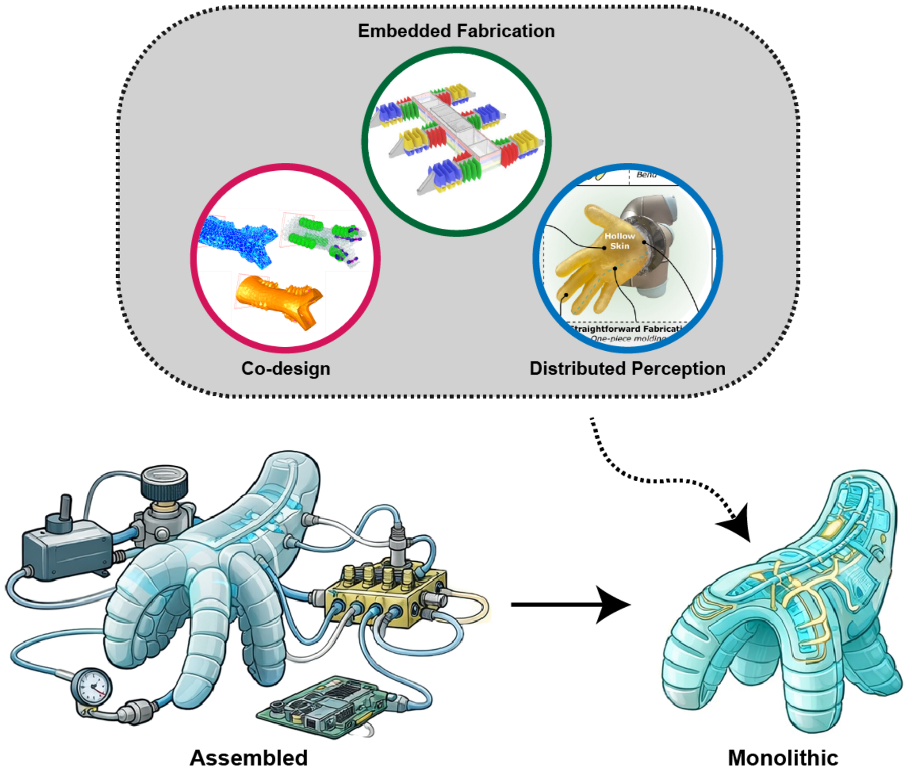

MONOLITHIC SOFT SYSTEMS

Co-design components, tools, materials, and fabrication strategies for next-generation robotics

IEEE RAS RoboSoft 2026 – Kanazawa, Japan

April 7, 2026 – Full-day Workshop

ROBOSOFT 2026

IEEE Robotics & Automation Society

This booklet will be archived online after the workshop.

Abstract

As the field of soft robotics continues to grow, it is clear that it is no longer in its adolescence. Simulation tools, sensing strategies, and fabrication methods are beginning to mature, providing a stronger foundation than ever before. Yet this progress also brings us to an impasse: should we continue to draw inspiration from traditional robotics paradigms, or rethink our design strategies to fully exploit the unique properties of soft materials?

Unlike rigid robots, where sensors are an afterthought or integrated into actuators such as motors with encoders, soft robots face inherent challenges of material mismatch. This creates unique demands for sensing, modeling, and control that are inseparable from fabrication and material choice. Bridging this gap calls for monolithic soft systems, where actuation, sensing, and structure are developed together through shared design strategies.

The first part of this workshop will highlight specific technologies that make such integration possible, including advances in simulation, embedded sensing, and fabrication. The second part will focus on integrated and monolithic systems, showcasing how these technologies come together in complete soft robots where sensing, actuation, and structure operate as one. Through talks, poster sessions, and discussions, participants will explore recent examples that demonstrate the benefits and challenges of achieving full integration in practice. By bringing together perspectives from engineering, biology, and materials science, the workshop aims to identify key directions for designing and realizing the next generation of soft robotic systems.

Description

Soft robotics is steadily moving beyond its formative years. Advances in fabrication, sensing, and simulation have enabled robots that are more capable and versatile than ever before. However, this maturity also highlights the limitations of traditional design approaches from system engineering, which often treat actuation, sensing, and control as separate layers that are assembled after they are designed and built. In contrast, the inherent compliance and material diversity of soft robots demand that these elements be developed together and perform symbiotically.

