Dafne’s skin
Microbially induced, robotically controlled patinas

a project by
MAEID [Büro für Architektur & transmediale Kunst]
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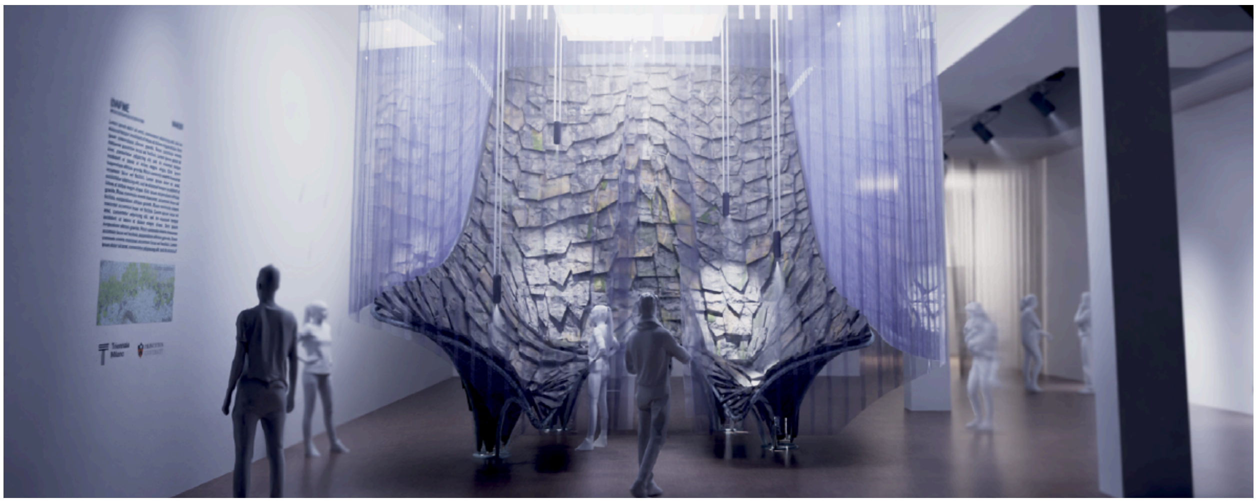
More information on www.dafnesskin.com and press images can be found here → LINK



"Dafne's skin" draws inspiration from the myth of Dafne, a nymph transforming herself into a tree, moving from the anthropogenic to the organic. In his famous sculpture -Apollo and Daphne- Bernini freezes the metamorphosis of Daphne in marble, her fingers sprouting leaves and her feet turning into roots. "Dafne's skin" shows a fragment of Dafne's transition: an enlarged cut-out of her skin that slowly changes throughout the exhibition through a robotically controlled, microbially induced patina. Patina—typically seen as a sign of decay—becomes the object of desire. It is cultivated, shaped, and choreographed in time, changing the appearance of the structure throughout the exhibition.

The project defines architecture as a living, ecological system transformed through dynamic interaction between machines, microbes, materials and humans. In contrast to traditional building systems, "Dafne" views architectural envelopes as organic interfaces. The project considers patina and biological growth—not as signs of deterioration but as active contributors to aesthetic, functional, and ecological enhancement.

Wood - at the core of the installation - is a biologically active material that continuously interacts with its environment, gradually changing its appearance. On the light brown wooden tiles, the microalgae *Tetradesmus deserticola* is cultivated and grown in symbiosis with the bacterium *Azospirillum brasilense*. Together, they form a dynamic, vibrant layer of deep green colour.
The growth of the bacteria and microalgae is supported by four robotic "geographers" that constantly observe and measure the bacterial growth and an environmental system that adapts its behaviour depending on the needs of the microorganism. Based on this data, the robotic geographers, with their choreographed movements, regulate the environmental factors (humidity and light) in real time so that an adaptive, self-regulating patina forms on the wood surface. Through this, "Dafne" challenges the

conventional notion that biological changes signal decay and demonstrates how natural development processes can be harnessed for aesthetic and functional purposes.
The project consists of these four main components: a living patina on robots that monitor the patina and visitors, an environmental system to help the growth of bacteria and an audio-visual installation. All elements are linked with a distributed control system that manages real-time communication, synchronization, and decision-making. Sensor data is continuously acquired and processed, allowing the system to adapt its behaviour dynamically.

