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ABSTRACT

Leveraging the “Superpowers” of Engineered Living Materials to Craft Soft Living Artefacts

GIORGIA BURZIO, Politecnico di Milano, Milan, MI, Italy

VENERE FERRARO, Politecnico di Milano, Milan, MI, Italy

NEEL S. JOSHI, Northeastern University, Boston, MA, United States

VALERIA REGIS, Politecnico di Milano, Milan, MI, Italy

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Leveraging the “Superpowers” of Engineered Living Materials to Craft Soft Living Artefacts

Giorgia Burzio
Design Department
Politecnico di Milano
Milan, Italy
giorgia.burzio@polimi.it

Venere Ferraro
Design Department
Politecnico di Milano
Milano, Italy
venere.ferraro@polimi.it

Neel S. Joshi
Department of Chemistry and Chemical Engineering
Northeastern University
Boston, Massachusetts, USA
ne.joshi@northeastern.edu

Valeria Regis
Design Department
Politecnico di Milano
Milan, Italy
valeria.regis@polimi.it

Abstract

In recent years several scholars from the design discipline attempted to conceptualize and frame “Living Artefacts” as a novel class of objects, alive and responsive in their relationship with humans. Simultaneously, a lesser explored but promising area is a synergetic collaboration between design, Human-Computer Interaction and synthetic biology, where the Engineered Living Materials (ELMs) developed by bioengineers could be explored and exploited to craft Living Artefacts and improve user experience. ELMs possess some hallmark features of life, such as self-regeneration, autonomy and environmental responsiveness. This Studio would engage participants in design-driven explorations of an ELM, specifically a “augmented silicone” (silicone with embedded proteins), a material with programmed “superpowers”, while exploring applications of ELMs beyond the sole bioengineering field. Participants and organizers would critically reflect on the Studio’s outcomes and map the challenges, opportunities and ethical considerations while integrating design and biology.

CCS Concepts

• Human-centered computing; • Interaction design; • Systems and tools for interaction design;

Keywords

Living Artefacts, Interaction design, Engineered Living Materials, Softness

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1 INTRODUCTION

Research is indicating how advanced materials with the qualities of living systems, including sensing, computation, and adaptation, are becoming an important challenge in designing next-generation systems [4]. Partnering with this trend is the field of synthetic biology, where innovations such as Engineered Living Materials (ELMs) envision new opportunities for collaboration across disciplines. These materials, developed by bioengineers, are designed to exhibit life-like abilities such as self-regeneration, environmental responsiveness, and adaptability, opening a unique frontier for Tangible User Interface (TUI) [6].

Within ELMs domain, a notable field is soft robots, machines made from highly flexible materials that mimic the soft tissue of living organisms, allowing them to perform tasks that rigid robots struggle with. Current experimentations rarely deviate from biomedical applications, and the employment of soft robots within HCI and interaction design is yet to be explored but seems to be promising [8]. With their flexible, adaptive, and responsive physicality, they could indicate novel trajectories in Tangible Interaction Design.

In this studio, authors and participants will attempt to merge design and synthetic biology by looking at materials made wholly or in part by genetically engineered microbes. Examples will include biodegradable bioplastics and silicone rubbers with embedded proteins developed by Neel S. Joshi’s research team at Northeastern University (Figure 1).

Silicone is known to be a good candidate for building soft electric actuators. Embedding proteins could enhance the electro-mechanical properties of the silicone so that the actuators can be lighter and require less power to operate. The long-term goals of this effort are to create wearable actuators capable of augmenting human movement – for example, a sleeve that could help someone lift a heavy object.

This studio has three main objectives: i) explore the potentiality of ELMs to give superpowers to a traditional material; ii) explore whether ELMs can enhance the user experience of the selected interactive artefacts; iii) critically reflect on interdisciplinary collaboration when designing Living Artefacts. Researchers from design



Figure 1: Silicone embedding proteins in the matrix

and biology disciplines will guide participants in exploring augmented silicone, focusing on enhancing Livingness in three “soft artefacts” interacting with bodies: a breast pump, a menstrual cup, and a pleasure object/sex toy.

2 GROUNDING IN THEORY

In the past years, an established focus of investigation has been the integration of living organisms such as algae, bacteria, fungi and plants in the design process to reduce the environmental footprint of products and to test alternative material expressions [3], tinkering materials for ICS objects [10], bridging biological and technological worlds.

Bio-based materials are made from substances derived from living or once-living organisms. The integration of such materials has shown many opportunities due to their ability to decompose at the end of life. This shift reflects an effort to reduce the environmental impact of interactive products [2], and to develop alternative material expressions that promote sensory engagement with physical matter [1, 7]. [7]

Nonetheless, in most cases the actual outcomes are not living but only resembling the aesthetic features of living organisms. An area of research within Biodesign is currently expanding to push the feature of Livingness from inert objects where living organisms are a material choice, to a persistent quality in the product’s life, with the materials sensing, growing, adapting, and dying [3].