This workshop brings together leading researchers who are advancing these frontiers from complementary perspectives, spanning design tools, embedded sensing, fabrication, and system-level integration. Central to this discussion is the notion of co-design, where material selection, actuation mechanisms, sensing modalities, and control strategies are developed as interdependent components of a single system.

The first half of the workshop focuses on design tools and strategies that make integration possible. Talks in this session will explore computational frameworks for co-design, soft sensing and electronics for distributed perception, and fabrication approaches that enable multifunctional materials. The second half of the workshop transitions from enabling technologies to realized integrated and monolithic systems. Speakers will showcase examples where structure, actuation, and sensing are co-fabricated into unified platforms.

Topics of Interest

- Co-design of soft robots
- Design tools for integrated systems
- Digital twins and physics-based simulation for integrated soft robots
- Embedded and distributed soft sensing
- Stretchable electronics for soft robot integration
- Fabrication strategies for monolithic systems

- Self-sensing soft actuators

Organizers

- **Trevor Exley** - Postdoc, Istituto Italiano di Tecnologia, Italy
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- **Felix Vanneste** - Postdoc, EnsadLab - École des Arts Décoratifs de Paris, France
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- **Lucia Beccai** - Senior Researcher, Istituto Italiano di Tecnologia, Italy
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Invited Speakers

#	Name	Affiliation
1	Diana Cafiso	Istituto Italiano di Tecnologia (Italy)
2	David Hardman	University of Cambridge (United Kingdom)
3	Stephanie Woodman	Yale University (United States)
4	Felix Vanneste	École des Arts Décoratifs (France)
5	Taekyoung Kim	Northwestern University (United States)
6	Michael T. Tolley	UC San Diego (United States)
7	Petr Trunin	Istituto Italiano di Tecnologia (Italy)
8	Miriam Filippi	ETH Zürich (Switzerland)
9	Vanessa Sanchez	Rice University (United States)
10	Majid Taghavi	Queen Mary University of London (United Kingdom)
11	Perla Maiolino	Oxford Robotics Institute (United Kingdom)
12	Edoardo Milana	University of Freiburg (Germany)

Program

Note: times are tentative and may be adjusted by the conference organizers.

Time	Description	Topic
8:45–9:00	Opening (by organizers)	Why monolithic? Why now?
9:00–11:40	**SESSION 1**	**Design tools and strategies**
9:00–09:20	Speaker 1: Diana Cafiso	Optical sensors for 3D printed monolithic soft robots
9:20–09:40	Speaker 2: Felix Vanneste	Modeling and fabrication of soft robots made of anisotropic mesostructured materials
9:40–10:00	Speaker 3: Stephanie Woodman	Stretchable Computation Embedded in Soft Systems
10:00–10:15	Coffee Break	
10:15–10:35	Speaker 4: David Hardman	Towards Stretchable Single-Layer Robotic Skins with Multimodal Sensing Capabilities
10:35–10:55	Speaker 5: Taekyoung Kim	Enhanced Soft Sensing and Actuation through Synergistic Integration of Materials and Structures

11:00–11:40	Panel Discussion 1 (Moderated by Trevor Exley and Majid Taghavi)	Design tools and strategies
11:40–12:30	**POSTER / INTERACTIVE SESSION**	
11:40–12:00	Pitch session (2 mins each) of posters	
12:00–12:30	Interactive poster session	
12:30–13:45	Lunch Break (Interactive poster session cont.)	
13:45–17:00	**SESSION 2**	**Integrated or monolithic systems**
13:45–14:05	Speaker 6: Michael T. Tolley	Printing Powerful Soft Robots on the Desktop
14:05–14:25	Speaker 7: Petr Trunin	Seamless integration of soft optical sensors with lattice-based robots
14:25–14:45	Speaker 8: Majid Taghavi	Artificial muscles with extended functions for monolithic medical robots
14:45–15:05	Speaker 9: Vanessa Sanchez	Textiles Strategies for Integrated Soft Robotic Devices
15:05–15:20	Coffee Break	
15:20–15:40	Speaker 10: Miriam Filippi	Unifying Biology and Machine: Co-Design Strategies for Bio-hybrid Soft Robots with Seamless Actuation and Sensing
15:40–16:00	Speaker 11: Perla Maiolino	Toward Sensorised Soft Bodies: Integrating Sensing, Actuation, and Design
16:00–16:20	Speaker 12: Edoardo Milana	Monolithic soft machines: design principles and fabrication strategies
16:20–17:00	Panel Discussion 2 (Moderated by Felix Vanneste and Lucia Beccai)	Integrated or monolithic systems
17:00–17:15	Poster Awards and Closing Remarks	
17:15–17:30	Informal Networking	

