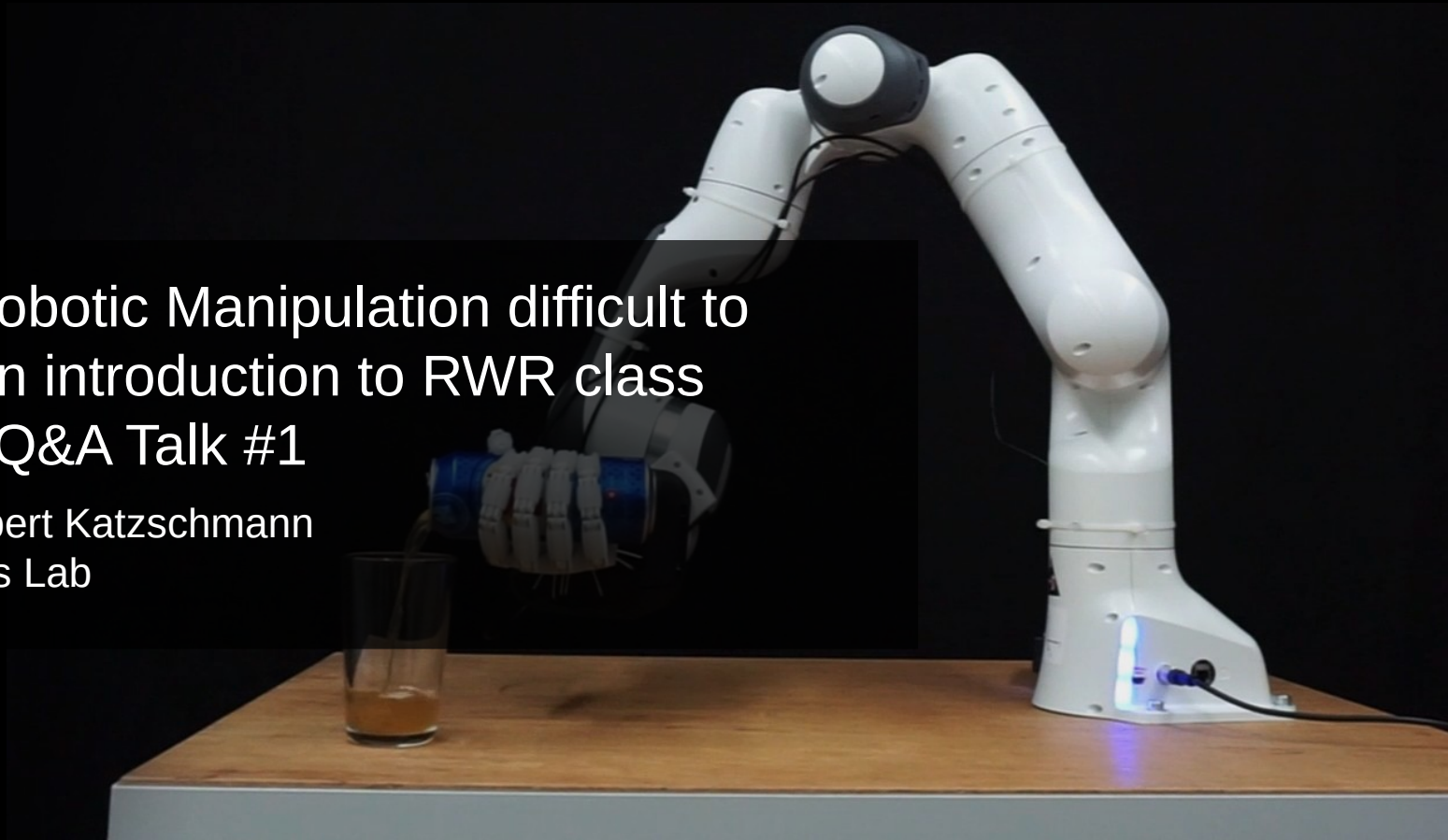




# Why is Robotic Manipulation difficult to solve – an introduction to RWR class Focus & Q&A Talk #1

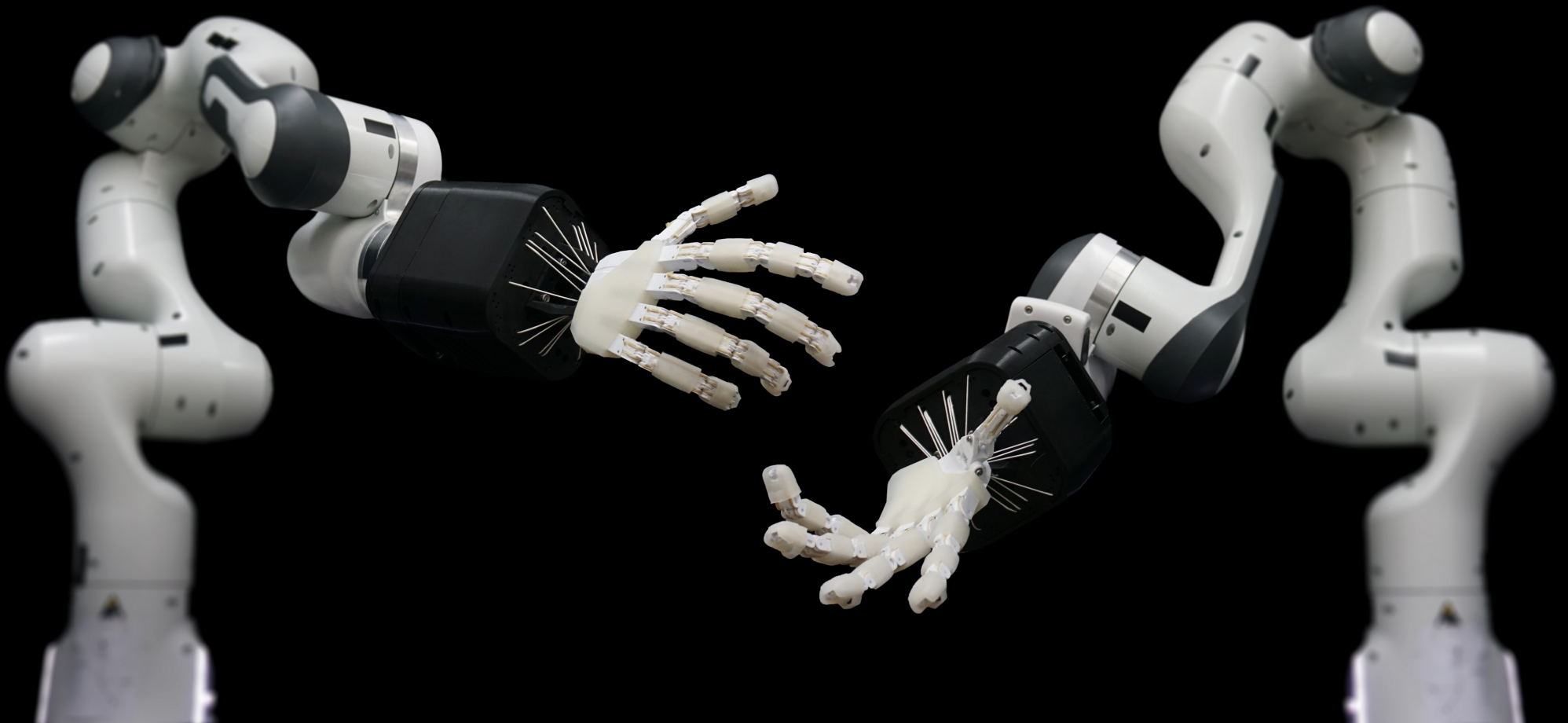
Prof. Dr. Robert Katzschmann  
Soft Robotics Lab  
ETH Zurich



Shall future AI do your art and writing or rather your laundry and dishes?

*SoftRobotics*  
Laboratory

**ETH** zürich





Make an image on: A cat wearing sunglasses by the lake

Please write me a short poem.



Of course! Here's a brief poem for you:

### **Silent Bloom**

In quiet moments, flowers grow,  
Whispers of the earth below.  
In a breath, the world is new,  
Bathed in morning's gentle hue.

I hope this captures what you're looking for!

