ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

INTELIGENCIA ARTIFICIAL APLICADA A LA BIOMEDICINA
Fundacio Ramon Areces, Madrid
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Soft Robotics for Intuitive Invisible Interactions

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Reconfigurable Robotics Laboratory

EPFL

Reconfigurable Robotics Lab

@robotician

Paradigm shift in robotic design

industrial environment

- Highly predictable
- Programmable

Augmented performance:

- **Force**
- **Speed**
- **Precision**

real-world environment

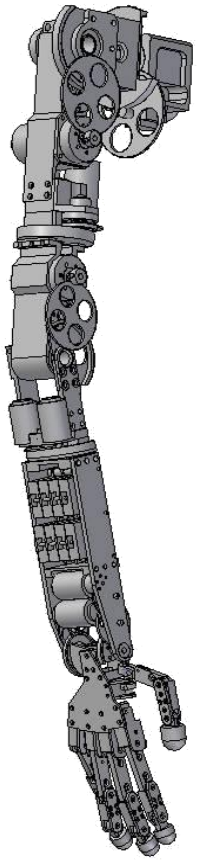
- Highly unpredictable
- Random tasks and uncertainties

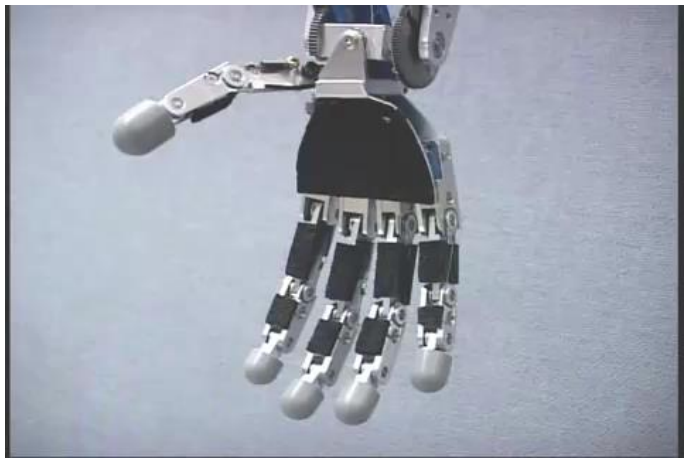
Augmented interactivity:

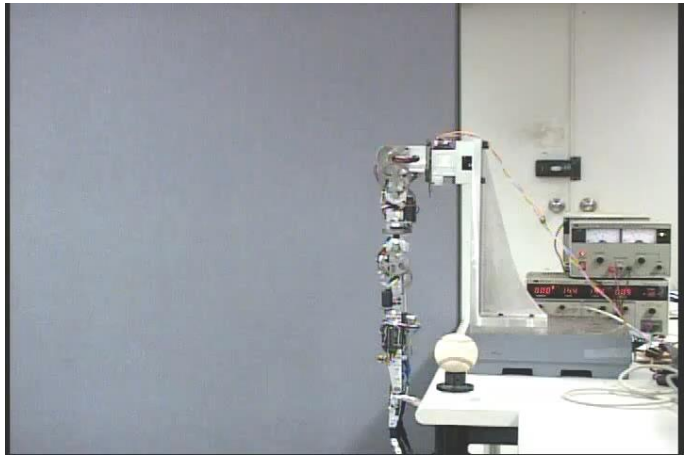
- **Adaptability**
- **Reconfigurability**
- **Safety**

Paradigm shift in robotic design: Is anthropomorphic robot the answer ?

Paradigm shift in robotic design: Is Anthropomorphic robot the answer ?







Bang, Y., Lee, K., Lee, W., Shin B., **Paik, J**., and Jeoung, J., "Automatic Belt Hole Punch", Korean Intellectual Properties Office IPC:B26F 1/02

Jarrassé , N., **Paik, J.**, Pasqui, V., and Morel, G., "Experimental Evaluation of Several Strategies for Human Motion Based Transparency Control", Experimental Robotics Springer Transaction in Advanced Robotics, 2009, Volume 54/2009, 557-565.

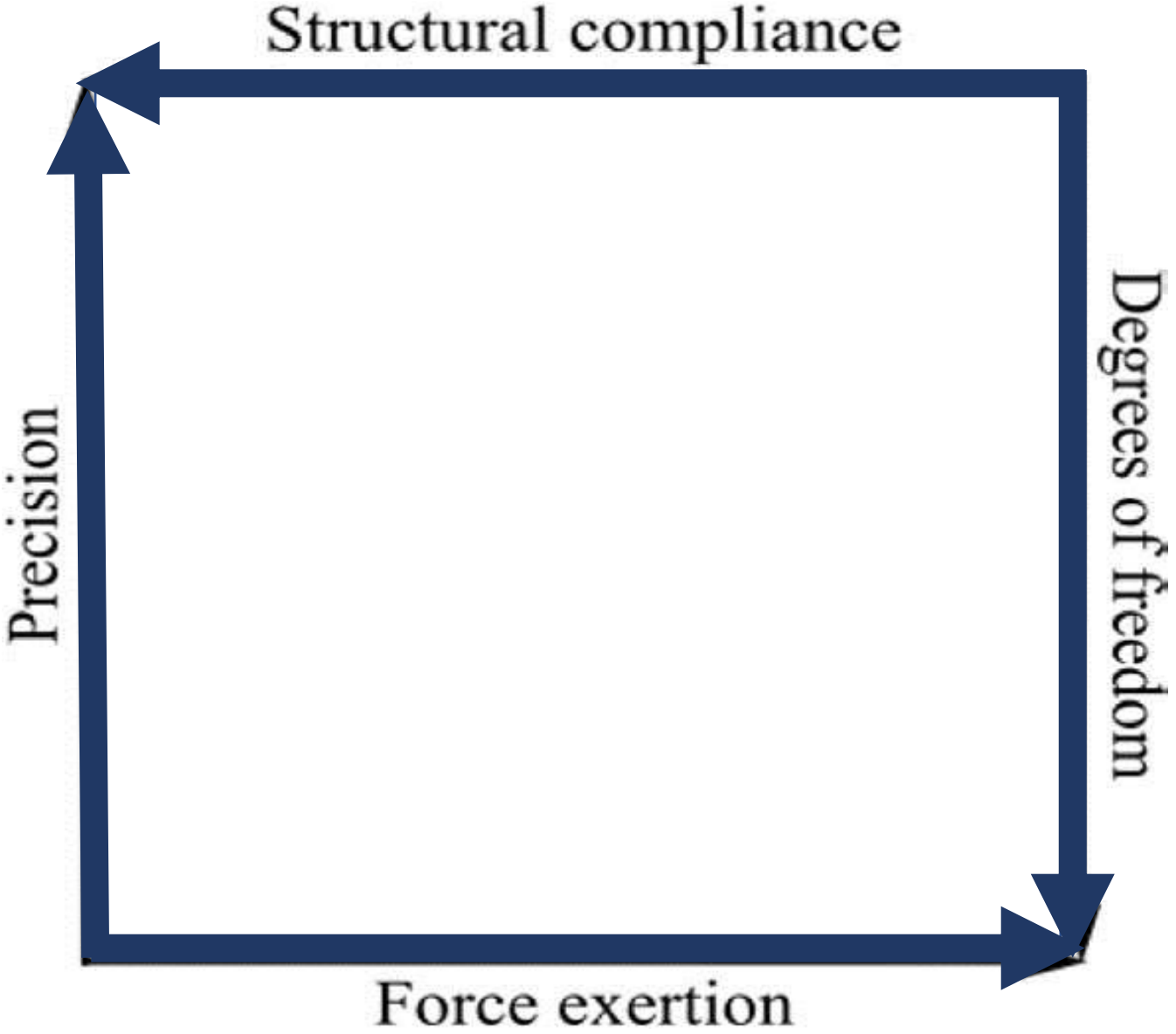
Jarrassé, N., **Paik, J.**, Pasqui, V., and Morel, G., "How Can Human Motion Prediction Increase Transparency?" ICRA 2008: 2134-2139.