Optical sensors for 3D printed monolithic soft robots

Diana Cafiso
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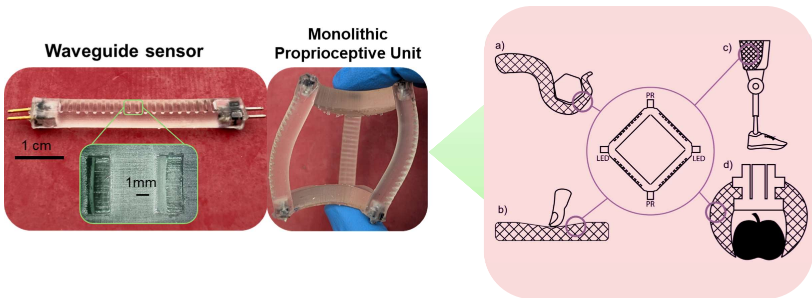
Building truly monolithic soft systems requires minimizing, and ideally eliminating, interfaces between a robot and its sensors. These interfaces complicate fabrication and assembly, introduce mechanical and material discontinuities, and often become failure points under repeated deformation. A direct way to enable monolithic integration is to fabricate the robot and the sensing elements in the same soft material, using a transduction mechanism that works without complex wiring. 3D-printed optical sensors are particularly well suited to this goal: light-based readouts require minimal wiring and are immune to electromagnetic interference, while additive manufacturing enables seamless fabrication of transparent soft structures where sensing can be built into the body itself. This talk presents a first step toward monolithic soft systems by demonstrating the feasibility of SLA-printed soft optical waveguides as deformation sensors using a widely available elastomeric photopolymer (Elastic 50A). A simple and transferable strategy to tune performance through surface microstructuring is introduced, based on patterned waveguides with parallelepiped-shaped wells. The effects of print layer orientation and surface geometry on sensor response are examined, showing how SLA can tailor sensing behavior while keeping material and fabrication continuity. Finally, complex prints with embedded sensing elements are showcased, highlighting a pathway to integrated and customizable sensorized soft systems designed as a single-material, continuous structure.



Diana Cafiso is a Postdoctoral Researcher at Istituto Italiano di Tecnologia (IIT) in the Soft BioRobotics Perception group. Her work focuses on enabling monolithic soft systems by developing 3D-printable photopolymers and fabrication strategies for soft mechanosensing, with a strong emphasis on vat photopolymerization and monolithic integration. A key line of research explores SLA/DLP printed optical sensors, supporting monolithic soft robots and sensorized structures.

Modeling and fabrication of soft robots made of anisotropic mesostructured materials

Felix Vanneste
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This presentation explores how material anisotropy and mesostructure can be used as design parameters to program the mechanical response of soft structures. Using finite element modeling (FEM) with complex constitutive laws, we can analyze how heterogeneous materials, such as foam-like or stochastic metamaterials, affect deformation and reachable configurations. To ensure reliable predictive models, we also present a generic calibration framework based on quadratic programming (QP) optimization for identifying the parameters of anisotropic FEM models. The method can estimate both classical mechanical properties, such as Young's modulus, and structural parameters related to anisotropy, enabling accurate modeling when sufficiently informative configurations are available. Finally, we will demonstrate how additive manufacturing enables monolithic soft structures with embedded sensing. Fully 3D-printed architectures using foam-like metamaterials allow mechanical properties to be tuned through mesostructure design, while conductive TPU elements patterned through anisotropic infill strategies act as integrated sensors capable of real-time shape estimation without external tracking. Together, these results highlight how material architecture can simultaneously support structure, sensing, and functionality, paving the way toward lightweight, manufacturable, and intrinsically perceptive monolithic soft robotic systems.

Félix Vanneste is a research engineer at Compliance Robotics. He completed his PhD at Inria in Lille, where he focused on the numerical modeling of mesostructured materials for soft robotics. He previously worked as a postdoctoral researcher at EnsadLab within the Reflective Interaction team. His research explores how finite element modeling and anisotropic metamaterials can be used to design new degrees of freedom in soft robotic systems. He combines simulation-driven design with additive manufacturing to develop soft robotic structures with programmable mechanical behavior and integrated actuation.