Besides, in the field of HCI several scholars promote the role of materials as lens, and material programming as approach, through which design novel forms of interaction, based on temporality [13],

soma aesthetic explorations [11], shape change [14], and tension-and-release [14], to cite but a few. These cases mimic the life-like abilities of natural systems when designing the interaction between humans and machines. A related thread of research looks at soft systems and encounters between technologies and bodies, including the concepts of soma design [5] and “Vibrant Wearables” [12].

Over the past years, several researchers built on the initial conceptualization of Living Artefacts. Few of the authors of this Studio proposal conducted a systematic literature review across the disciplinary fields of design, HCI and synthetic biology to understand the different interpretations of Livingness, proposing an extended definition and a conceptual model to inform the research area (currently being blind reviewed).

3 STUDIO PROPOSAL

This studio will explore the potential of Engineered Living Materials (ELMs) in the design of interactive artefacts in contact with bodies to enhance the overall user experience. The Studio’s structure will follow an adapted framework (Figure 2) developed during the former Erasmus+ project DATEMATS (Knowledge & Technology Transfer of Emerging Materials & Technologies through a Design-Driven Approach) [9]. The first phase is Understand: a module where the fundamental knowledge is given to students. The second phase is Exploring/Shaping: while Exploring put emphasis on the designer getting knowledge on the materials and processes by documenting and evaluating, Shaping is focused on the material being manipulated in many ways. Participants divided into three groups will start by mapping the “superpowers” of the silicone (for instance, a programmed material behavior in response to an input) and the areas of improvement of one of the chosen artefacts. Areas of improvement are intended as UX issues of such artefacts. In fact, there are several critiques and problems when it comes to design choices of artefacts in touch with bodies, resulting in usability difficulties and overall challenging UX. From an ideation phase supported by cards and other tools provided by organizers, participants will draft scenarios, thinking about specific user and context of use (Shaping). The challenge will be to understand how a specific behavior that could be programmed within the material could improve usability, accessibility and/or equity when using such products. The third phase is Applying: the material is embedded and encoded into a project. From this process, participants will develop their idea, further representing their scenarios of interaction visually and/or through physical mock-ups. Considering the Studio being a one-day experience, a significant time will be dedicated to a closing roundtable where participants will both present their outcomes and reflect on the process followed. The organizers will document the Studio (photos and videos, prior permission) and collect critical insights on a Figma board, which will be shared with participants as a knowledge depository.

4 MATERIALS TO BE EXPLORED

The explored materials will be of two kinds. On the one hand we will look at three products carrying several critiques and questions related to user experience: menstrual cup, breast pump and sex toy. On the other hand, bioplastic films and augmented silicone with embedded proteins, programmed to carry out specific tasks.