“  
I want **AI** to do my **laundry** and **dishes** so that I can do **art** and **writing**,

Not for **AI** to do my **art** and **writing** so that I can do my **laundry** and **dishes**.  
”

- Joanna Maciejewska





## Easy for AI

Tasks that require high-level reasoning

Winning chess games



Perform calculations at warp speed



## Moravec's Paradox

## Difficult for AI

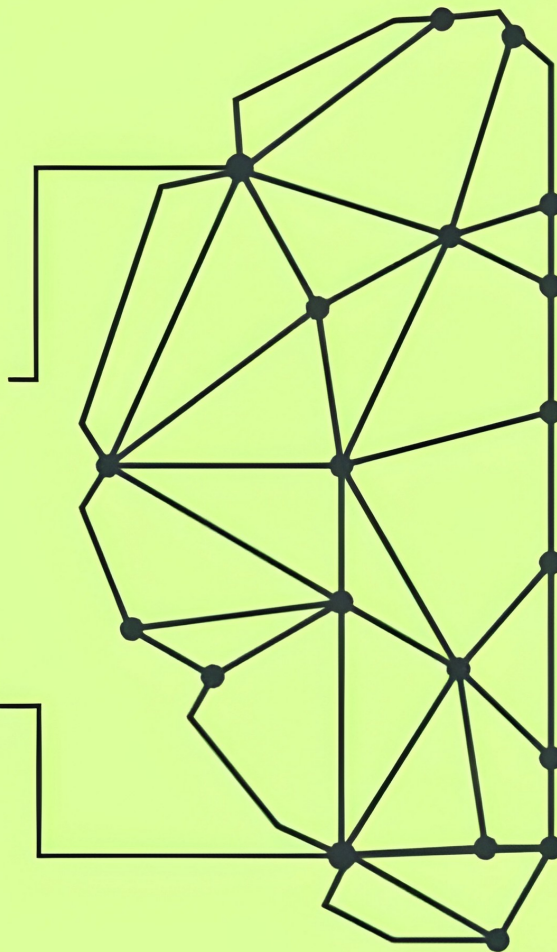
Tasks requiring sensorimotor and perceptual skills



Maneuver a busy room



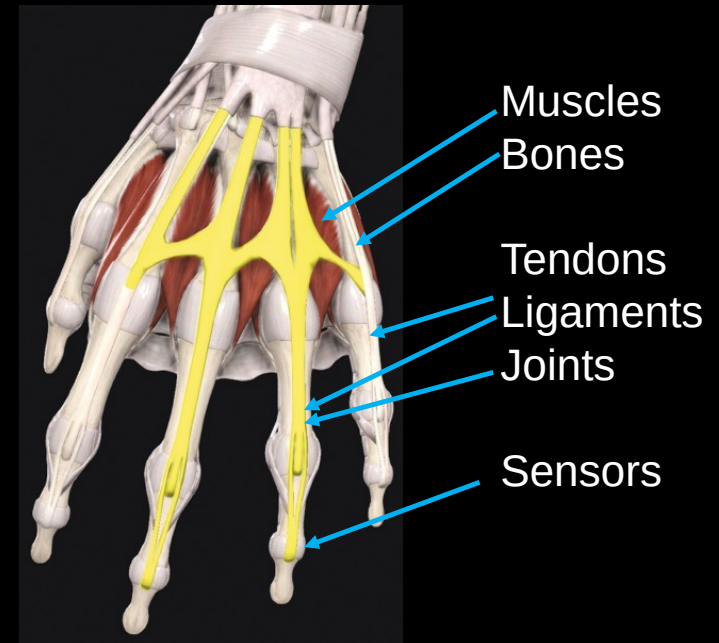
Recognize a familiar face in low light



A blurry, low-angle shot of a robotic arm in a factory setting. The arm is positioned in the foreground, and the background shows various industrial equipment and structures. The image is dark and out of focus, emphasizing the complexity of the task.

Why is the robot manipulation problem so hard to solve?

