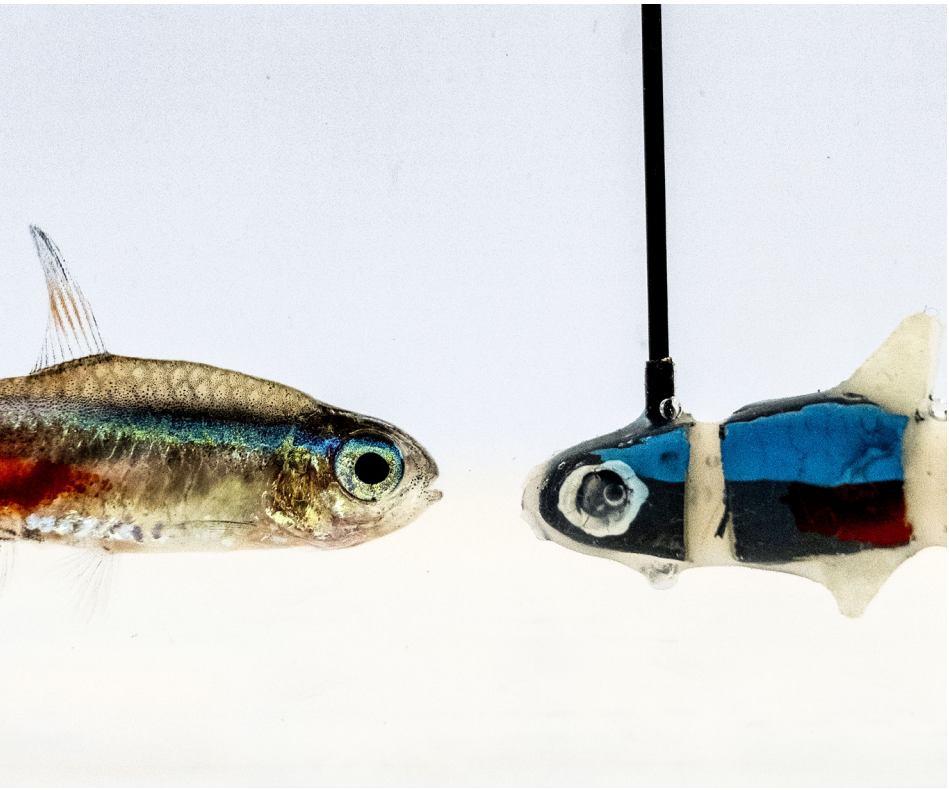
COLIBRI Focus Workshop
PROGRAMM & ABSTRACTS

18th—19th February

GRAZ AUSTRIA 2024



BIOHYBRIDS THROUGH ORGANISM-TECHNOLOGY-INTERACTIONS

Models, Methods, Potentials, Epistemology & Ethics

Lecture room 02.11
Universitätsplatz 2, 1st floor

RoboRoyale WATCHPLANT Robocoenosis HIVEOPOLIS

Complexity of Life in Basic Research and Innovation

Field of Excellence
University of Graz

UNI GRAZ

VENUE

The main reception desk will be in the foyer of the lecture room HS 02.11 at of University of Graz, Universitätsplatz 2 (Biology & Psychology building), 1st floor pointers to other rooms will be given there)

FEBRUARY 17, 2024

Unofficial get-together at restaurant "Propeller", Zinzendorfgasse 17, 8010 Graz at 19:30.

ONLINE PROGRAM

Schedule,
Speaker Overview
& Abstracts

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SCHEDULE

FEBRUARY 18, 2024

08:45 – 09:00 **Opening**

09:00 – 10:00 **PLENARY TALK 1**

Thomas Schmickl (Univ. Graz, Austria)
Bio-hybrid robotic systems: A contingency for ecosystem decay?

10:00 – 10:30 **Jean-Louis Deneubourg (ULB, Belgium)**
Dynamics of aggregation and collective memory

10:30 – 11:00 **Emanuela Del Dottore (IIT, Italy)**
Are there intelligent behaviors in plants?