Stretchable Computation Embedded in Soft Systems

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To achieve real-world functionality, robots must have the ability to carry out decision-making computations. However, soft robots stretch and therefore need a solution other than rigid computers. Examples of embedding computing capacity into soft robots currently include appending rigid printed circuit boards to the robot, integrating soft logic gates, and exploiting material responses for material-embedded computation. Although promising, these approaches introduce limitations such as rigidity, tethers, or low logic gate density. The field of stretchable electronics has sought to solve these challenges, but a complete pipeline for direct integration of single-board computers, microcontrollers, and other complex circuitry into soft robots has remained elusive. We present a generalized method to translate any complex two-layer circuit into a soft, stretchable form. This enabled the creation of stretchable single-board microcontrollers (including Arduinos) and other commercial circuits (including SparkFun circuits), without design simplifications. As demonstrations of the method's utility, we embedded highly stretchable (>300% strain) Arduino Pro Minis into the bodies of multiple soft robots. This makes use of otherwise inert structural material, fulfilling the promise of the stretchable electronic field to integrate state-of-the-art computational power into robust, stretchable systems during active use.

Stephanie Woodman is a Ph.D. candidate in Mechanical Engineering and Materials Science at Yale University, studying under Prof. Rebecca Kramer-Bottiglio. As a NASA NSTGRO Fellow and NSF GRFP awardee, her research has focused on enabling general shape-changing robots through stretchable computation, model-free shape-sensing, and control. Her work has been featured in Science Robotics, IEEE RA-L, Advanced Intelligent Systems, Advanced Materials, and others, and she has applied her work in industry at Meta Reality Labs and in the government sector at NASA Ames Research Center. She has also brought academic technology into the real world through entrepreneurship, winning the highest award at Startup Yale 2023, and has contributed to and written several patents. In 2025, she was invited to talk at the Max Plank Institute for Intelligent Systems, and recognized as a Rising Star of the 2025 IEEE Conference on Soft Robotics. Recently, she has been selected as a finalist for both the Schmidt Science Fellows program, and the Harvard Rowland Fellowship, and was honored to give a seminar at Tufts University. Ultimately, her work comes at shape-changing robotics from a new, generalized perspective that maximizes robotic hardware capabilities to address real-world societal challenges.

Towards Stretchable Single-Layer Robotic Skins with Multimodal Sensing Capabilities

David Hardman
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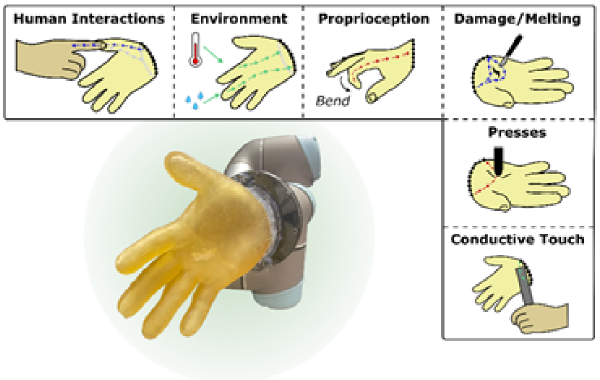
Sensing tasks which we perform with ease, such as high-resolution tactile localization or multimodal sensing, are extremely cumbersome to reproduce for robots; artificial skins might be covered with hundreds of high-density wired sensors which present numerous challenges in fabrication and fragility: such as delamination of soft-rigid interfaces upon stretching. To avoid these difficulties, single-layer multimodal sensory skins can be directly cast into complex shapes using stretchable and conductive membranes. With electrical impedance tomography techniques, thousands of conductive pathways can be monitored across these membranes, containing data on a variety of multimodal stimuli, including human touch, damage, multipoint insulated presses, and local heating. This talk will explore these single-layer solutions, focusing on how they can be practically integrated into task-based robotic systems including tool-use, braille-reading, and full-sized humanoid hands.



David Hardman is a Junior Research Fellow and Affiliated Lecturer in the University of Cambridge's Bio-Inspired Robotics Lab. His thesis on multimodal soft sensors reached the finals of the 2025 Georges Giralt Award for the best European PhD in Robotics, and won a CSAR Award for outstanding research with real world applications. Prior to his current position, David was a visiting researcher at EPFL's CREATE Lab in 2024, where he worked on modular and customizable robotic fingertips.