Living Patina

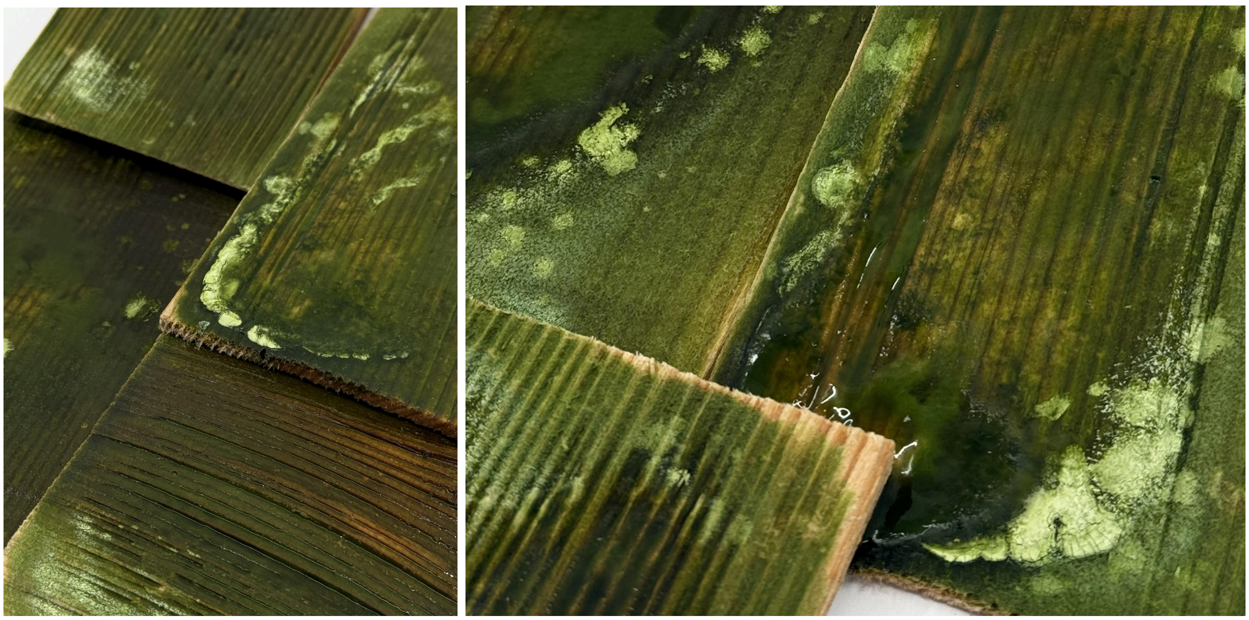


Fig. 1: Close-up of wooden shingles coated with a vivid green microbial patina, showing active growth of Tetradesmus deserticola and Azospirillum brasilense.

The living patina on 'Dafne's skin' is created using a microbial paint. Such paint is based on a hydrogel that acts as carrier for two terrestrial microorganisms. The micro-organisms - *Tetradesmus deserticola and Azospirillum brasilense* - characterising the microbial paint were selected for their environmental resilience and complementary traits.

Azospirillum brasilense is a nitrogen-fixing bacterium commonly used in natural soil fertilization. It enriches its microenvironment and supports microbial growth. Though its natural habitat is the area near plant roots, in this installation it plays a supportive role by fostering a nutrient-rich environment for *Tetradesmus deserticola*. It can also indirectly limit the growth of other microorganisms by competing with them for space and resources, creating favorable conditions for the intended species to thrive.