11:00 – 11:30 **COFFEE BREAK**

11:30 – 12:00 **Erol Sahin (Middle East technical University, Ankara)**
Tracking and feeding bees

12:00 – 12:30 **Manfred Hartbauer (Univ. Graz, Austria)**
Stink bug control using robots and drones

12:30 – 14:00 **LUNCH**

14:00 – 15:00 **PLENARY TALK 2**

Silvia Kober (Univ. Graz, Austria)
Neural Interfaces - Closing the loop between brain and technology with brain-computer interface and neurofeedback applications

15:00 – 15:30 **Reinhold Scherer (Univ. Essex, UK)**
Non-invasive Neuroadaptive Brain-Computer Interfaces: Learning to Learn

15:30 – 16:00 **Guilherme Maia de Oliveira Wood (Univ. Graz, Austria)**
Neuroenchantment, real risks of neurotechnologies, and neurorights

16:00 – 16:30 **COFFEE BREAK**

16:30 – 17:00 **Ritu Raman (MIT, USA)**
Engineering biohybrid actuators for medicine and robotics

17:00 – 17:30 **T. Thang Vo-Doan (Univ. of Queensland)**
Insect-machine hybrid robots: from novel robotic platforms to cutting-edge tools for biological science

17:30 – 18:30 **PLENARY TALK 3**

Edoardo Datteri (Univ. Milano-Bicocca)
Biorobotics and scientific understanding

19:30 **SOCIAL EVENT**
The social dinner will take place at "Herzl's Weinstube", Prokopigasse 12 / Mehlplatz

FEBRUARY 19, 2024

09:00 – 10:00 **PLENARY TALK 4**

Donato Romano (Scuola Superiore Sant'Anna)
Biohybrid complex networks to unveil and control behavioral dynamics in insects

10:00 – 10:30 **Marco Tamborini (Univ. Freiburg, Germany)**
From Imitation to Integration: Exploring Bio-Integration in Robotic Design

10:30 – 11:00 **Ronald Thenius (Univ. Graz, Austria)**
History of Biohybrid Sensors

11:00 – 11:30 **COFFEE BREAK**

11:30 – 12:00 **Thorsten Schwerte (Univ. Innsbruck, Austria)**
Eco-Friendly Pest Control: The Emerging Role of Sensory Illusions

12:00 – 12:30 **Wen-Chi Yang (Bokang Holding Group, Shanghai, China)**
Can Augmented Perceptions Change the Evolutionary Equilibrium of Collective Behaviours in Fish

12:30 – 14:00 **LUNCH**

14:00 – 14:30 **Farshad Arvin (Univ. Durham, UK)**
Multi Robotic Design for Robots-Insect Swarms Interactions

14:30 – 15:00 **Tom Krajnik (CVUT, Czechia)**
Enhancing Insect Swarm Resilience Through Targeted Light Stimuli

15:00 – 16:00 **POSTER SESSION**

16:00 – 16:30 **COFFEE BREAK**

16:30 – 18:00 **Discussion**

18:00 **Conclusion**

SPEAKER OVERVIEW & ABSTRACTS

FARSHAD ARVIN (Durham University, United Kingdom)

Multi Robotic Design for Robots-Insect Swarms Interactions

The presentation will cover the integration of a robotic system collaborating with a swarm of social insects within their hive. The primary focus will be on robots equipped with both micro and macro manipulators, employing bio-mimetic agents to facilitate direct or indirect interactions with individual insects and the swarm. The presentation will mainly delve into the design challenges and engineering solutions implemented in our RoboRoyale project funded by H2020-FET-Open funding.

© Edoardo datteri

EDOARDO DATTERI (University of Milano-Bicocca, Italy)

Biorobotics and scientific understanding

Robots that mimic biological form and behavior, and interact with living systems in controlled settings, have been regarded as novel experimental tools for understanding social behavior and cognition. As a result, they are subjects of investigation for philosophers of science, who reflect on the structure of scientific research and the rationality of scientific methods. In this talk, I will specifically focus on the concept of scientific understanding within the realm of biorobotics research. My goal is to illustrate influential conceptions of "scientific understanding" as elaborated in the philosophy of science, particularly referring to the causal and unificatory accounts of explanation. This is done in order to constructively challenge the idea that biorobots can genuinely enable an understanding of the (social) behavior of living systems. At the same time, I will also suggest that biorobotics can benefit from a scientifically informed epistemological inspection, and that philosophy of science can significantly contribute to defining the scientific role that biorobotics can play in 21st-century research.