Enhanced Soft Sensing and Actuation through Synergistic Integration of Materials and Structures

Taekyoung Kim
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Next-generation robots require deeper integration across materials, structures, and functionality. In this talk, I present my research toward physically intelligent robotic systems by developing soft sensing and actuation capabilities through functional soft materials and programmed soft structures. First, I introduce multifunctional soft sensing strategies that embed multiple transduction materials within a single deformable body, enabling physically intuitive sensing. By seamlessly integrating soft functional materials with learning-based functionalization, these systems efficiently achieve both proprioception and awareness of physical interactions. Next, I present motorized soft actuation approaches that provide geometry-driven mechanical behaviors using handed-shearing auxetic and origami-based material architectures to realize adaptive and biological robotic systems. These actuators are further integrated with soft sensing and equipped with an intrinsically proprioceptive capability. Together, these examples illustrate how the seamless, synergistic integration of materials and structures can provide enhanced robotic physical capabilities. By highlighting design strategies that bridge materials, structures, and robotic embodiment, this talk contributes to the broader vision of physically intelligent next-generation robotic systems.

Taekyoung Kim is currently a postdoctoral researcher in the Robotic Matter Laboratory at Northwestern University. He received his M.S. and Ph.D. in Mechanical Engineering from Seoul National University. His research interests lie in soft robotics, mechatronics, soft actuators and sensors, architected soft materials, soft 3D structure fabrication, embodied intelligence, and physical human-robot-environment interaction. He has focused on implementing physically intelligent soft-rigid hybrid robotic systems by synergistically integrating soft sensing and actuation technologies with existing robotic platforms. He received a Global Ph.D. Fellowship from the National Research Foundation of Korea during his Ph.D. He also received the Best Conference Paper Award at IEEE RoboSoft 2019 and was nominated as a Rising Star at IEEE RoboSoft 2025. Currently, he is developing 3D-printable soft actuators and sensors and also implementing artificial musculoskeletal robotic systems and soft legged robots capable of adaptive behaviors for real-world autonomy through embodied learning.

Printing Powerful Soft Robots on the Desktop

Michael T. Tolley
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Recently, soft autonomous robots embedded with pneumatic control circuits have shown great promise for achieving complex functions without electronic controllers. However, previous soft robots have mainly been fabricated by hand (e.g., by silicone molding), limiting their consistency and scalability. In addition, most existing soft robots have relatively low power output compared with traditional rigid robotic systems, which limits their practical use. We and others have recently used automated digital fabrication to manufacture entire robotic systems. In this talk, I will discuss a new approach for designing and fabricating high-power soft robots using a monolithic desktop 3D printing process. A key enabling component is a double-expansion pneumatic oscillator that drives high-frequency cyclic motions of actuators in any form, while allowing compressed air to expand sequentially in two stages to perform mechanical work more efficiently. Using this architecture, we have demonstrated a powerful, fully 3D-printed soft running robot that we believe is the fastest reported to date.

Michael T. Tolley is a Professor in Mechanical and Aerospace Engineering and Materials Science and Engineering, Director of the Bioinspired Robotics and Design Lab (bioinspired.ucsd.edu), and a member of the Contextual Robotics Institute at UC San Diego. Before joining the faculty at UC San Diego in the fall of 2014, he was a postdoctoral fellow at the Wyss Institute for Biologically Inspired Engineering, Harvard University. He received the Ph.D. and M.S. degrees in mechanical engineering with a minor in computer science from Cornell University in 2009 and 2011, respectively. His research seeks inspiration from nature to design robotic systems with the versatility, resilience, and efficiency of biological organisms. His work has appeared in leading academic journals including Science and Nature, and has been recognized by various awards including a US Office of Naval Research Young Investigator Program award. He is active in the robotics community, serving in multiple associate editor and conference organizer roles including as Program Chair of the IEEE International Conference on Soft Robotics (RoboSoft) in 2020, and as General Chair in 2024. Prof. Tolley is a Senior Fellow of the Institute of Electrical and Electronics Engineers (IEEE), a member of the IEEE Robotics and Automation Society (RAS), and of the American Society of Mechanical Engineers (ASME), and is currently a Distinguished Lecturer of the IEEE Robotics and Automation Society.