Alongside it, *Tetradesmus deserticola*—a soil-dwelling microalga native to the Western United States—forms the visible green layer of the patina. Adapted to extreme dryness, this alga can survive repeated drying and rehydration cycles, resuming photosynthetic activity quickly after exposure to moisture. These properties make it well-matched to the rhythms of the robotic caretakers, which nurture the surface with periodic misting to sustain microbial life. By mimicking natural moisture cycles, the system supports the alga's metabolic activity and encourages its continued growth on the structure.

To apply the initial layer of microorganisms, the wooden shingles were first sterilized and then coated with a specially developed hydrogel-based formulation created at ETH Zurich. This hydrogel helps the microbes adhere to the surface and retains moisture, creating a supportive environment for their growth. Rather than sealing the surface with a fixed finish, this process introduces a living layer that changes over time. From this controlled beginning, the microorganisms gradually transform the appearance of the wood—its colors, patterns, and textures shifting in response to environmental cues and their own biological activity.

Structure and digital fabrication

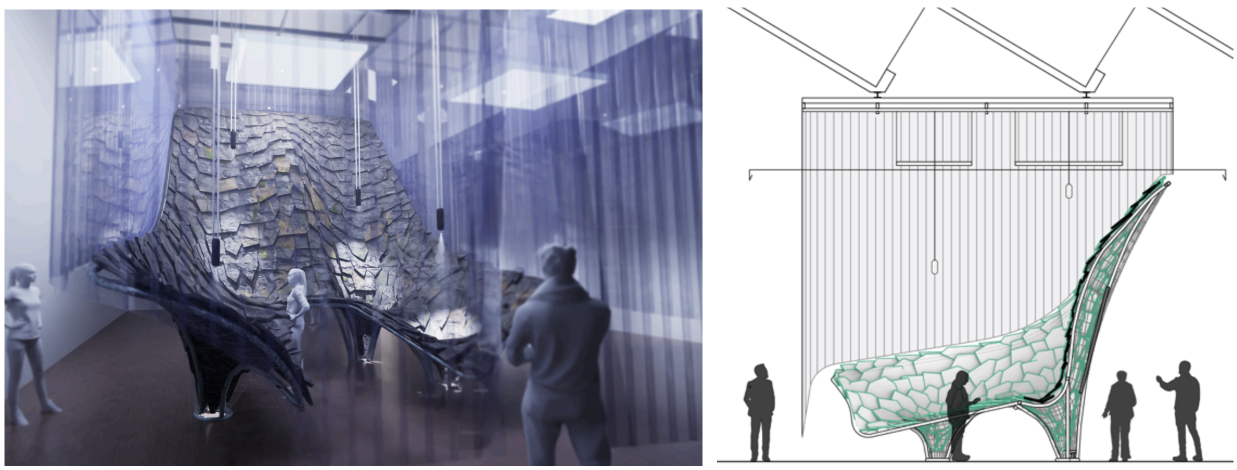


Fig.2: A canopy covered with hand-split larch shingles is supported by a steel frame and monitored by four cable robots suspended from an overhead grid. Grow lights and sprinklers create optimal conditions for microbial growth.

The wooden canopy is held by a 3-dimensional network of tubular steel elements and wrapped in a stainless steel mesh. The steel mesh is covered with 2000 hand-split larch shingles, which provide a breeding ground for bacteria and microalgae. A steel grid is suspended above the free-form structure to support the project's infrastructure. Growing lights and sprinklers ensure that the bacteria have ideal growing conditions. Four cable robots are lowered from the grid in different choreographies to observe the structure. The cable robots are each equipped with cameras, lights, and a loudspeaker. At the back of the structure screens visualize data from a distributed control system in two ways. First, in an architectural drawing style, imagining a building system from a different angle and second an abstract visualization of microscopic images of the bacteria using CGI images and machine learning.

