Design of a Mussel-Inspired Passive Underwater Robot for Littoral Sensing and Transport

Laboratory of Sustainability Robotics (LSR) — Dr. Luca Romanello

Description

Mussels have evolved shell shapes that provide stability, controlled drift, and passive reorientation in underwater currents. Their compact geometry, density distribution, and surface features allow them to settle, tumble, or relocate with minimal energy. This project explores how these principles can inform the design of a **mussel-inspired passive robot**.

The goal is to study real mussel morphology and hydrodynamics, extract shape-based mechanisms for motion and reorientation, and design a biodegradable robotic body that moves using natural currents rather than active propulsion. The robot will also leverage the **littoral zone**—the region between high and low tide—where changes in temperature, humidity, pressure, and light can act as natural triggers for deployment, anchoring, or activation.

This work sits at the intersection of bioinspired design, hydrodynamics, and sustainable robotics, aiming to develop a low-energy platform for distributed littoral and underwater environmental sensing.

Work packages

WP1 Study mussel shell morphology (3D scanning, cross-sections, density, roughness) and characterise hydrodynamic behaviour under different flow regimes.

WP2 Model passive locomotion modes (drift, reorientation, tumbling, flipping) using CFD and physical tank experiments.

WP3 Design and prototype a mussel-alike robotic body using biodegradable materials and integrated passive/low-power sensing modules.

WP4 Explore littoral zone triggers (light, temperature, humidity, hydrostatic pressure) for passive activation, anchoring, or deployment.

WP5 Test the system in controlled tanks and natural littoral conditions, evaluating drift patterns, robustness, and sensing performance.

Figure 1: Mussel shell morphology provides natural mechanisms for passive transport and reorientation.

About us

The Laboratory of Sustainability Robotics (LSR) at EPFL and EMPA.
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Requirements

- Background in robotics, mechanical engineering, marine biology, or environmental engineering.
- Experience in CAD design, materials, hydrodynamics, or underwater devices is beneficial.
- Interest in bioinspired morphology, passive mechanisms, or ecological robotics.

Application

- CV and motivational letter.
- Transcript of records.
- Portfolio or project examples.
- Short statement on your interests and experience.

Timeframe

Start date flexible; earliest star