## The Problem - Hardware



27 degrees of freedom (DoF)  
over 17,000 touch receptors just in the palm



# The Problem - Control

## Data



Cannot simply scrape the internet

## Control Frequency



Need real time control

## Cross-embodiment



Diverse observations and actions

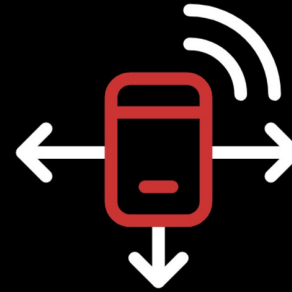
# The RWR class – what you will learn



Design and Fabrication



Kinematics, Dynamics  
and Control



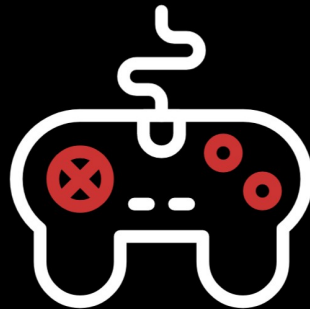
Sensors



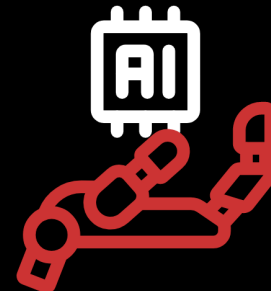
Simulation



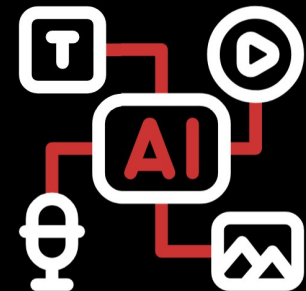
Reinforcement Learning



Teleoperation and  
Data Collection



Imitation Learning



VLA's and  
Foundation models

# Market

## Complex Manual Labour Tasks



# Market - Humanoids





# Market - Robotic Hands

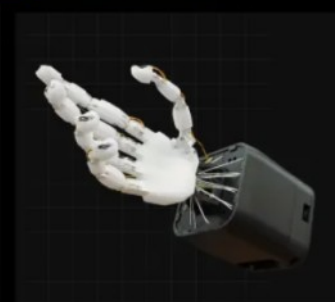
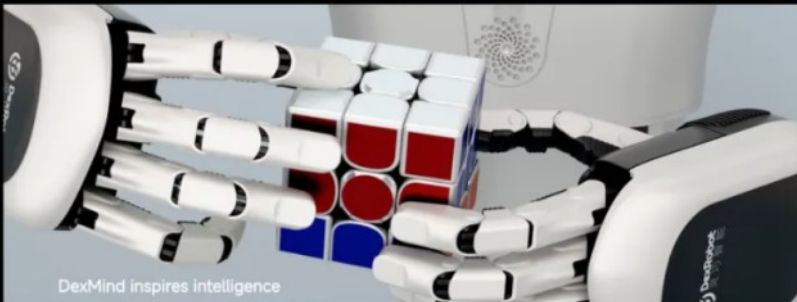