Jarrassé, N., **Paik, J.**, Pasqui, V., and Morel, G., "Design and Acceptability Assessment of a New Reversible Orthosis" IROS 2008: 1933-1939.

Paik, J., "Anthropomorphic Robot Arm and Hand for Interactive Humanoids", Transaction on Robotics submitted.

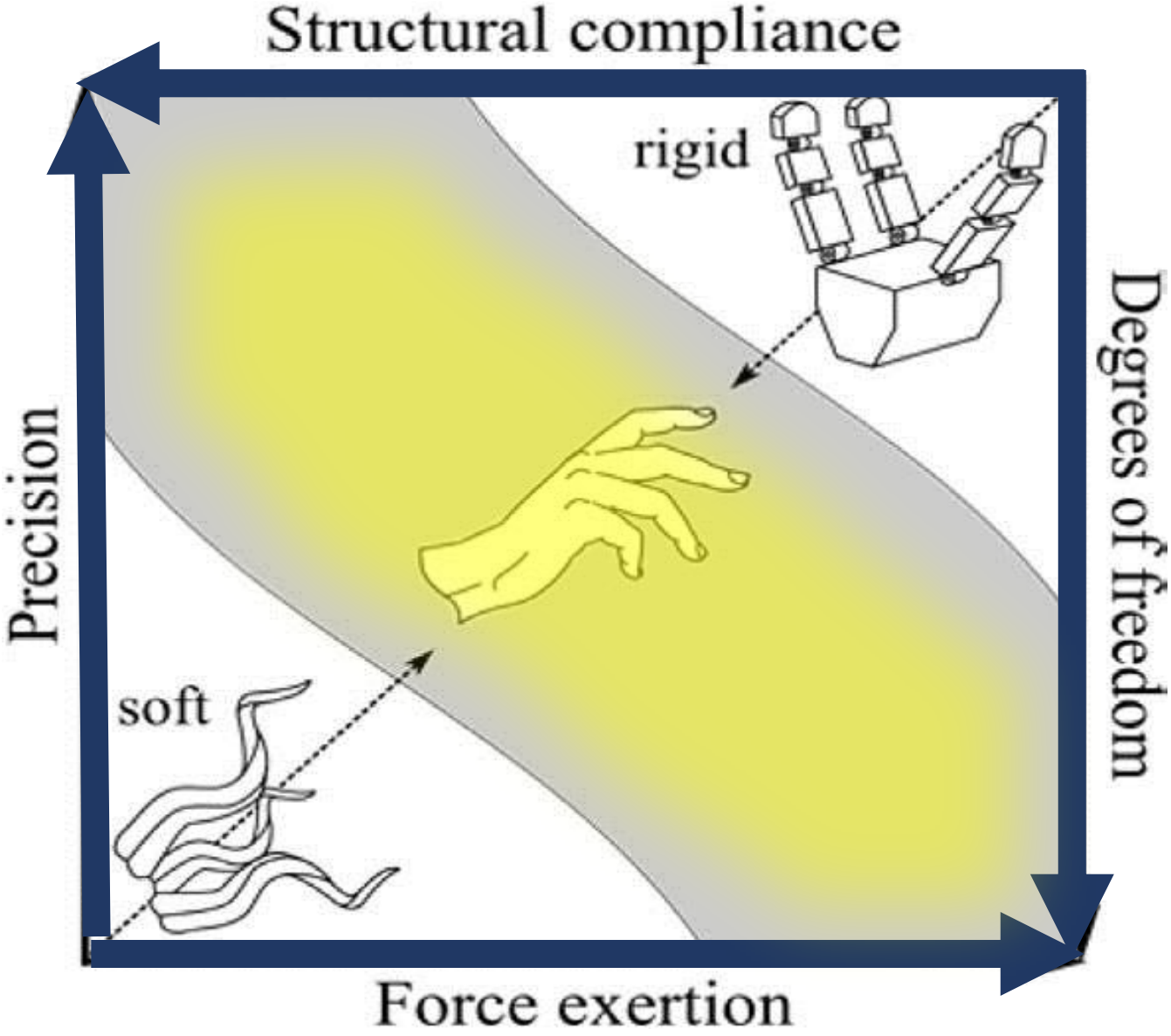
W. Lee, Y. Bang, K. Lee, B. Shin, **J. Paik**, and I. Kim, "Motion Teaching Method for Complex Robot Links Using Motor Current", International Journal of Control, Automation, and Systems, 2010 8(5): 1072-1081.

