient swimming. Finally, we turn to collective swimming and the role of sensing. In a simplified schooling scenario, 1-guilla swims in a vortex street generated by an upstream oscillating foil. A bio-inspired controller based on stretch feedback enables frequency and phase locking to the incoming vortices, suggesting a mechanism for energy saving in schools. Together, these studies illuminate how tuning kinematics, morphology, and sensing enables robust and efficient undulatory locomotion.