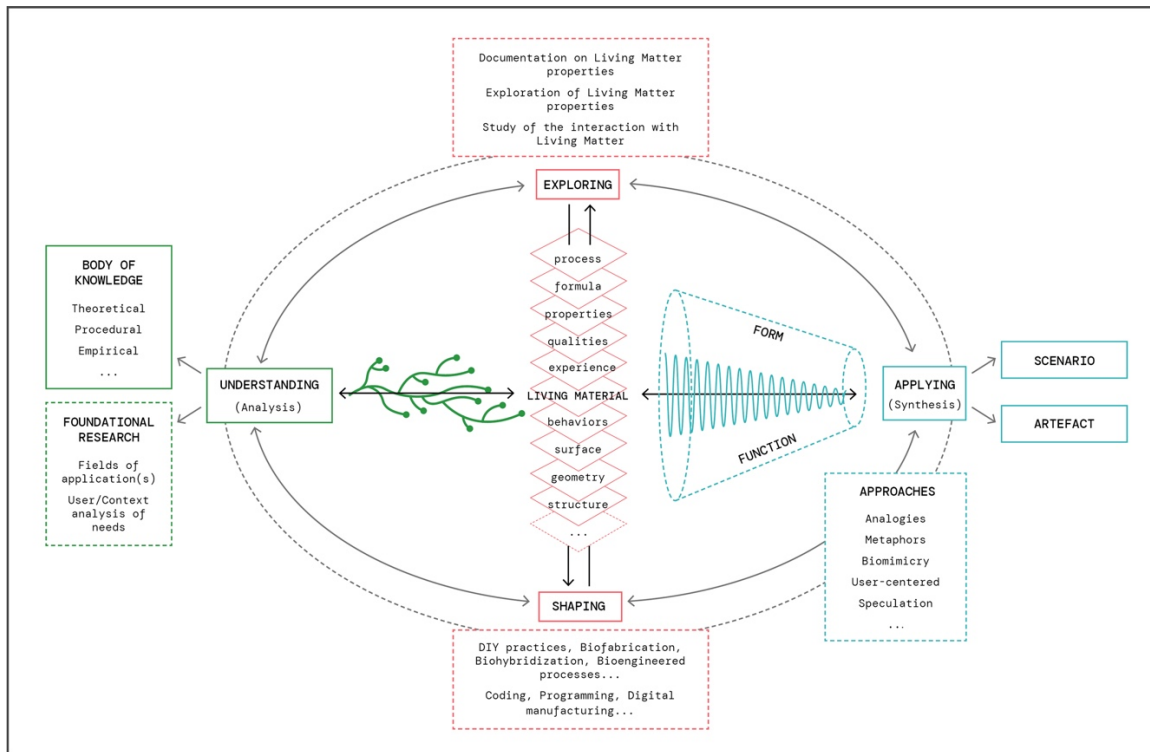


Figure 2: The process developed during DATEMATS project.

Participants will explore how the use of living factories in the design and production of these artefacts could enhance functions and user experience. The bioplastics will be composed only of the remains of bacterial cells and the biopolymers they were genetically engineered to create. Questions to explore might involve connecting molecular-level structure to properties, or brainstorming how such materials might be manufactured to create more sustainable futures. The silicone rubbers with embedded proteins can be compared to the same rubber composition without the embedded proteins to directly experience the difference in their “feel” (i.e., mechanical properties) in a tactile manner. Brainstorming for these artefacts might include a discussion of trade-offs related to power needs versus comfort for wearable technologies.

Due to logistic reasons and fragility of the material, the silicone rubbers with embedded proteins will physically be at Northeastern, Boston. The organizers will provide silicones with a very similar feel and look to speculate possible artefacts and material behaviors, possibly with the support of electronic prototyping. During the *Understanding* phase, Professor Joshi will showcase material samples and videos.

Since the material is still in a development phase, the expected outcomes of this studio are speculative artefacts and scenarios. The findings of this Studio will be presented and discussed in a publication (article or book chapter to be defined).

5 STUDIO LEARNING GOALS

The team will organize the day through well-defined activities aiming to specific goals and learning outcomes, providing participants with several tools to approach each activity. The Studio learning goals are the following:

- *Getting in touch with Engineered Living Materials.* In this studio participants will approach ELMs learning what they are, how they are programmed, and their “augmented” life-like abilities.
- *Explore UX issues of the three artefacts.* Participants will map the material’s “superpowers” and highlight UX issues of the artefacts, all supported by several tools.
- *Applying the programmed abilities of ELMs to solve a UX problem.* Participants will address a UX issue of a chosen artefact from the three proposed by leveraging a particular material behavior/ability of the silicone.

Even if not included in a standalone learning goal, all participants will be engaged in critical reflections. In fact, designing with living matter, as well as engaging in interdisciplinary endeavors, opens many ethical considerations and novel ways to approach materiality. These points, even if not the core of this Studio, will be discussed.

6 STUDIO SCHEDULE

Assuming the Studio lasting 8 hours (including 1 hour lunch break), authors propose the following schedule, being flexible according to changes and needs:

Welcome (30 minutes)

Icebreaking activity and groups making.

Understanding 1 (30 minutes)

Introducing three artefacts: menstrual cup, breast pump and sex toy.

Exploring 1 (45 minutes)

Mapping UX issues/problems of the three artefacts *Lunch* (60 minutes)

Break (15 minutes)

Understanding 2 (60 minutes)

Introducing Engineered Living Materials (Neel S. Joshi from Northeastern University)

Exploring 2 (60 minutes)

Mapping the ELM “superpowers”

Lunch (60 minutes)

Collective reflection 1 (10 minutes)

Applying 1 (60 minutes)

Participants will draft potential scenarios, thinking about specific user and context, where a UX issue could be solved from a programmed ability of the material.

Break (15 minutes)

Collective reflection 2 (10 minutes)

Applying 2 (60 minutes)

Participants will apply the material’s superpower in a finalized idea and visualize it through visual and/or physical representations (mock-ups).

Ideas presentation (30 minutes)

Discussion (30 minutes)

Mapping challenges and opportunities, feedback session.

Closing remarks (15 minutes)

7 SUPPORTING DOCUMENTS

Physical tools for mock-ups, a Figma board with case studies, inspirational cards and scenarios canvases will be present. Moreover, there will be three objects to redesign and where integrate the augmented silicone rubbers and biodegradable bioplastics.

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system, to foster regenerative futures and enable novel disruptive interactions with users.

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