Seamless integration of soft optical sensors with lattice-based robots

Petr Trunin

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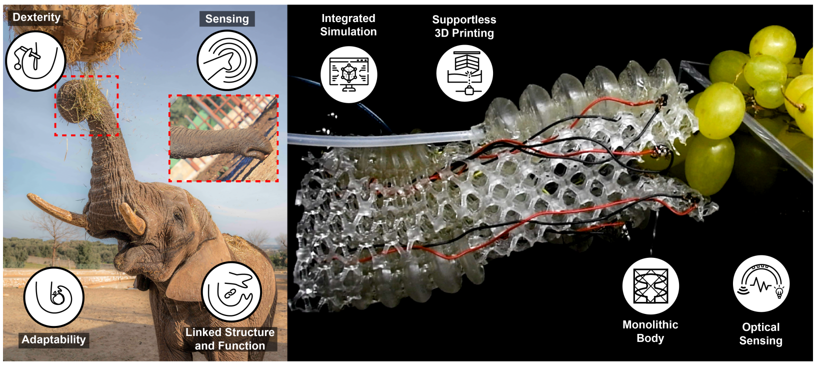
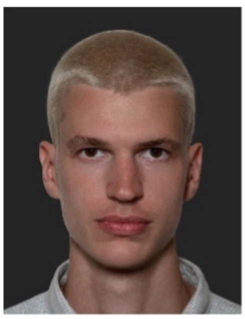
Soft robots are commonly sensorized through post-assembly integration of sensing elements. This workflow can introduce performance variability, promote interfacial delamination, and raise concerns about long-term durability. To address these limitations, a monolithic fabrication paradigm for sensorized soft robots has been proposed. In this approach, stereolithography (SLA) is used to 3D-print both the robot body and embedded sensors from the same material system, thereby minimizing material and interface mismatches. Sensor functionality is achieved by geometric and structural design strategies for bending-sensitive elements, enabling configurations that operate as either proprioceptive sensors (internal state estimation) or tactile sensors (external contact detection).



A further advantage is improved tractability for modeling and simulation: although soft-material simulation remains challenging, a single-material construct reduces interfacial complexity and simplifies constitutive and contact modeling relative to multi-material assemblies. This supports multistage optimization workflows in which sensor placement within the body is optimized first, followed by refinement of sensor geometry and response characteristics with respect to the robot's target motions. Overall, the monolithic approach enables rapid transition from concept to a functional sensorized robot in a single printing step. The method is also compatible with multiple transparent material formulations, indicating robustness and adaptability across different photopolymer systems.



Petr Trunin is a PhD student at the Istituto Italiano di Tecnologia (IIT) in the Soft BioRobotics Perception group led by Dr. Lucia Beccai. His research focuses on monolithic soft robotic systems enabled by 3D-printed soft optical sensors, with an emphasis on sensorization strategies for large-scale soft robots.

Artificial muscles with extended functions for monolithic medical robots

Majid Taghavi
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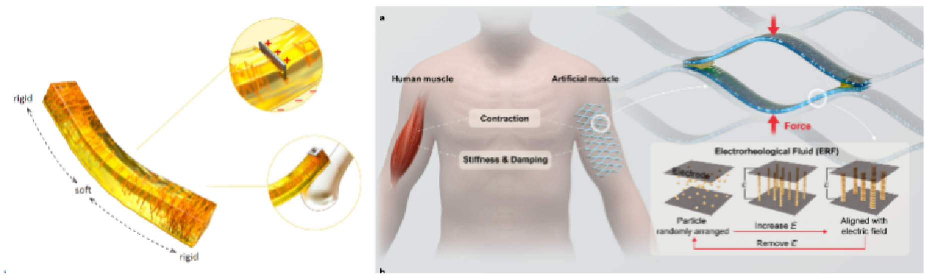
There is a growing demand for compact and adaptable robots with energy transduction capabilities comparable to, or even exceeding, those of biological systems for a wide range of healthcare applications. Such systems could address numerous unmet challenges in wearable, implantable, and surgical robotics. The use of compliant materials and adaptable structures offers distinct advantages over traditional rigid designs, enhancing robots' ability to interact safely with the human body and delicate biological tissues. However, developing compact and versatile robots from soft materials presents several fundamental challenges. First, while sensing technologies have advanced significantly, largely driven by developments in AI, soft actuators still lag behind. Substantial improvements are needed for them to match biological counterparts in energy and power density, efficiency, and adaptability. Second, integrating components with dissimilar properties and enabling system-level modulation often leads to mismatches in material, mechanical, and electrical performance, resulting in energy losses and reduced system efficiency. In this talk, I will present our approach to developing next-generation monolithic soft robots for healthcare applications through the design of robotic muscles with enhanced functionality. I will discuss our strategy for exploring multifunctionality at the material, structural, and functional levels, incorporating capabilities such as temporally and spatially variable stiffness, self-sensing, self-powering, adaptability, and shape-shifting in soft actuators. These advances aim to establish novel core technologies for future compact and adaptable robotic systems.