Figure A1





a preview of model capabilities

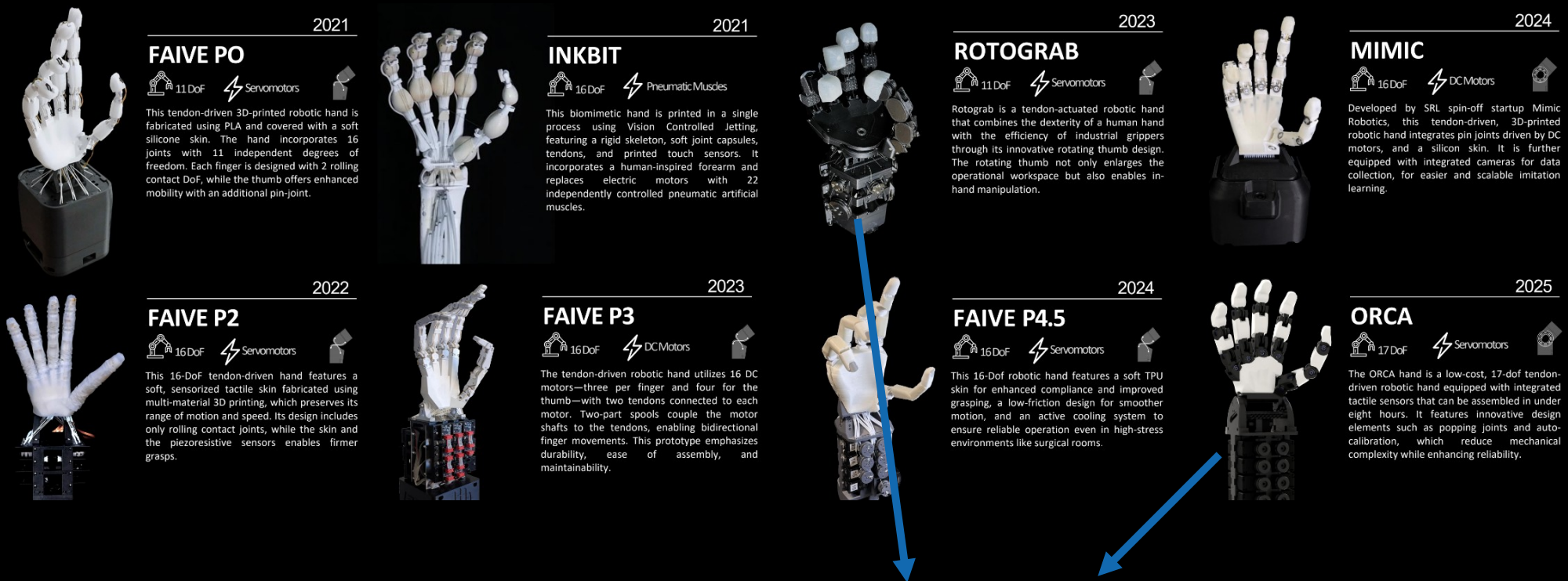
# Physical Intelligence



$\pi$

# Dexterous Robotic Manipulation @ SRL

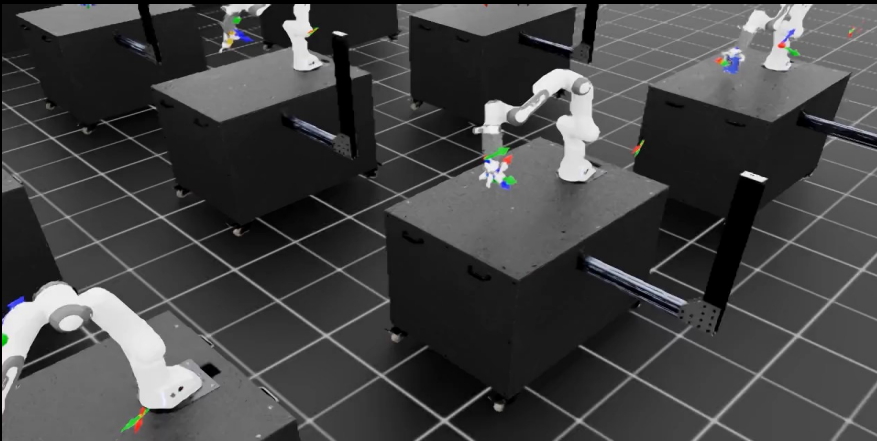
## Continuous iterations to create better hardware



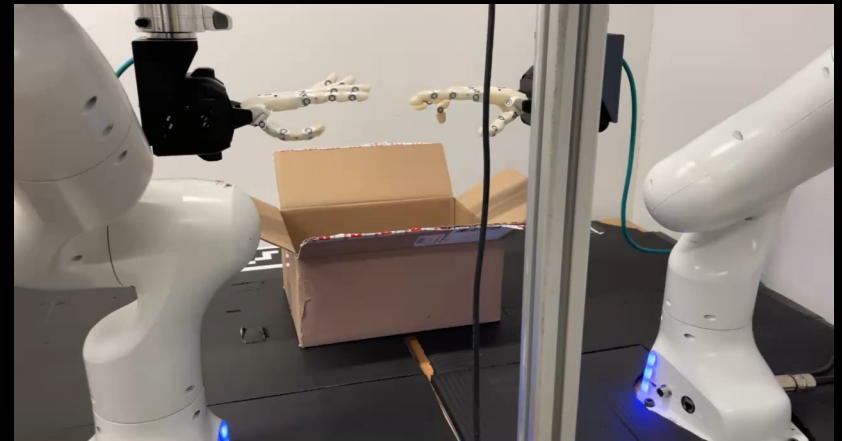
From RWR class!