© Emanuela Del dottore

EMANUELA DEL DOTTORE

(Instituto Italiano di Tecnologia, Italy)

Are there intelligent behaviors in plants?

Plants thrive in virtually all natural and human-adapted environments displaying intelligent behaviors. I will discuss how the embodiment of plants adaptive behaviors offer new approaches for designing, modeling, and controlling artificial systems acting in unstructured scenarios. At the same time, the development of artifacts based on their working principles reveals how plants promote innovative approaches to preservation and management plans and open new applications for engineering-driven plant science.

© Jean-Louis Deneubourg

JEAN-LOUIS DENEUBOURG

(Université libre de Bruxelles, Belgium)

Dynamics of aggregation and collective memory

All social systems are governed by a series of feedback leading to multiple states. In mixed social systems (interspecific or hybrid), artificial agents or heterospecific individuals introduce new feedbacks. Nonlinear model (ODE, Master equation) are "low cost tools" to study how these new feedbacks contribute to achieve a set of desired responses and to decipher the behaviour of the host species. We will focus on the gregariousness and on the collective memory.

© Studio Lou

MANFRED HARTBAUER (University of Graz, Austria)

Stink bug control using robots and drones

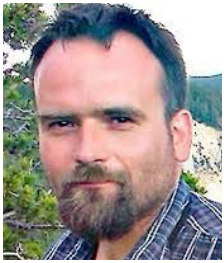
IoT sensors are becoming smarter and can also be used for the recognition of substrate-born signals in the field. By using this technology, it is possible to detect intra-specific communication signals of various invasive stink bug species to orchestrate bug defense with the help of a ground drone and a multi-copter drone.

© Silvia Kober

SILVIA KOBER (University of Graz, Austria)

Neural Interfaces – Closing the loop between brain and technology with brain-computer interface and neurofeedback applications

Brain-computer interface (BCI) and neurofeedback (NF) systems are closed-loop systems between the brain and technology. While BCI applications aim to control external devices, the goal of NF is to modulate one's own brain activation in a desired direction to improve cognitive, motor or affective functions. BCI and NF systems can be invasive or non-invasive. The presentation will discuss different systems and their possibilities and limitations as well as ethical issues.



TOM KRAJNIK
(Czech Technical University in Prague, Czech Republic)

Enhancing Insect Swarm Resilience Through Targeted Light Stimuli

The ongoing climate change, along with farmland overexploitation, mono-crop and pesticide abuse, habitat reduction, and fragmentation, has drastically reduced species diversity, threatening the stability of many ecosystems. Among the most affected groups are honeybees, keystone species that play a crucial role in pollination and, hence, are crucial for ecosystem stability. We present a novel visible light-based swarm control through a single colony member. We demonstrate how this minimally invasive stimulus can be used to affect a key individual in a social insect colony with the ultimate goal of influencing the interaction of the colony with the surrounding ecosystem. This is achieved by a closed-loop system capable of real-time localization and light-based stimulation of the honeybee queen inside of a colony. By applying the light stimuli, we can affect her likelihood to remain in a particular area. Using this system to affect the locations where the queen lays eggs, we are able to affect the spatial distribution of the larvae and the queen pheromones. This might increase the reproduction rate, reduce brood cannibalism, and strengthen the resilience of the colony to adverse weather or parasites.

GUILHERME MAIA DE OLIVEIRA WOOD
(University of Graz, Austria)