Challenges in robotic design

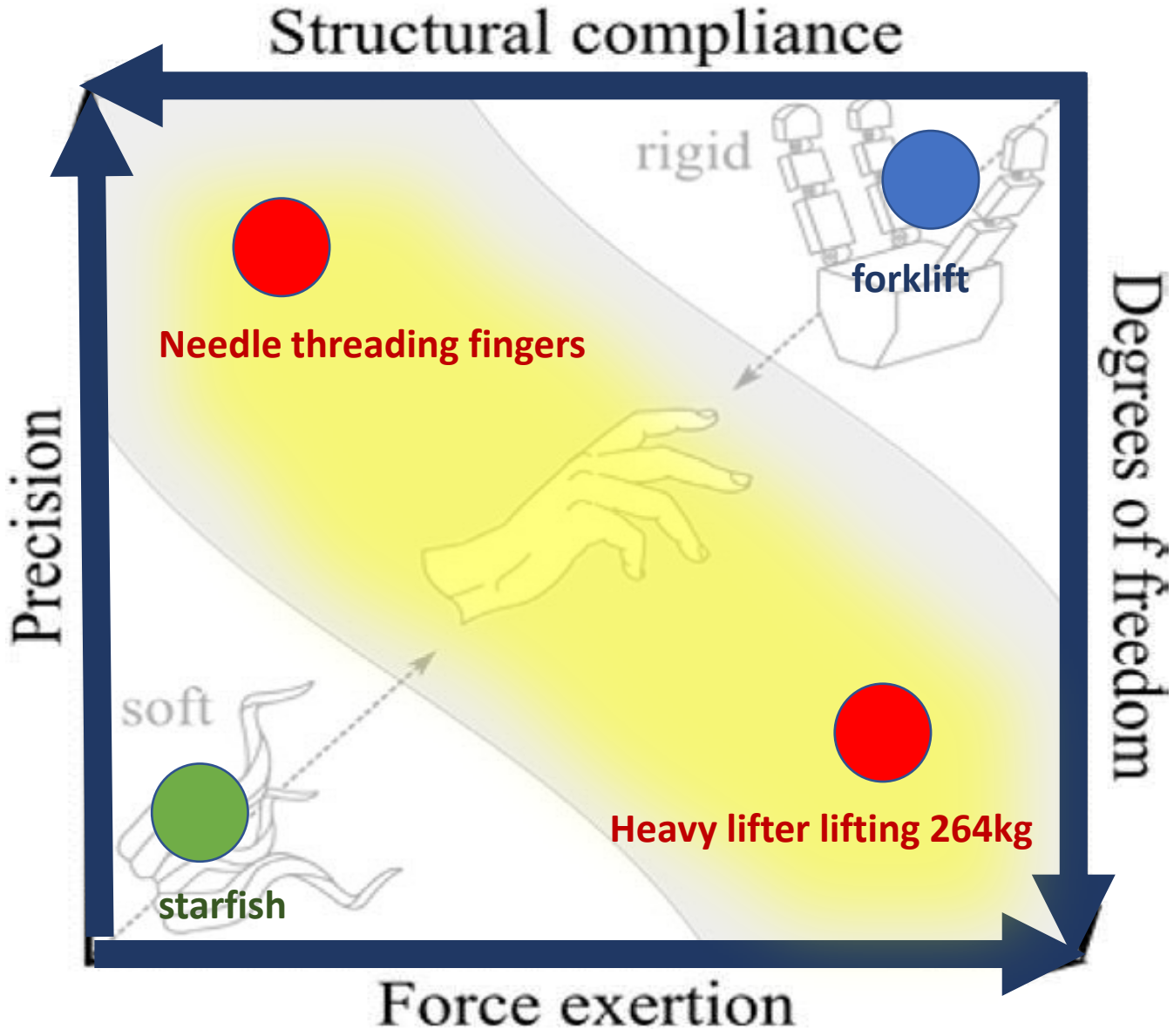


Adapted image from *Hughes et al, Front. in Robotics (2016)*

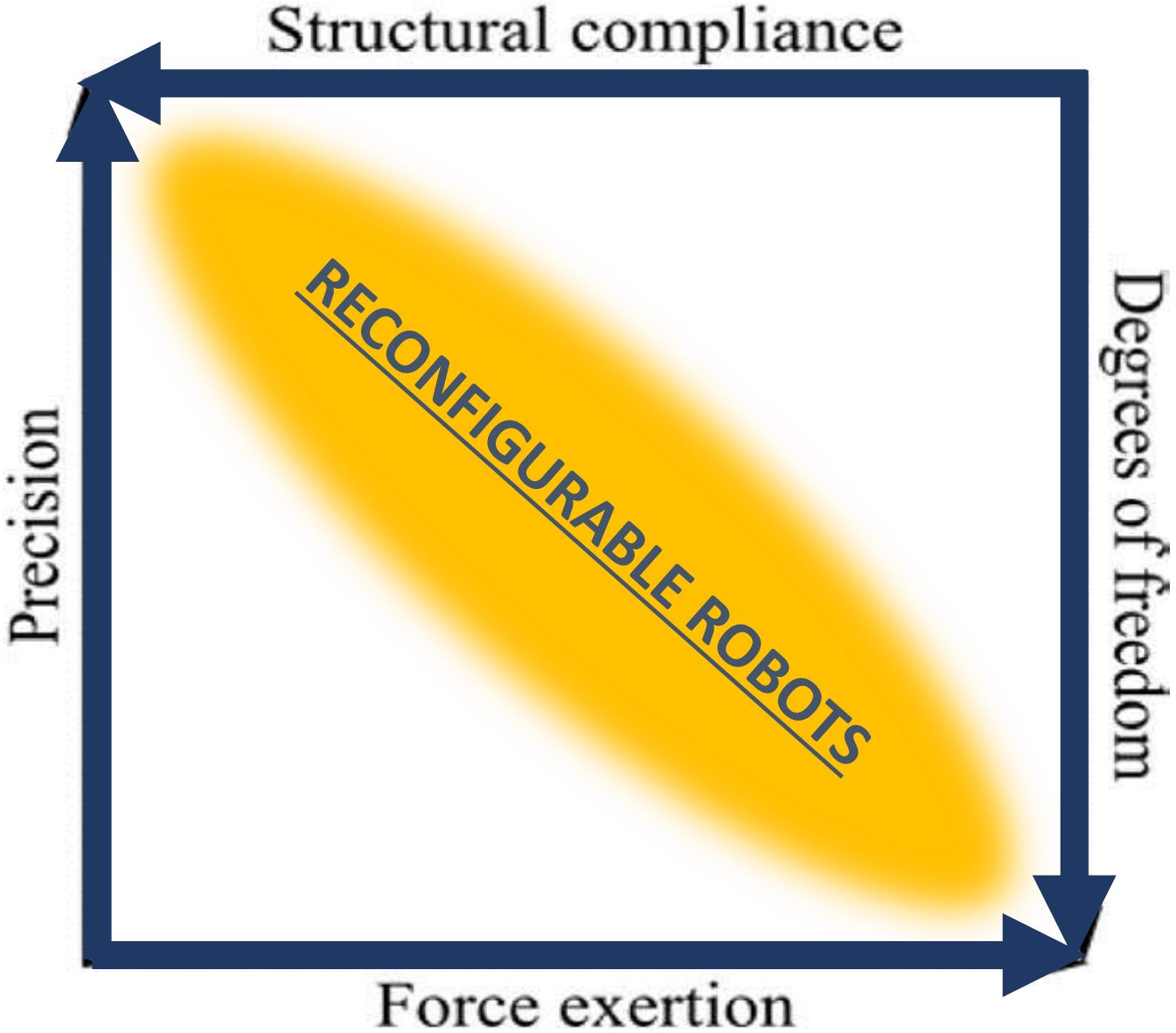
Challenges in robotic design



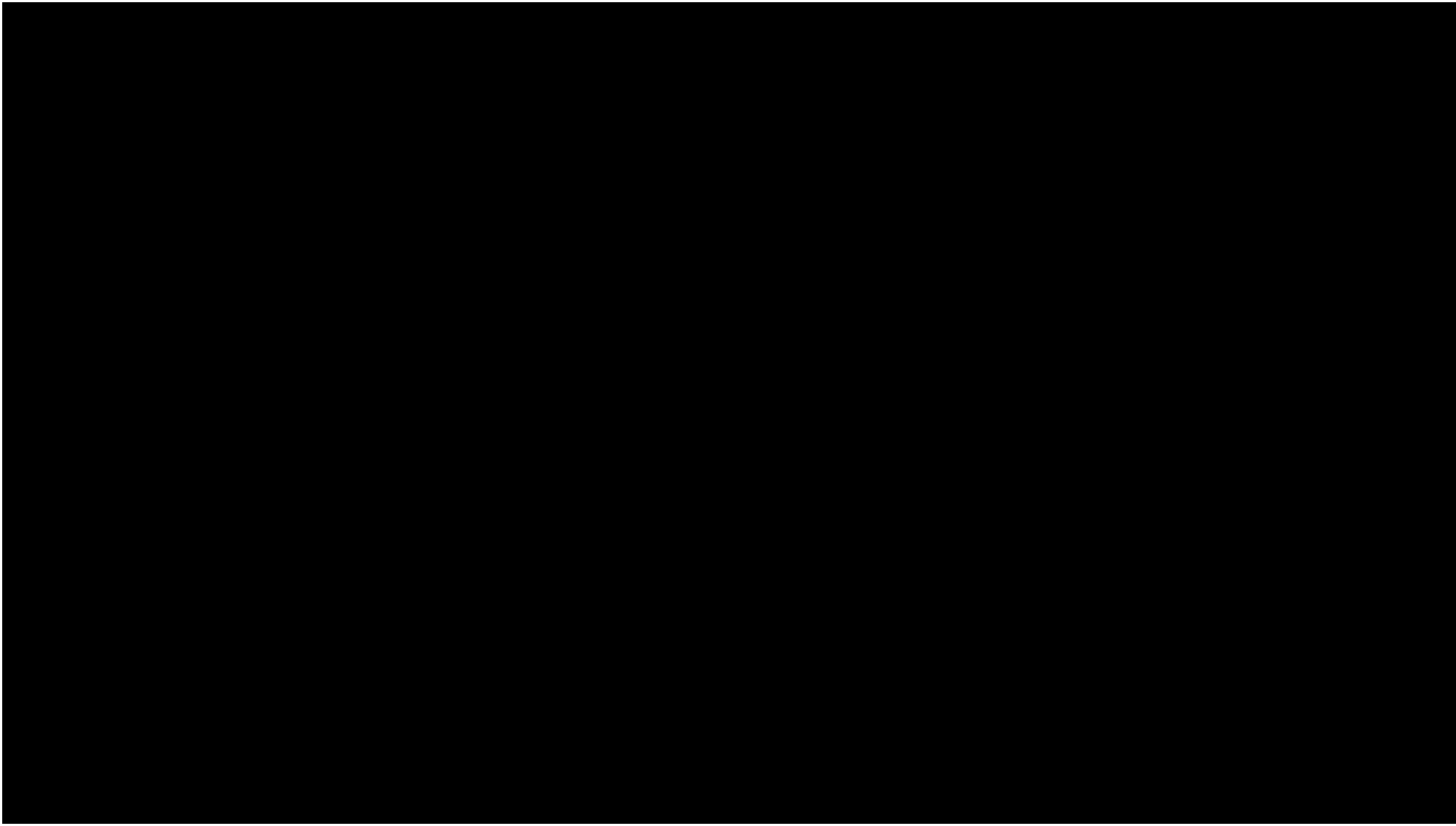