Majid Taghavi is an associate professor at Queen Mary University of London, where he leads the Intelligent Muscles Group. He has previously worked at the Department of Bioengineering at Imperial College London, SoftLab at the University of Bristol, and the Italian Institute of Technology at Scuola Superiore Sant'Anna. Majid has pioneered several technologies in artificial muscles, variable stiffness systems, energy harvesting, and self-powered sensing.

Textiles Strategies for Integrated Soft Robotic Devices

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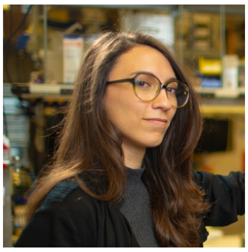
Wearable robots—garments with embedded sensing and actuation—require seamless integration of materials, components, and manufacturing to achieve comfort, functionality, and accessibility. Textiles offer a scalable and highly customizable platform for this integration, but demand new strategies that unify sensors, actuators, and interconnections within soft, body-conformable systems. This talk introduces textile-based strategies for component development and integration that enable the design and fabrication of wearable soft robotic devices.



Vanessa Sanchez is an Assistant Professor in Mechanical Engineering at Rice University (since 2024). She studied fashion design at Fashion Institute of Technology and earned a BS in Fiber Science from Cornell University (2016). She completed her MS (2020) and PhD (2022) in materials science and mechanical engineering at Harvard University advised by Robert J. Wood. She was an NSF MPS-Ascend Fellow at Stanford University, working with Zhenan Bao. Her work has been supported by NDSEG and GEM Fellowships and she has recognized by Forbes 30 Under 30, ACS CAS Future Leaders, and 50 Women in Robotics to Know.

Unifying Biology and Machine: Co-Design Strategies for Bio-hybrid Soft Robots with Seamless Actuation and Sensing

Miriam Filippi
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Soft robotics is entering a stage of maturity where design, fabrication, and sensing can be integrated to exploit the unique properties of compliant materials. Yet, bringing together living tissues with synthetic functional components presents distinct challenges, as biological materials are inherently soft, dynamic, and heterogeneous, while embedded sensors or structural elements often require greater stiffness or robustness. In this talk, I will present co-design strategies for bio-hybrid soft robots that address these material mismatches and enable seamless integration of actuation and sensing. I will discuss our approaches to sensorizing engineered muscle tissue-based actuators, creating bio-actuators capable of distributed feedback while maintaining viability and contractility. Furthermore, I will highlight strategies for efficient force transfer across interfaces between soft living actuators and rigid connectors, using graded-stiffness designs to minimize stress concentrations and optimize performance. By integrating fabrication, material selection, and sensing design from the outset, these approaches exemplify a monolithic co-design philosophy, where biological and synthetic components are treated as interdependent elements of a unified system. The resulting platforms demonstrate how biohybrid soft robots can achieve coordinated actuation, functional sensing, and robust interfacing with structural elements, bridging the gap between living and engineered materials. This work illustrates both the potential and the practical challenges of creating biohybrid soft machines and provides a framework for advancing monolithic, fully integrated soft robotic systems that combine biological function with engineered capabilities

Miriam Filippi is a Principal Investigator and Lecturer at ETH Zurich, leading research in Biohybrid Robotics at the Soft Robotics Lab. Her work explores the integration of living and synthetic materials to create adaptive, autonomous, resilient, and functional robotic systems, with applications from automation to tissue engineering and sustainable technologies. She has published extensively in biomedicine, robotics, and materials science, and her research has received multiple awards. Miriam is also an advocate for diversity and the advancement of women in academia, fostering inclusive and interdisciplinary collaborations to advance biointelligence and biohybrid machines