An augmented reality (AR) workflow was developed to improve the design and shingle laying process with an unknown material stock. The 2,000 larch shingles covering the steel mesh were split by hand, resulting in various shingle widths between 5 and 16 cm. The exact geometries of the individual shingles were unknown until the build-up on-site. Therefore, a fast design and fabrication logic had to be set up that allowed us to re-compute the design based on the available materials. We also needed an AR system that allowed multiple workers to work collaboratively to lay shingles in a predetermined sequence to avoid construction errors.

On-site, each shingle was digitally registered using an image processing algorithm. An operator monitored the process and corrected errors via a smartphone-based interface to ensure accurate registration. Once registered, the digital data of each shingle was integrated directly into the computational design model, with design parameters dynamically adjusted to match the available materials accurately. Assembly steps were then generated from the design model, and instructions were provided via an AR interface. Workers viewed the instructions via head-mounted devices (HMDs), allowing them to work hands-free. The structure was assembled in teams of two, each accessing a shared cloud-based model. This ensured all teams worked from the same up-to-date information, reducing construction errors by clearly communicating the required assembly steps and sequences. Progress was monitored and supervised on-site and remotely through a smartphone-based AR application.

Fig.3: A worker wears an AR headset to follow real-time assembly instructions for placing irregular wooden shingles, guided by a shared digital model on-site.

Visual and audio concept:

The visuals function as real-time aesthetic representations derived from the sensory and perceptual processes of the autonomous robotic agents operating within the living environment. Rather than offering a documentary record of the bacterial colony's current state, these visualizations attempt to pre-construct—or "predict"—a possible condition of the microbial ecosystem, as inferred from the robots' situated perceptions and embedded computational models.

Central to this system is a dataset compiled from physical samples of the bacterial culture collected at various stages of its development through a micro-camera. This dataset informs the generation of big batches of precomputed CGI imagery that represent four distinct evolutionary phases of the colony. These synthetic visual states are selected and visualized autonomously by the system in real time, based on roughness and color data extracted via machine vision, as well as behavioral data from the robotic agents. As the robots navigate the environment, their sensor inputs serve as parameters that shape the selection of the colony's hypothesized condition.

