



PhD in DESIGN - 39th cycle

PNRR 118 PNRR Research Field: BIO FABRICATION: A NEW FRONTIER OF WEARABLE DEVICES

Monthly net income of PhDscholarship (max 36 months)

€ 1195.5

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

Motivation and objectives of the research in this field

This research proposal addresses the problem of finding sustainable alternatives to the traditional and often polluting materials used in wearable devices by also overcoming the unavoidable impact of e-waste. Wearable devices are mainly made of plastics, textiles, and electronics, thus creating several environmental and health problems, from raw materials extraction to their final disposal. The latter is often different from the life cycle of the artefact itself and requires special attention to the environmental and ethical impact, the technological aspect of which often overshadows the sustainability aspect. According to a 2022 report by the United Nations University (UNU), the 53.6 million tonnes (MT) of e-waste generated in 2021 will increase by 38% by 2030. Notably, most of the e-waste in 2021 consisted of small devices (i.e., wearables). On these bases, the research aims to map, analyze, and experiment with alternative (sustainable) materials to envision sustainable wearables using digital fabrication. The collaboration between electronics and micro-organisms could lead to terrific implications: reducing the environmental impact of materials, exploring new interactive perspectives, and expanding the vision of the user experience. In recent years, several experiments have been carried out in the field of wearable devices integrating and embedding microorganisms such as bacteria, fungi, and algae. (Vasquez, E. S. L., & Vega, K, 2019; Pataranutaporn, P., 2020) The peculiar growth and synthesis processes of such materials allow for finding alternatives radically more sustainable than traditional production processes. The



	<p>general objectives will be to: (i) analyze the issues related to the production, use and disposal of wearables and classical materials and to practices likewise, reuse, recycling and repair; (ii) research and develop alternative materials or as living and active components integrated into wearables; (ii) propose a methodology for researchers and practitioners to integrate in a functional and ethical way living organisms such as fungi, algae and bacteria into wearable devices. In this regard, the proposal stays at the core of three areas: Human-Computer Interaction (HCI) (Studies how people interact with computers. Processes to design and engineer wearables and tangible objects.) Bio Design (Bio-design embraces design and biology in a transdisciplinary approach, focusing more on the concept of “livingness”; It uses living materials such as fungi, algae, yeast, bacteria, and cultured tissue, to enhance sustainable design) and Digital fabrication (Design and manufacturing processes where a computer controls the machines). The research will allow the PhD to take on a more-than-human approach by extending the agency of humans beyond their impact on humans to include the need to consider the impacts on non-human actors in the world. (Tarcan, B., Pettersen, I. N., & Edwards, F., 2022)</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The research will mainly leverage a Research Through Design Approach and will be conducted through four main phases:</p> <p>Knowledge generation:</p> <p>The first phase will generate the general knowledge at the core of the research. To this end, a literature review of existing approaches and methods presented in the field of wearables, and bio-design will be conducted, together with a state of the art of existing sustainable materials, biomaterials (i.e., bacterial cellulose, mycelium, algae etc.), digital/bio fabrication techniques.</p> <p>Experimentation/Prototyping (partially executed at Delft)</p> <p>The experimentation phase will follow a well-known approach in the scientific community of Human-Computer Interaction (HCI): tinkering with materials (Bevan B. et al., 2015; Parisi S. et al., 2017). It is an experiential learning</p>



	<p>process that involves playing/hacking/manipulating with biomaterials and technologies to trigger a critical vision of sustainable matter and generate new sustainable wearables. This phase will produce at least three prototypes of wearables: current materials (polypropylene, PPT, textile, etc.) will be replaced by the new material samples to make products embedding technologies sustainable, recyclable and/or re-usable and/or repairable. The prototype process will use traditional digital fabrication techniques integrating biomaterials. During the permanence at the Delft, the PhD student will work in an outstanding research team composed of design researchers with expertise in human-computer interaction, biomaterials and tinkering.</p> <p>Methodology establishment: This phase involves the creation of a methodology for practitioners and researchers in the field of sustainable wearables, which includes methods and procedures for establishing controlled integration of biomaterials and technology.</p> <p>Validation and Consolidation: Validation with designers and end-users. Through a participatory session, designers and users will be involved in the design and verification of the methodology and identifying the user experience aspects related to perceptual, sensory and emotional aspects of materials and their application. A final and refined version of the methodology will be released.</p>
<p>Educational objectives</p>	<p>The innovative and distinctive aspect of the research is represented by the integration of three research domains. (Biodesign, HCI and Digital Fabrication). The educational objectives will be to:</p> <ul style="list-style-type: none"> - Strengthen theoretical knowledge in the field of, bio-based materials, wearable technologies, and digital fabrication. - Generate Practical knowledge in the use of tinkering and innovative practices for bio-fabrication. - Generate Critical thinking: the experimentation phase with different materials will allow to critical reason on the needed switch from a human centred design to a more



	<p>than human one.</p> <p>- Strengthen the typical design research expertise.</p> <p>The trained researcher will have the knowledge and skills to approach sustainable wearables and to lead research on innovative bio-based (interactive) materials, focusing on all the characteristics of materials (from performative to the experiential ones) by using new forms of fabrication. The new profile will be able to meet the demand of complex problems coming from the research field and the contemporary productive world in search of solutions in the field of wearable technologies facilitating the ecological transition and the practices of recycling, upcycling, and repairing.</p>
<p>Job opportunities</p>	<p>Thanks to this Ph.D. program, the student will be able to explore the world of existing biomaterials, develop new ones and study innovative possibilities of interaction with them and wearables devices, thus becoming a 360° expert in the field. After this Ph.D., s(h)e will be able to enter the world of Industry 4.0 as a biomaterial (wearable) designer or as a consultant to whom companies will contact to find sustainable alternatives.</p> <p>The companies working in the field of digital products will need to update their production processes and invest in new job profiles; in fact, several companies (such as Comftech, Pangaia Grado Zero group) have already shown great interest in the new profile.</p> <p>On the others side, the academic context needs skilled researchers to generate innovative and effective approaches for using sustainable materials.</p> <p>Consequently, the doctoral candidate may also decide to continue the academic journey by becoming a professor in new courses, sustainability-themed, that are emerging every day. Few examples are the master's degree in Bidesign at UAL in London, at IAAC in Barcelona or IDE in Delft (and we hope to say also Politecnico very soon).</p>
<p>Composition of the research group</p>	<p>0 Full Professors 2 Associated Professors 0 Assistant Professors 0 PhD Students</p>
<p>Name of the research directors</p>	<p>Venere Ferraro; Valentina Rognoli</p>



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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	597.75 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	
By number of months at the company	0
Institution or company where the candidate will spend the period abroad (name and brief description)	Delft University of Technology, Industrial Design Engineering
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p>Educational activities (purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences):</p> <p>financial aid per PhD student per year max 4.872,90 euros per student (total for 3 years)</p> <p>Teaching assistanship: availability of funding in recognition of supporting teaching activities by the PhD student there are various forms of financial aid both for research and teaching activities. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.</p> <p>Computer availability: 1st year, 2nd year and 3rd year: Each research group will supply PhD student with a computer, if necessary.</p> <p>Desk availability: 1st year, 2nd year and 3rd year: Each research group will supply phd student with a desk.</p>