Challenges in robotic design



Reconfigurable robots for embodied intelligence

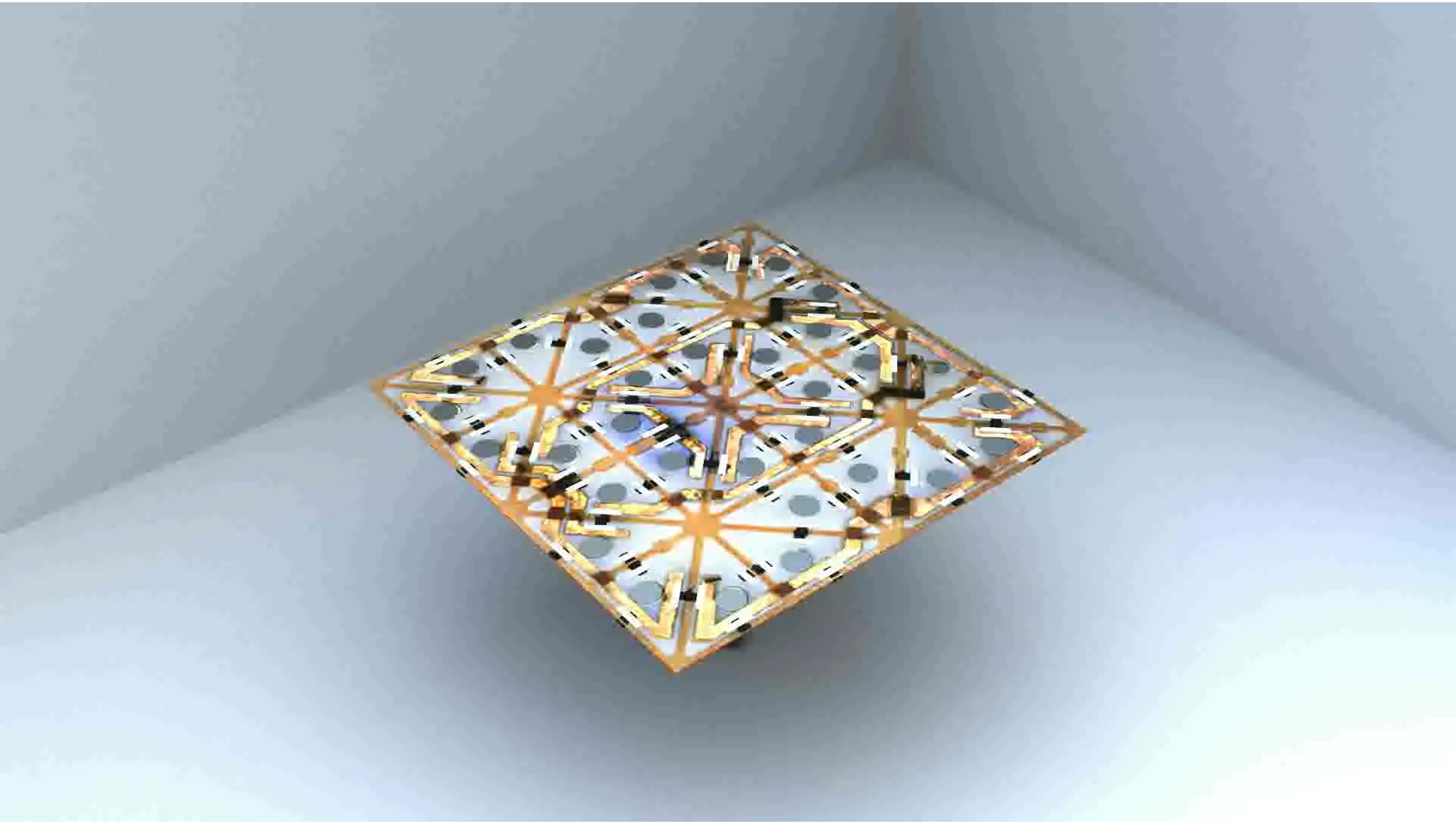


Reconfigurable robots



https://www.youtube.com/watch?v=SHPibEyeDe0&feature=youtu.be

What is an Origami Robot ?