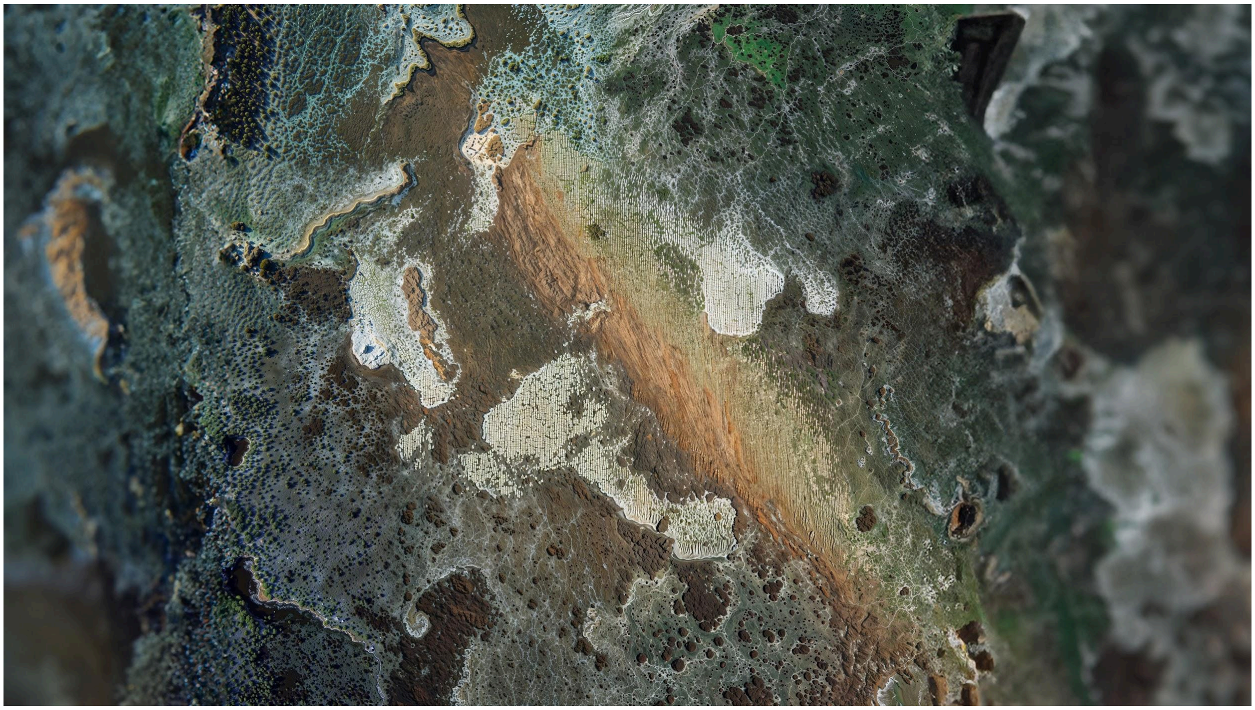


Fig.4: CGI image of bacterial growth generated using AI, visualizing microbial textures, colors, and surface patterns as part of the system's data-driven interpretation of the living patina.

What emerges is not a photograph or a simulation in the conventional sense, but a real-time computational visualization of microbial life, scaled between 100:1 and 500:1, produced through a complex interplay between machine vision, robotic movement, and aesthetic decision-making processes encoded into the system. The video, then, does not show what is, but what might be perceived in that precise location, under those precise conditions.

The audio component of the installation is conceived as a distributed, real-time sonic system that operates in direct relation to the spatial, visual, and behavioral dynamics of both the robotic agents and the surrounding environment. Four mobile speakers, each mounted on an individual robotic unit, are complemented by two stationary speakers positioned adjacent to the visual displays. This networked configuration produces a decentralized, spatialized acoustic field that reflects the state of the ecosystem as perceived and enacted by the robotic agents.

Each mobile speaker receives data streams pertaining to the immediate data input of its respective robot—interpreted via onboard machine vision—but also to its behavioral parameters, such as velocity, orientation, and interaction with the built-in irrigation apparatus. These variables are integrated into a custom-built Max/MSP patch employing granular synthesis engines and machine learning–generated speculative samples. Such synthesized audio is in dialogue with the mechanical and organic sounds produced by the ecosystem itself. The hissing of irrigation sprays, the subtle friction of robotic components, the pulsing of hydraulic pumps, and the ambient textures of the environment are all folded into the perceptual field of the listener. Non-designed, yet materially grounded sonic events interact with the generative audio output, producing a composite soundscape in which machine-generated speculation and environmental actuality resonate together.

The result is a continuously evolving auditory field in which robotic speed, visual texture (including the roughness and chromatic profile of the bacterial cultures), and systemic interactivity give rise to resonances, phase relations, and complex polyrhythmic structures. This approach positions sound not as supplementary to visual representation but as a parallel epistemological layer: a non-verbal, non-human mode of ecological speculation.