Toward Sensorised Soft Bodies: Integrating Sensing, Actuation, and Design

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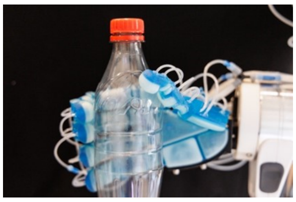
Soft robots offer a vast and still challenging-to-explore design space, where morphology, materials, sensing, and control are deeply coupled. Exploring this space requires extending traditional design approaches and developing computational tools that enable task-driven morphology design, where functionality is increasingly distributed within the body rather than solely centralized in the controller. This paradigm is inspired by biological systems, where evolution shapes bodies to fit ecological niches, embedding intelligence directly into morphology. In soft robotics, this aligns with the principles of embodied intelligence, where morphology, sensing, and control are co-designed to shape behaviour, building on concepts such as morphological computation. In this talk, we present a general framework for the systematic design of soft robotic systems across tasks and environments, combining high-fidelity modelling with efficient reduced-order representations to enable scalable exploration of the design space and task-level optimisation. Beyond morphology, we argue that the body itself is part of the sensing and perception system. This requires not only new fabrication approaches for monolithic integration of sensing within soft structures, such as optical fiber-based proprioception and embedded tactile sensing, but also design methodologies that jointly optimize sensor placement, morphology, and mechanical properties. We further show how embodied co-design approaches enable systems in which sensing and mechanics are intrinsically coupled, shifting from "robots with sensors" toward sensorised bodies that compute through their physical structure. Together, these contributions outline a vision for soft robotics in which design, sensing, and embodiment are unified, enabling more efficient, adaptive, and intelligent systems.



Perla Maiolino is an Associate Professor in the Department of Engineering Science at the University of Oxford and the deputy director of the Oxford Robotics Institute, where she leads the Soft Robotics Laboratory. Her research focuses on soft sensing, actuation, and embodied intelligence, with the goal of understanding how mechanical properties and morphology contribute to perception and control in robotic systems. She received her B.Eng., M.Eng., and Ph.D. in Robotics from the University of Genoa. Her work has contributed to advances in tactile sensing technologies, integrated soft robotic systems, and multi-material fabrication, including the development of CySkin. She serves as Associate Editor for IEEE Robotics and Automation Letters and Soft Robotics Journal, and has played key roles in the robotics community including RoboSoft conference organization. Her research has been featured in major outreach platforms including the BBC Royal Institution Christmas Lectures, and continues to explore the future of soft, sensitive, and intelligent robotic systems.

Monolithic soft machines: design principles and fabrication strategies

Edoardo Milana
University of Freiburg (Germany)

The development of soft robotic systems increasingly demands design strategies that integrate structure, actuation, sensing, and function into unified architectures. Traditional robotic design approaches often rely on assembling separate components, which introduce interfaces that complicate fabrication and reduce robustness under large deformation. In contrast, monolithic soft systems aim to embed multiple functionalities directly within a continuous structure, providing new forms of intelligence. This approach address sustainability concerns by reducing disassembling efforts in recycling and by using sustainable bio-based materials. This talk presents recent efforts toward the development of sustainable monolithic soft mechanisms enabled by rapid prototyping and advanced fabrication techniques. By combining computational design with fabrication strategies, it becomes possible to create soft structures whose mechanical behavior is programmed directly through geometry and material distribution. These approaches allow complex motion, instability-driven actuation, and adaptive mechanical responses to be realized within single-piece structures. Several recent examples will be presented of monolithic soft robotic structures that exploit origami-inspired architectures, snapping instabilities in dome-shaped shells, and compliant metamaterial designs fabricated through different rapid prototyping strategies. These systems demonstrate how co-design across materials, geometry, and fabrication enable complex motion, mechanical adaptation, and functional behaviors without relying on multi-part assemblies.

Edoardo Milana holds a BSc in Mechanical Engineering and a MSc in Nanotechnology Engineering from the University of Rome La Sapienza, and a PhD in Engineering Science from KU Leuven (2020). He had postdoctoral experiences at the Institute for the Protection of Terrestrial Infrastructure of the German Aerospace Center (DLR) and then at the Freiburg Center for Interactive Materials and Bioinspired Technologies (FIT) of the University of Freiburg thanks to the Walter Benjamin Programme of the German Research Foundation (DFG). Since 2023, he has been Assistant Professor at the Department of Microsystems Engineering (IMTEK) of the University of Freiburg, Principal Investigator of the DFG Cluster of Excellence livMatS and full member of FIT. His research interests include soft robots and transducers, flexible mechanical metamaterials, bioinspired material systems, and embodied intelligence. His expertise lies in mechanical design and advanced manufacturing of soft and compliant structures.