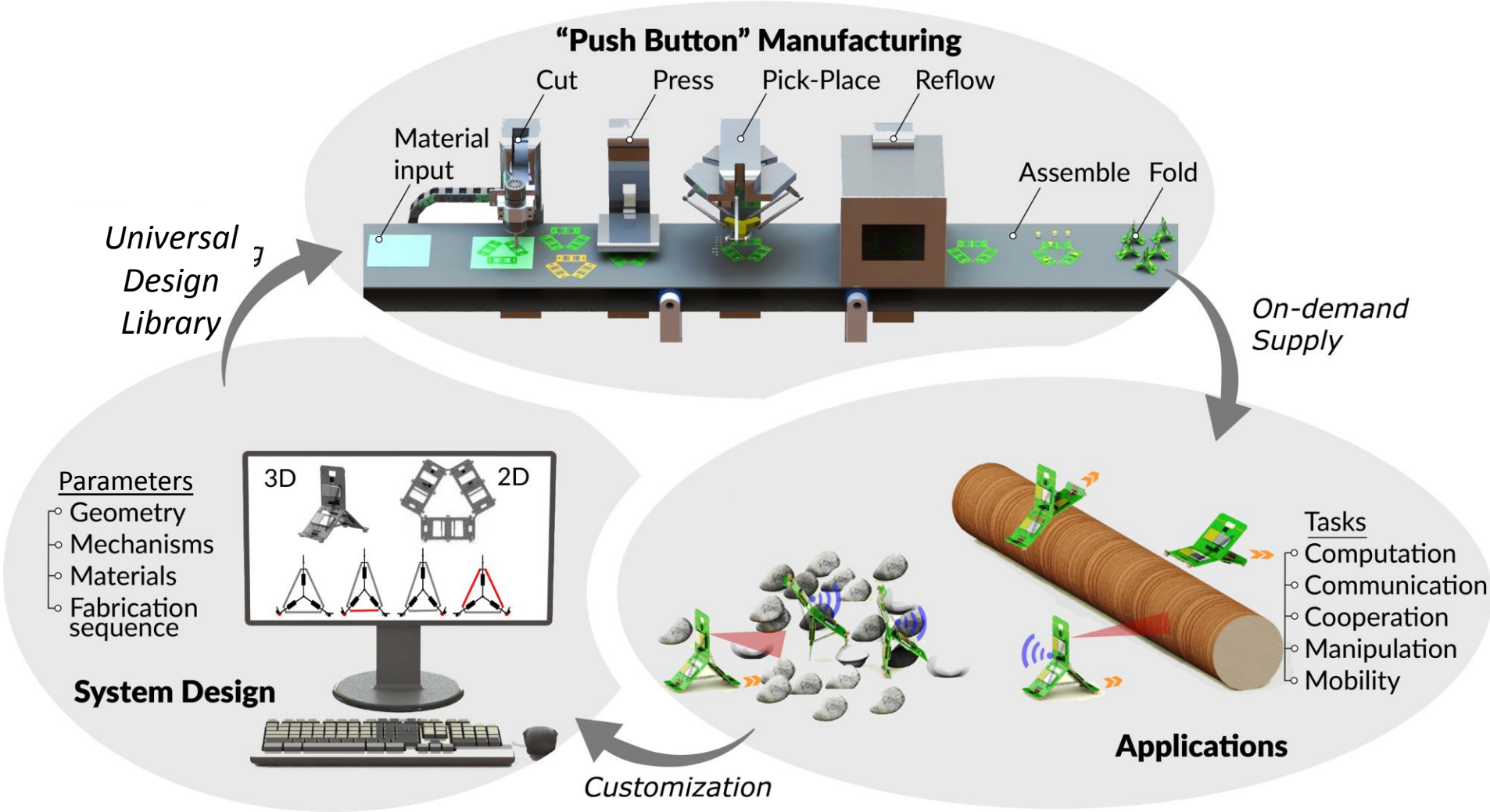
Wearable Soft Robot

A wearable robot for facial palsy rehabilitations

Robogami manufacturing

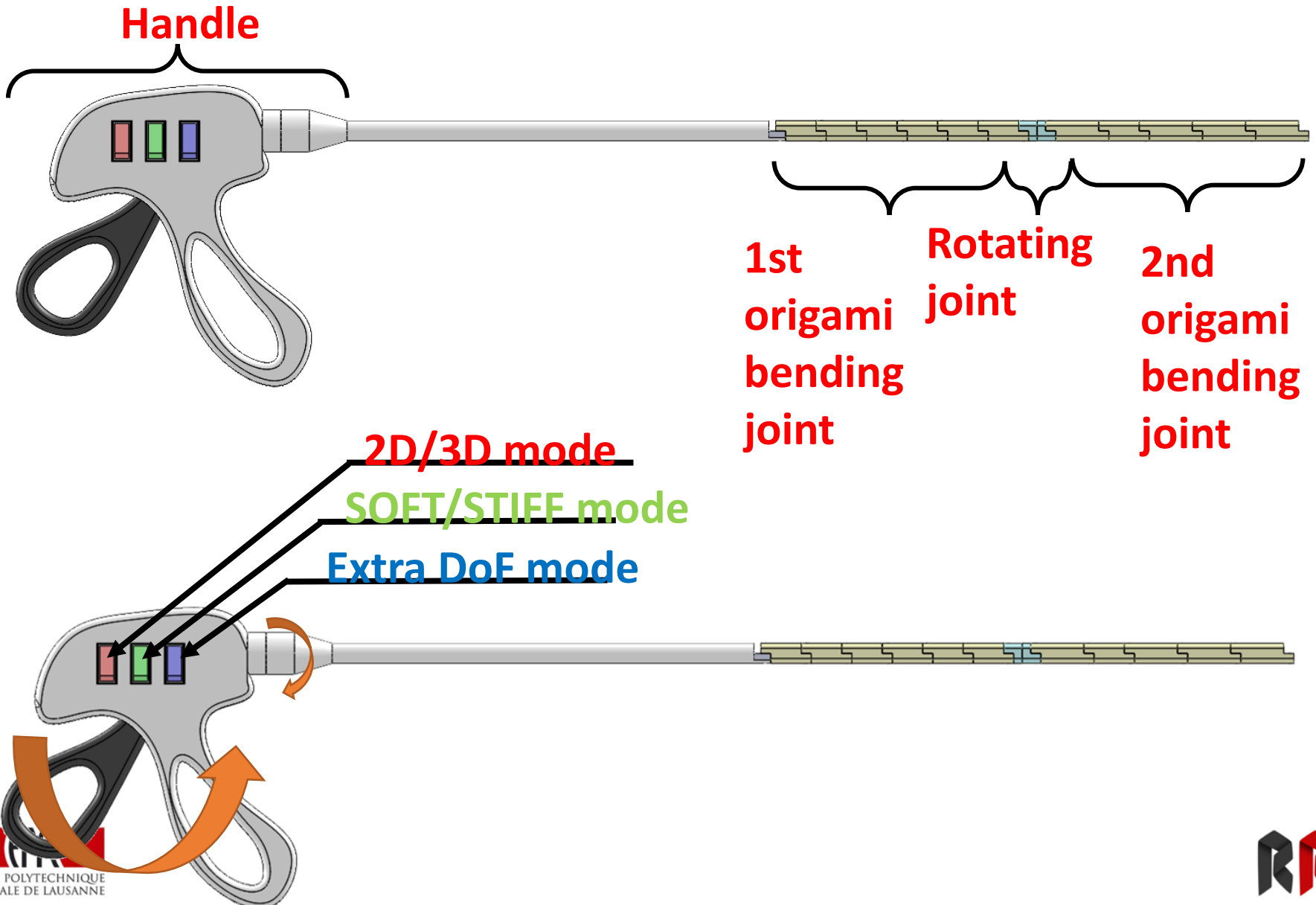
Paik, ***Nature Reviews Materials*** *(2018)*
Zhakypov & Paik, ***IEEE Trans. on Robotics*** *(2018)*