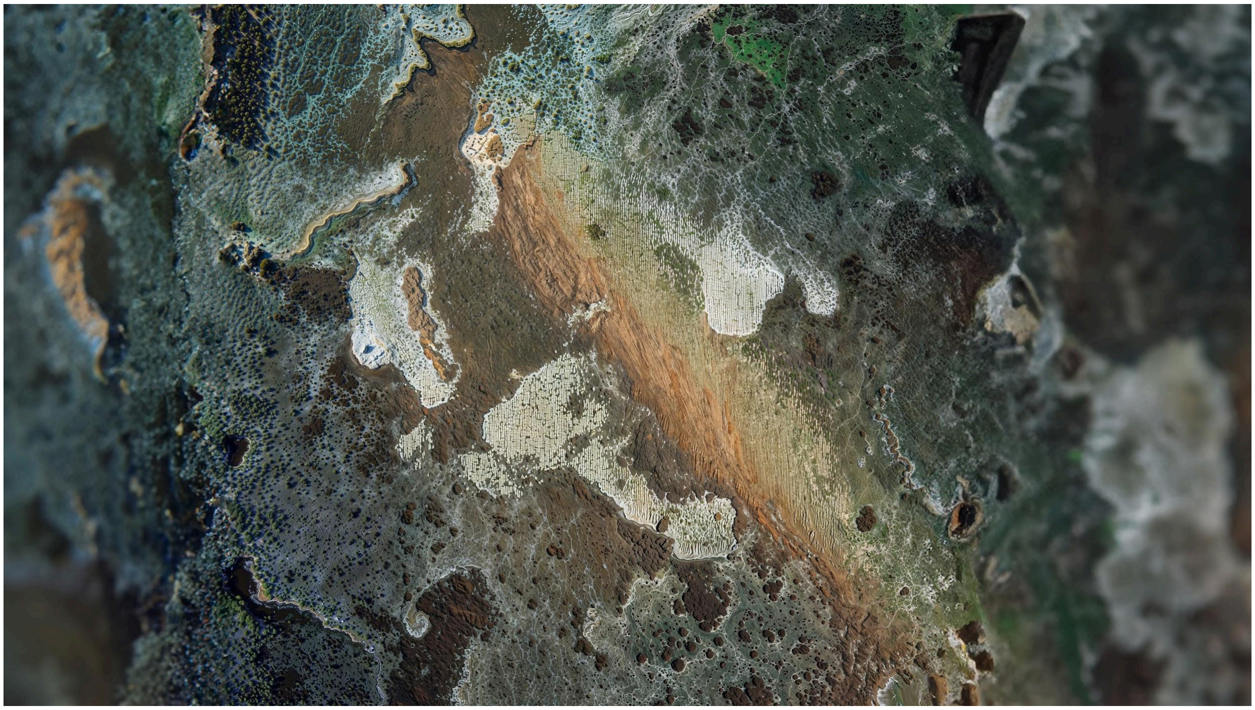


Fig.5: Auditory interface to sonify in real-time robot movement and system interactivity

Software architecture and robotic control:

The software architecture for ‘Dafne’s skin’ is a distributed control system designed specifically for the installation. It coordinates all robotic and environmental components through a modular architecture that manages real-time communication, synchronization, and decision-making. Sensor data is continuously acquired and processed to drive event-based logic, allowing the system to adapt its behavior dynamically. Each subsystem operates as a networked node, orchestrated through a central framework that ensures coherent responses and precise timing across the entire installation.

Four robots, suspended from cables on a grid, continuously monitor the structure, the presence and movement of museum visitors, and the growth of the bacteria. When the system detects that the bacteria are not thriving, environmental conditions—such as light, humidity, and nutrient levels—are automatically adjusted. Visitor interaction plays a key role: the more people engage with the bacteria, the more their growth is encouraged.

These monitoring actions occur at regular intervals, marked by synchronized movements of the robots. During each of these intervals, a digital scan of the structure is generated. Using image processing and AI, we analyze color tones, surface roughness, and object recognition to assess the interaction between humans and bacteria. Based on this analysis, environmental conditions are updated, and sprinklers are activated when additional nutrients or moisture are needed.

Credits:

A project by MAEID Büro für Architektur & transmediale Kunst (Daniela Mitterberger and Tiziano Derme)

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AR fabrication: Eleni Alexi (XAIA lab, Princeton University)
Robotics: Max Polzin and Kai Junge (Embodied AI)
Living Material Design: Dalia Dranseikė (Macromolecular Engineering Lab at ETH Zurich)

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Academic Partners: Princeton University (School of Architecture), ETH Zurich (Institute of Technology in Architecture: Prof. Dillenburger; Macromolecular Engineering Lab: Prof. Tibbitt), University of Wyoming (Prof. Oakey)