Empa EPFL
Laboratory of Sustainability Robotics

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Student:	Name:	
	Student ID:	Departement:
	University: EPFL	
Thesis:	Title: Mycelium-wood hybrid soft sensors for transient soft robotics	
	Kind of Thesis:	Semester: SS or FS 2026
Supervisor:	Prof. Dr. Mirko Kovac	
Advisor:	Dr. Kyung-Sub Kim	
Co-Advisor:		

Start of the Project:	01.03.2026
Deadline delivery final report:	31.08.2026

Introduction

The adoption of biodegradable materials in electronics and robotics can help mitigate the ecological footprint caused by the multidisciplinary applications of intelligent devices. In this context, transient robotics composed of biodegradable materials has attracted increasing attention, offering potential applications in various fields such as medical robotics, environmental exploration, and agriculture [1].

For intelligent tasks performed by transient robots, sensors providing feedback from external signals are essential. Accordingly, platforms integrating transient sensors and actuators have been reported, such as gelatin hydrogel soft robots incorporating zinc/gelatin-based pressure sensors [2] and PLCL soft robots with Si nanomembranes-based temperature sensors [3]. However, these approaches often require the use of various organic solvents during sensor fabrication, involve expensive raw materials, or demand high energy input, all of which reduce sustainability from an eco-cycle perspective. In particular, the degradation of biodegradable materials caused by ambient moisture during fabrication necessitates additional encapsulation layers. Furthermore, the ecological toxicity of inorganic materials such as zinc and silicon remains unclear due to the lack of comprehensive studies on their byproducts in soil or marine environments.

Meanwhile, with the recent rise of bio-hybrid materials, mycelium-based hybrid materials that generate electrical signals in response to external stimuli have attracted attention as sensing components [4,5]. Integrating sensors made from **mycelium–wood hybrid materials** into transient robots offers potential solutions to the issues mentioned above, including **low production costs, minimized fabrication steps through self-growing, inherent encapsulation capabilities via the naturally produced melanin layer, and negligible ecological toxicity upon natural degradation**.

However, several fundamental questions remain unanswered. It is still unknown whether mycelium can grow effectively in biodegradable polymer molds, whether the melanin layer on the mycelium network provides water resistance comparable to conventional encapsulation materials, and over what distance the mycelium network can transmit electrical signals in response to external stimuli. Therefore, this project aims to address these gaps by **investigating mycelium cultivation, characterizing the resulting material properties, optimizing sensor design, and ultimately developing processes for integrating mycelium-based sensors into transient actuators.**

Objectives

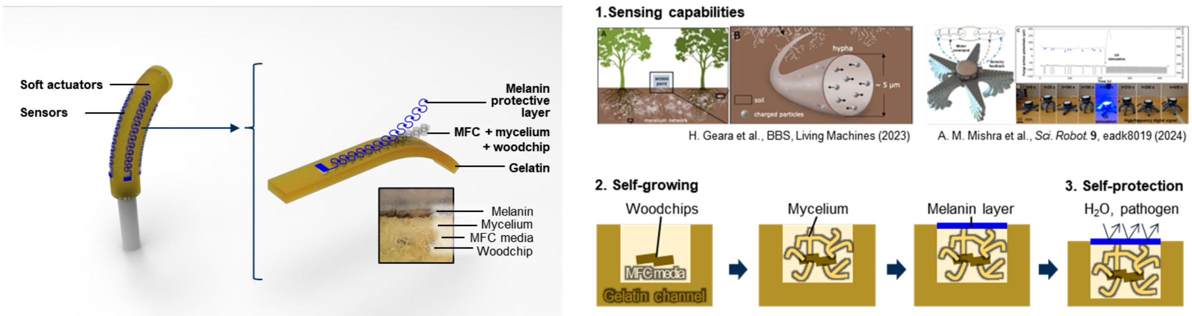

Figure 1. Exploded-view of a proposed transient soft actuator integrated with a mycelium–woodchips hybrid sensor (left). The right panels schematically illustrate the characteristics of the mycelium–woodchips hybrid sensor.

The primary goal of this project is to **<u>optimize the fabrication process of mycelium–woodchip materials and to develop integration processes with biodegradable soft actuators</u>** (Fig. 1). Depending on the progress of the project, the student may further work on sensor design, sensor performance evaluation, and feedback control of soft robots using the developed sensors.

Work breakdown

The work will be subdivided in the following tasks:

<u>Surveying of literature:</u>
The student will first study the fabrication methods of mycelium-hybrid composites. Next, the student will learn about the types of mycelia that induce changes in electrical signals in response to external stimuli, as well as the methods for measuring these electrical signals. Finally, the student will study the characteristics of the melanin layer and its role as an encapsulation layer in electronic devices.

<u>Fabrication:</u>
The student will culture mycelium by fabricating composites composed of MFC media, fungal strains, and woodchips using equipment (Fig. 2).
The student will produce molds based on PGS or gelatin hydrogels and verify whether mycelium can be successfully cultured within these molds.
The student will develop methods to induce the formation of a melanin layer on the mycelium.

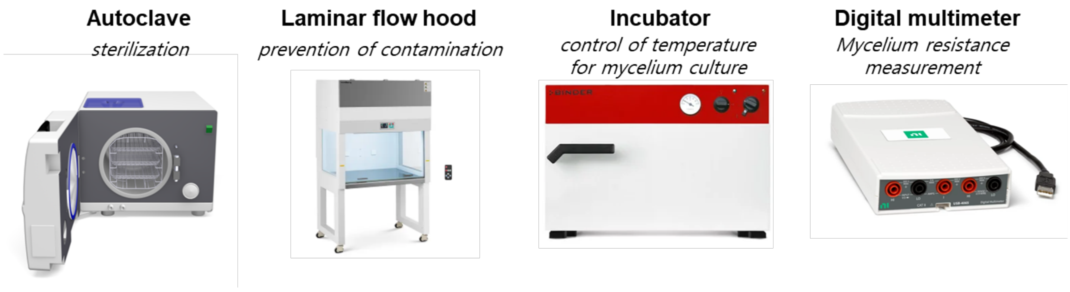

Figure 2. The equipment required for mycelium-woodchip composite-based sensors for transient actuators.

<u>Characterization:</u>
The student will characterize the mechanical properties and electrical activity of the composites, which vary depending on the type of fungal strain and woodchips used. Additionally, the student will evaluate the water permeability and durability of the melanin layer.

<u>Integration:</u>
The student will integrate sensors made from the composites onto biodegradable pneumatic actuators. Depending on the progress, this may include robotic control based on feedback from the electrical signals.

The work location will be the Laboratory of Sustainability Robotics at EPFL (Lausanne) and will be conducted in collaboration with Empa (Dübendorf, Zurich). The formal supervision will be performed by Prof. Mirko Kovac. The project starting day would be discussed with Kyung-Sub Kim.

Requirements

The student belongs to EPFL ENAC or STI.
The student is motivated to work on an interdisciplinary research topic encompassing material/electrical/environmental/mechanical science & engineering.

Bibliography

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[5] A. K. Mishra, J. Kim, H. Baghdadi, B. R. Johnson, K. T. Hodge, and R. F. Shepherd, Sensorimotor control of robots mediated by electrophysiological measurements of fungal mycelia. *Sci. Robot.* **2024** 9, eadk8019

Lausanne, 29/01/2026

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Co-Advisor:	Student:
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