RRL Vision: 'push button' manufacturing



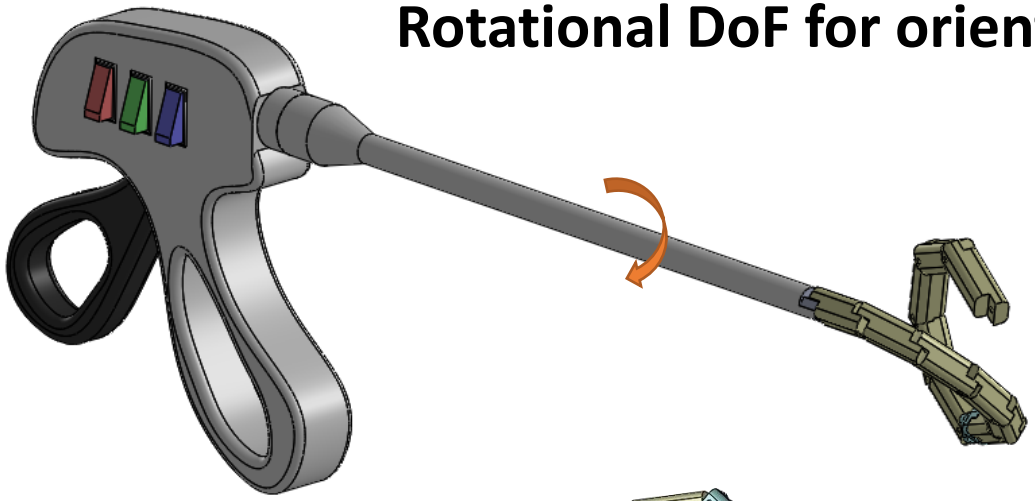
Paik, ***Nature Reviews Materials*** *(2018)*

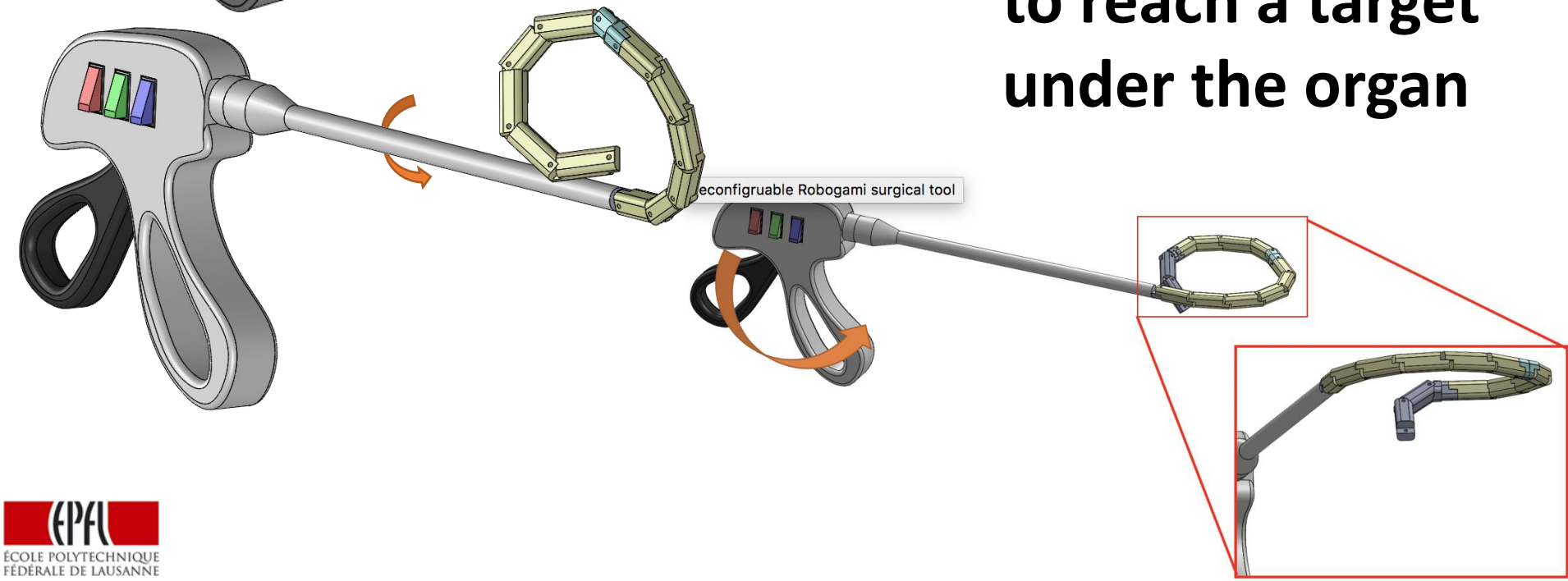
Reconfigruable Robogami surgical tool



Reconfigruable Robogami surgical tool

Rotational DoF for orientating the shape of the tool





- **Stiffening**
- **Organ lifting**
- **Using extra DoFs to reach a target under the organ**

Reconfigruable Robogami surgical tool : REGULATE

- **V1:**

  Basic design (kinematics)

- **V2:**

  Electronics integration

  HMI

- **V3:**

  Structural improvements

  Ergonomic improvements

Origami robot application : Foldable haptic joystick

FOLDAWAY haptics

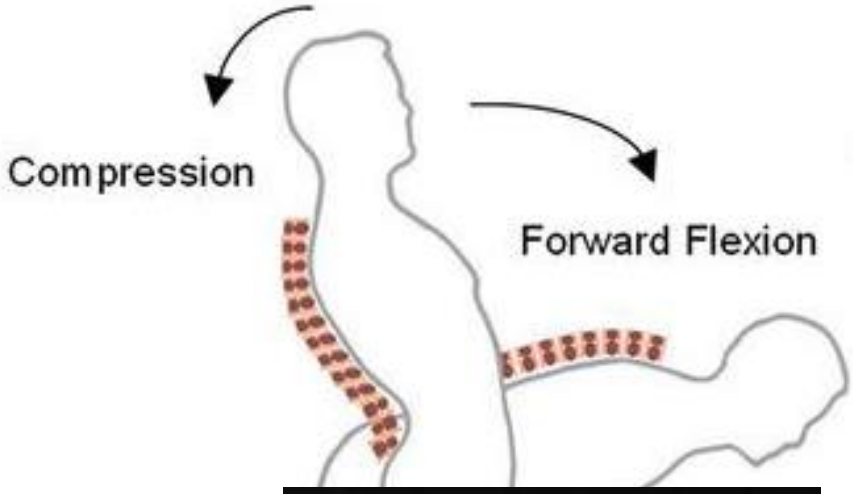
***US Patent** 15/229,157*

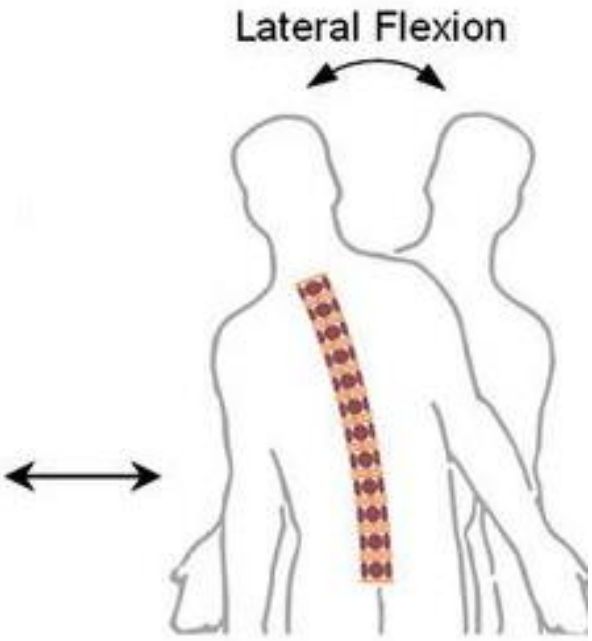
Best Demo Award ***IEEE Haptics Symposium** (2018)*