Neuroenchantment, real risks of neurotechnologies, and neurorights

The percolation of technological and social networks by means of modern digital technologies engenders a new form of human existence, which is best described as that of complex and hierarchically organized biohybrids. Due to the anarchical character of technological advance and the extreme complexity of the outcomes of its application in all domains of collective and individual activity, the manipulation of cognition and emotions with the help of these technologies is a serious problem in need of more scientific description and legal attention. For the ubiquity of digital technologies has the potential to distort very efficiently and reshape our sense of reality, our priorities and preferences in ways that undermine solidarity bonds, contagious and risky behaviors and fake news. In this study, our aim is to identify the main threats to individual autonomy regarding one's own central nervous system, cognitive and emotional activity. For that we combine efforts from three disciplines, law, ethics and neuropsychology and develop a hierarchy of urgence in dealing

with specific challenges, from the most immediate to more remote ones. Moreover, we also will develop a taxonomy of risk based on the degree of pervasiveness and invasiveness of specific applications designed to manipulate cognition and emotions. The study methodology is literature review and in-depth discussions around pre-specified topics. The outcomes of these activities will flow into a final document, which will include a list of the most important threats to the autonomy of European citizens and, where possible concrete suggestions on how to develop a legal body to offer higher levels of protection to European citizens.


© Ritu Raman

RITU RAMAN (Massachusetts Institute of Technology, USA)

Engineering biohybrid actuators for medicine and robotics

Human beings and other biological creatures navigate unpredictable and dynamic environments by combining compliant mechanical actuators (skeletal muscle) with neural control and sensory feedback. Abiotic actuators, by contrast, have yet to match their biological counterparts in their ability to autonomously sense and adapt their form and function to changing environments. We have shown that engineered skeletal muscle actuators, controlled by neuronal networks, can generate force and power functional behaviors such as walking and pumping in a range of untethered robots. These muscle-powered robots are dynamically responsive to mechanical stimuli and are capable of complex functional behaviors like exercise-mediated strengthening and healing in response to damage. Our lab uses engineered bioactuators as a platform to understand neuromuscular architecture and function in physiological and pathological states, restore mobility after disease and damage, and power soft robots. This talk will cover the advantages, challenges, and future directions of understanding and manipulating the mechanics of biological motor control.


© Donato Romano

DONATO ROMANO (Scuola Superiore Sant'Anna, Italy)

Biohybrid complex networks to unveil and control behavioral dynamics in insects

Focused on the integration of robots into animal populations and communities, animal-robot interaction systems create augmented biohybrid networks where artificial agents and animals collaborate, promoting emerging collective abilities. This interdisciplinary approach extends from fundamental biological investigations to bioinspired engineering designs. This talk delves into the world of high-complexity behaviors exhibited by insects, showcasing the symbiotic relationship between their miniaturized brains and technological systems. These mixed societies not only monitor and

control but also restore and enhance the functionality of ecosystems, emerging as crucial tools in addressing contemporary environmental challenges.


© Erol Sahin

EROL SAHIN (Middle East Technical University, Turkey)

Tracking and feeding bees

In my talk, I will be presenting the latest advances in our work within the RoboRoyale project towards tracking and feeding honeybees. Specifically, in the first part, I will present a machine-learning methodology for detecting and tracking the poses of honeybees in a crowded hive, without using any markers. The method uses minimal user labeling so that it can be easily adapted to perform in different imaging conditions of the bees. I will show how the method can count the incoming and outgoing bees in a robotic pollen trap placed at the entrance of the hive. In the second part, I will share the challenges involved and the advances we have made towards developing a robotic bee to feed the queen.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REINHOLD SCHERER (University of Essex, United Kingdom)

Non-invasive Neuroadaptive Brain-Computer Interfaces: Learning to Learn

Main barriers to the use of spontaneous electroencephalogram (EEG)-based Brain-Computer Interfaces (BCIs) are the wide variation in performance when using BCIs and the inability of BCIs to provide meaningful control to a large proportion of users. In this talk, I will argue that EEG-based online co-adaptive BCIs, which automatically adjust or recalculate the model parameters of the algorithms that translates the patterns, help to overcome the above problems.


© Joel Kannasenko

THOMAS SCHMICKL (University of Graz, Austria)

Bio-hybrid robotic systems: A contingency for ecosystem decay?

We are facing the onset of the 6th mass extinction on earth. Our ecosystems are "thinning out" rapidly, diversity-wise and biomass-wise. The weaker the intra- and inter-specific interaction network in an ecosystem gets, the more unstable it will become: A deadly downward spiraling effect will be the result. I will discuss how robotic systems can act in support of ecosystems and communities, in an effort to at least slow-down ecosystem decay. This might give us more time to solve these problems at their core. I will showcase some systems that we have designed and built over the recent years that are supposed to be the first steps of learning how eco-effective robotics can be established. Of course, I will also discuss the dangers and alternatives of such systems.