# Dexterous Robotic Manipulation @ SRL – Learning Strategies

RL and Simulation



IL and Cross-Embodiment





# Dexterous Robotic Manipulation @ SRL - Applications

Robot Hands for Surgery Rooms



Megahand for disaster response



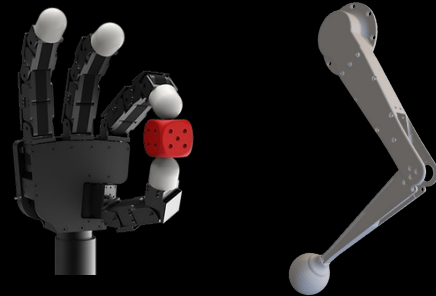
**Beyond this class**

# Musculoskeletal designs bring together multiple worlds

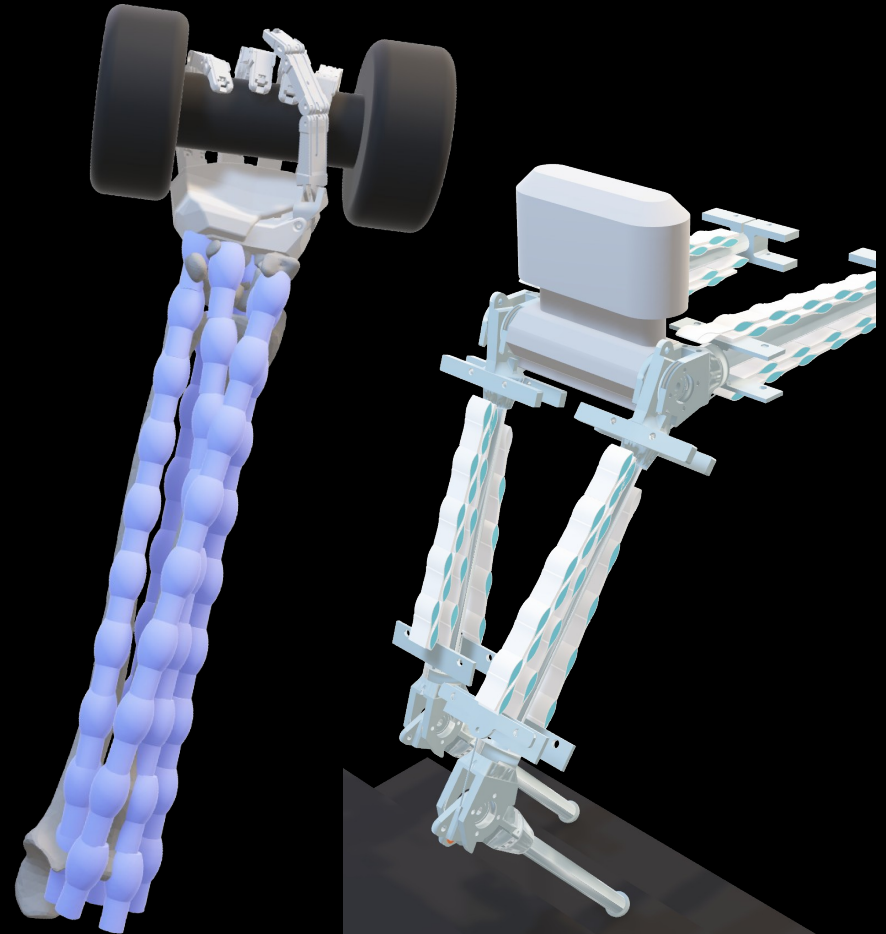
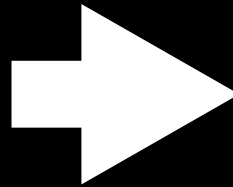
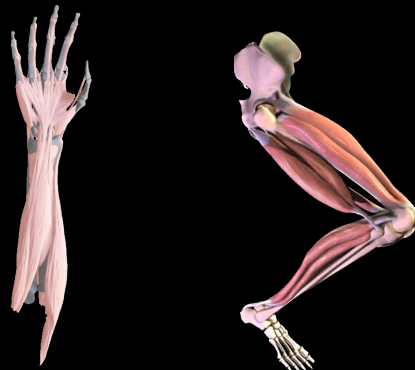
Soft