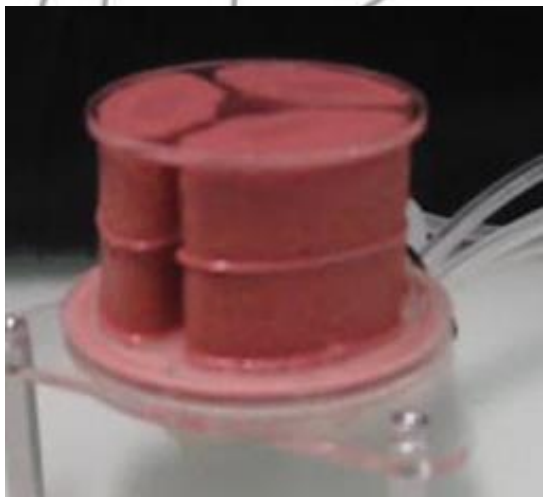
*Salerno et al. **Sensors & Actuators** (2017)*

*Salerno et al. **J of Mechanisms & Robotics** (2017)*

What are soft pneumatic actuators?



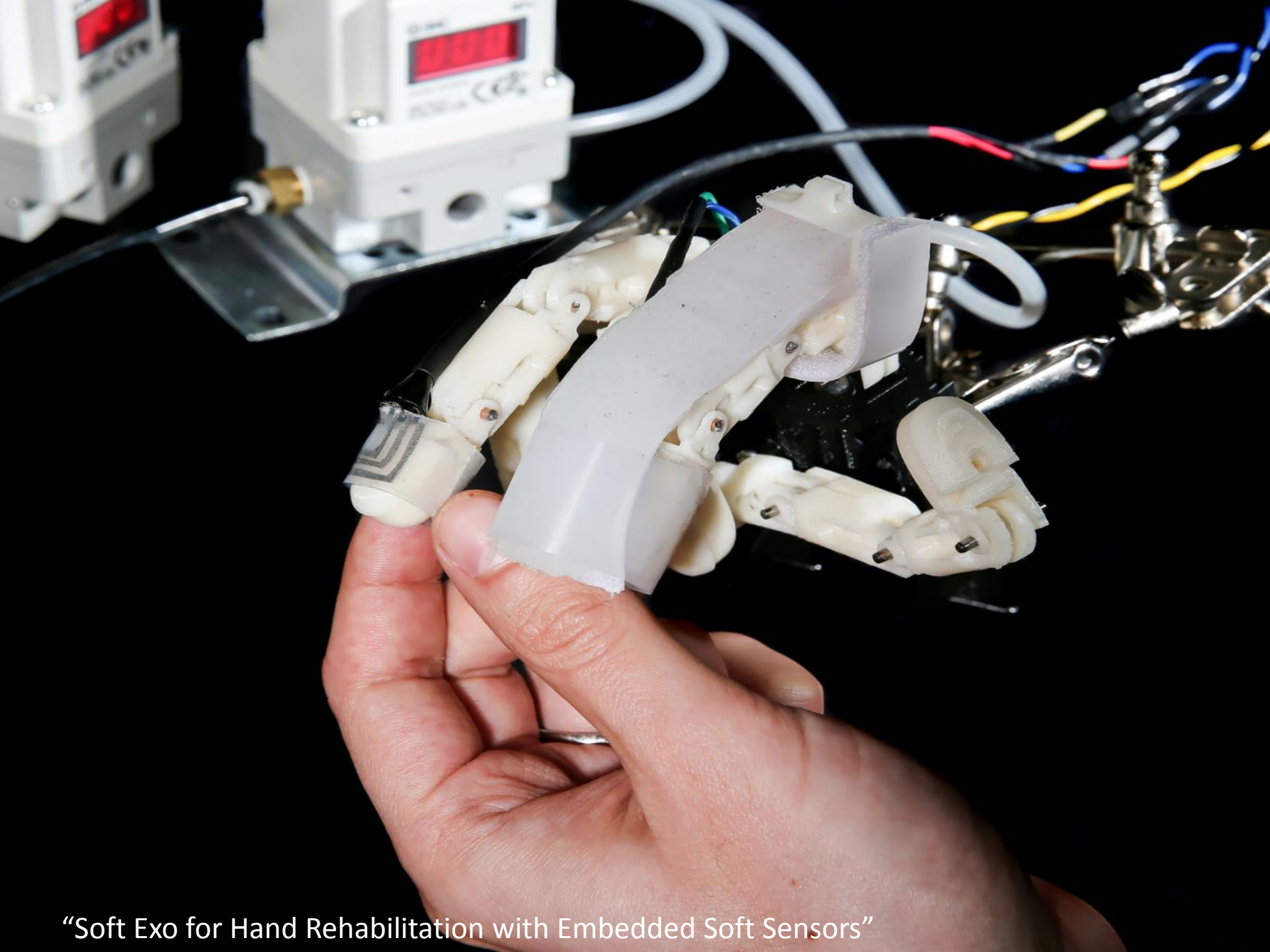




Agarwal et al. ***Scientific Reports*** *(2016, 2017)*

Soft Pneumatic Actuator (SPA) modules

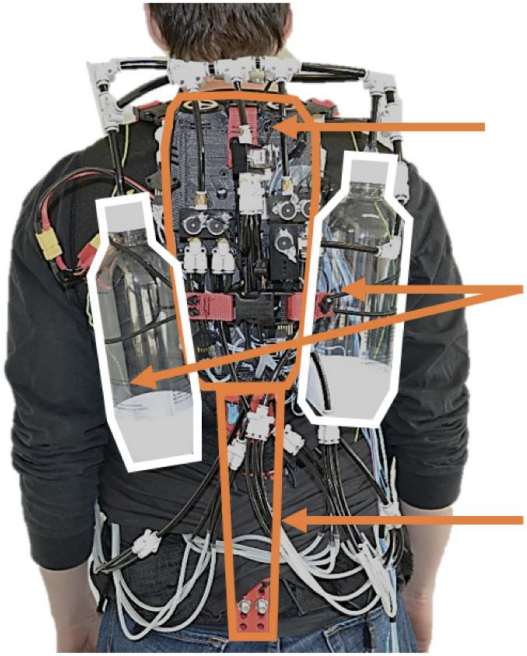
Robertson & Paik, ***Science Robotics*** *(2017)*



“Soft Exo for Hand Rehabilitation with Embedded Soft Sensors”

Portable vest for assistance

a.) The soft robotic vest.
Actuators marked 1-6



b.) Portable pneumatic supply system for powering wearable soft robots

For elderlies and occupational hazard :
Prevention of fall, heavy load assistance, posture assistance