© Thorsten Schwerte

THORSTEN SCHWERTE (University of Innsbruck, Austria)

Eco-Friendly Pest Control: The Emerging Role of Sensory Illusions

In recent years, the need for eco-friendly pest control methods has become increasingly critical, aligning with global environmental conservation efforts. One example is the use of sensory illusions, particularly to disrupt the visual navigation capabilities of flying pests. A development in this field is a device that utilizes a combination of detectors, projectors, and control units to identify the biological features of an organism and project light patterns that interfere with its trajectory. By exploiting specific sensory vulnerabilities of pests, this method offers a promising solution for eco-friendly pest control without the detrimental impacts associated with traditional chemical pesticides. This approach not only aligns with environmental concerns but also introduces a novel application of sensory psychology in pest management, paving the way for more humane and sustainable pest control practices.

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MARCO TAMBORINI (University of Freiburg, Germany)

From Imitation to Integration: Exploring Bio-Integration in Robotic Design

In the last 15 years, a significant research area has emerged alongside the advancements in hard and soft biorobotics—the field of bio-hybrid robotics design. Instead of directly emulating biological entities, scientists are now developing design practices focused on hybridizing the grammatical structures of both biological and technological objects. This shift emphasizes moving beyond mere bio-inspiration and towards incorporating biological materials into robots (i.e., bio-integration). My talk is an invitation to an interdisciplinary dialogue on new possibilities for integrating robotics, design, and nature. I ask: How can new cross-movements between bio-inspired science and design be fostered? How might we envision the future possible intersection (bio-integration) between technology and nature? To address these inquiries, I first revisit key aspects of classical bioinspired engineering and underscore the role of nature in influencing technological developments. Subsequently, I introduce a novel approach to bio-hybrid engineering, focusing on the role of bio-hybrid robots in design and construction processes. This analysis underscores the parallels in bio-integration, setting the stage for a broader exploration of transformative trends in bio-inspired design. Like in the past, collaboration between biologists, roboticists, engineers, and architectural designers should also emerge today as a catalyst for exploring the fusion of material performance, robotics, and shared agency.


© C. Strobl

RONALD THENIUS (University of Graz, Austria)

Robocoenosis - Biohybrid sensors for aquatic environments

Project Robocoenosis introduces the "life form in the loop" paradigm, aiming to develop biohybrid entities by symbiotically integrating various living organisms and technological components. These biohybrid entities feature notable attributes like energy harvesting, low-power electronics, sensory capabilities, and actuation mechanisms. Their seamless integration into the operational environment, along with autonomy, resilience, and minimal invasiveness achieved through adapted life forms and biodegradable materials, distinguishes them. The project demonstrates the potential of these biohybrid entities through extended autonomous field operations for underwater biomonitoring and sensing in ecologically sensitive aquatic environments.


© T. Thang Vo-Doan

T. THANG VO-DOAN (University of Queensland, Australia)

Insect-machine hybrid robots: from novel robotic platforms to cutting-edge tools for biological science

Insect-machine hybrid robot is a fusion of a living insect platform and a miniature control backpack mounted on. Such a hybrid robot can easily adapt to complex terrains due to the benefit of living structure such as soft interface and self-adaptation inherited from the living insect. Electrical stimulation of the sensory receptors enables us to control the insect locomotion and navigation on the ground while stimulating flight muscles in untethered condition help to investigate the real functions of those muscles.


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WEN-CHI YANG (Bokang Holding Group, Shanghai, China)

Can Augmented Perceptions Change the Evolutionary Equilibrium of Collective Behaviours in Fish

The artificial enhancement of perceptions has changed the human behaviours and interactions. Similar impacts are widely found in dogs, monkeys, and even less smart animals like bees and fish. These findings suggest a new methodology that we may re-examinate evolutionary theories that used to be treated as 'unverifiable'. In this presentation, we will discuss some published attempts. One is that by letting fish sense its blind area, we observed if the shoaling behaviour can be affected. The other is that we checked whether varied vision enhancements can lead to different replies in fish's social interactions.