Rigid



Nature



# Electrohydraulic Muscles





## Biohybrid Robots

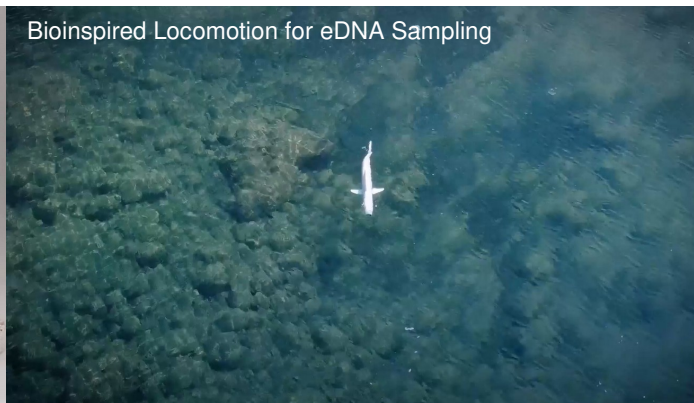




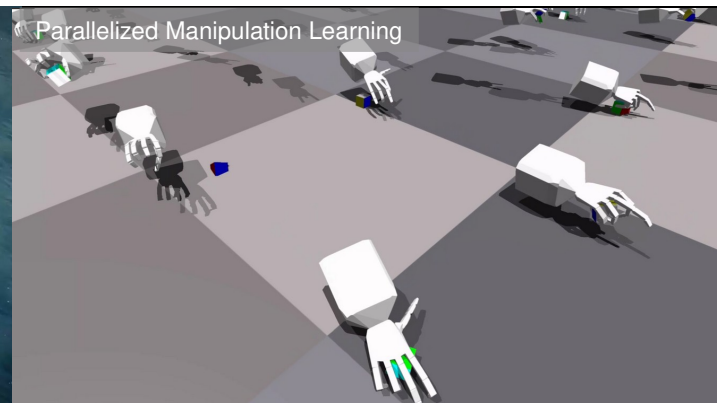
Electrohydraulic Musculoskeletal Robots



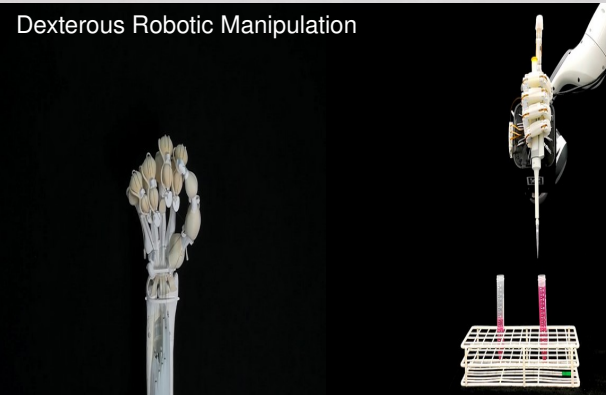
Bioinspired Locomotion for eDNA Sampling



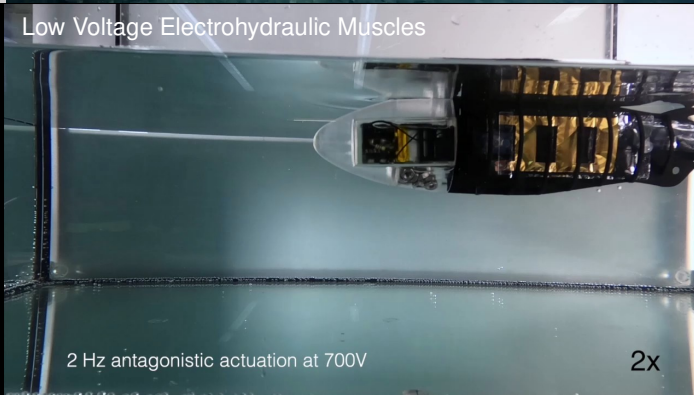
Parallelized Manipulation Learning



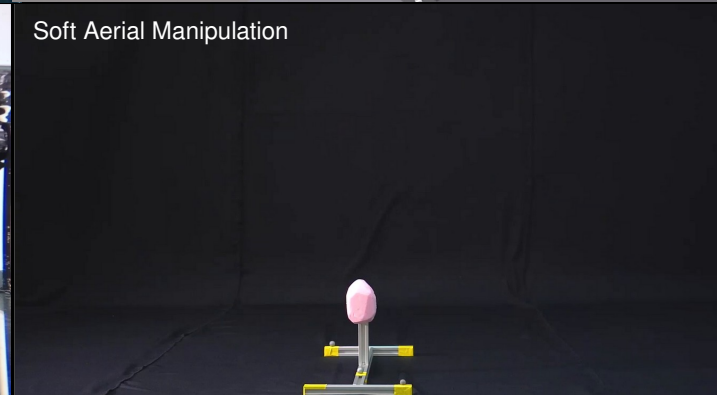
Dexterous Robotic Manipulation



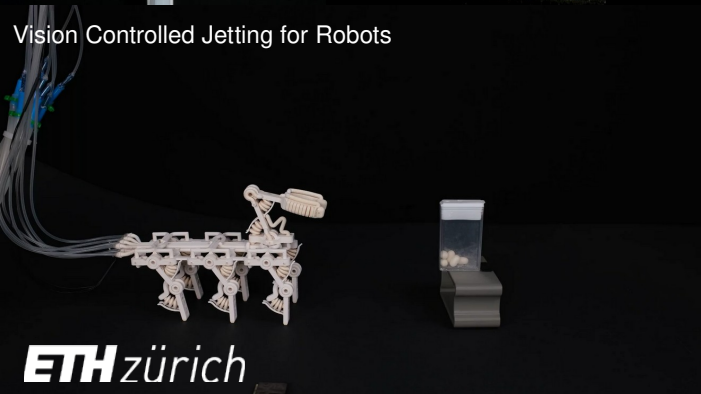
Low Voltage Electrohydraulic Muscles



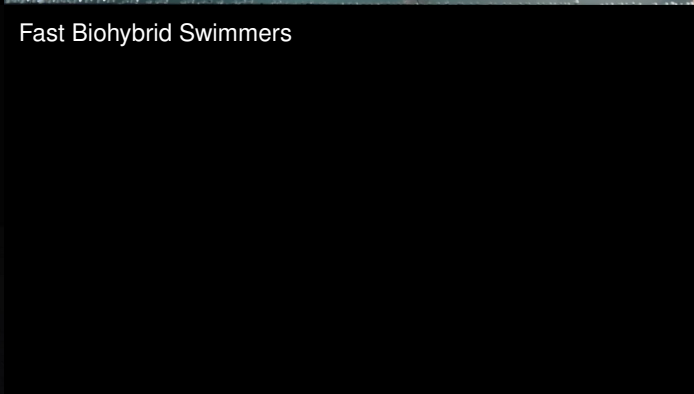
Soft Aerial Manipulation



Vision Controlled Jetting for Robots



Fast Biohybrid Swimmers



# Teaching Team



**Prof. Robert Katzschmann**  
*Lead Organizer*



**Dr. Ronan Hinchet**  
*Sr. Scientist @ SRL*



**Yasunori Toshimitsu**  
*PhD @ SRL*



**Chenyu Yang**  
*PhD @ SRL*



**Davide Liconti**  
*PhD @ SRL*



**Jaehoon Kim**  
*PhD @ SRL*



**Robert Jomar Malate**  
*Lead Teaching Assistant*



**Aristotelis  
Sympetheros**



**Filippas Katsimalis**  
*Teaching Assistant*



**Habib Ben Abda**  
*Teaching Assistant*



**Esteban Padilla  
Cerdio**



**Dr. Anhui Wu**  
*Lab Technician  
+ Manager*



**Dr. Miriam Filippi**  
*Perfusable  
Large-scale Muscles*



**Lewis Jones**  
*Volumetrically Printed  
Cardiac Muscles*



**Aiste Balciunaite**  
*Untethered Biohybrid  
Muscle Actuators*



**Manuel Mekkattu**  
*Modeling Biohybrid  
Muscles*



**Asia Badolato**  
*Neurotised Biohybrid  
Muscles*



**Dr. Ronan Hinchet**  
*Electrostatic Actuators  
and Soft Robots*



**Thomas Buchner**  
*Printed Robots +  
Electrohydraulic Legs*



**Deniz Albayrak**  
*Electric Muscles for  
Robots*



**Amirhossein Kazemipour**  
*Autonomous  
Musculoskeletal Robots*



**Gavin Cangan**  
*Proprioceptive Robotic  
Manipulation*



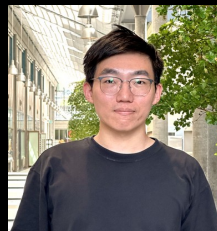
**Davide Liconti**  
*Learning-Based Control +  
Design for Manipulation*



**Federica Poltronieri**  
*Lab Admin  
+ Organizer*



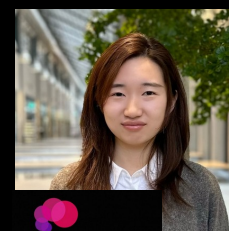
**Chenyu Yang**  
*Learning Representation  
for Musculoskeletal Robots*



**Yasunori Toshimitsu**  
*Co-optimized  
Robotic Hands*



**Hehui Zheng**  
*Soft Robotic  
Reconstruction*



**Mike Michelis**  
*Learned Multiphysical  
Surrogates*



**Elvis Nava**  
*Dexterous Robotic  
Transformers*