Portable vest for assistance
Kinesthetic feedback

a.) The soft robotic vest.
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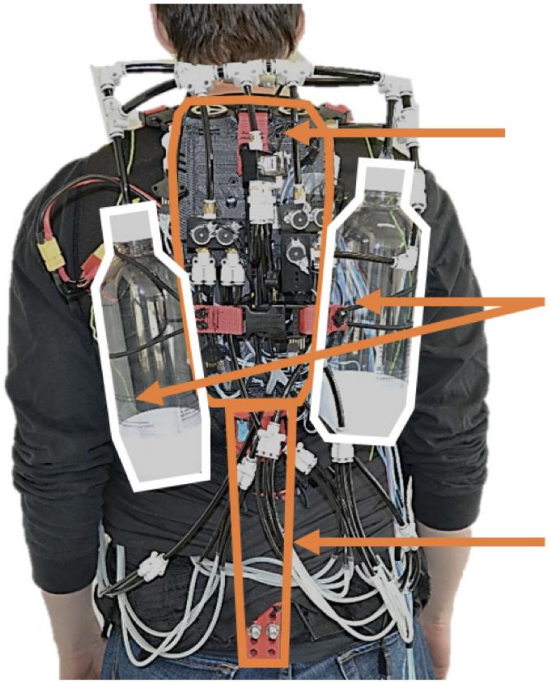

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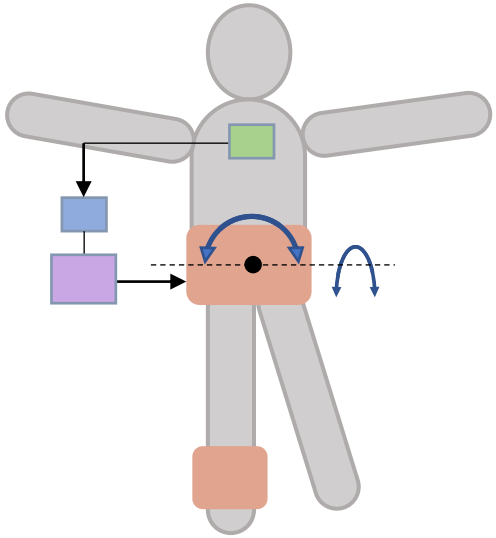
Soft kinesthetic assistance applications

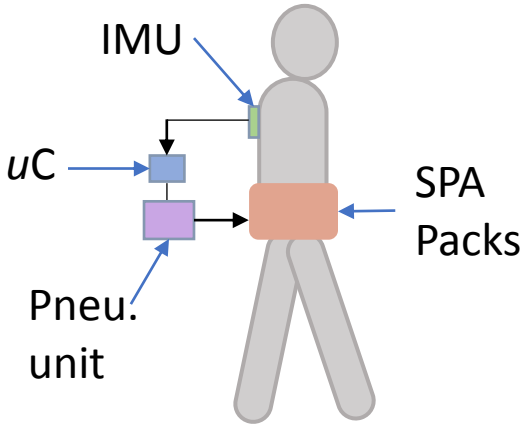
Balance Assistance

- up to **112 N** force or **18 Nm** moment for balance augmentation



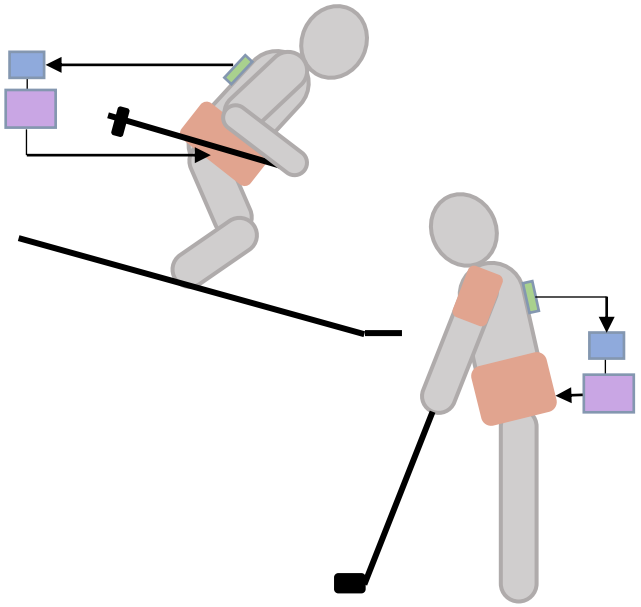
Gait Correction

- **±4°** Angular displacement
- **1.3 Hz** bandwidth to support weakness or compensate for asymmetric *during* walking



Sports Training

- Multimodal, quantified feedback to correct **form** and **posture**
- Integrated with low profile vibrotactile feedback **SPA Skin**



Soft kinesthetic assistance applications

Subtle movements?

Balance Assistance

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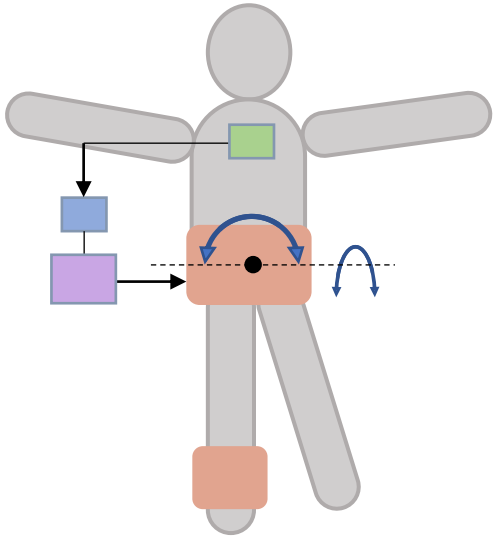

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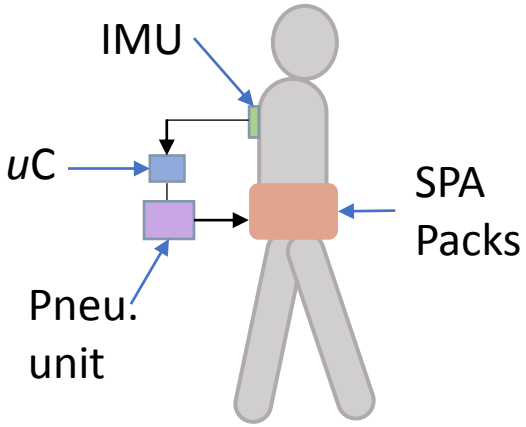

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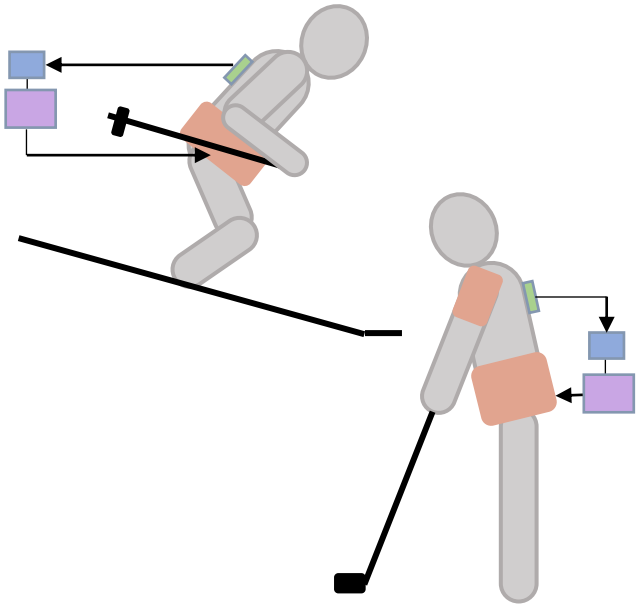
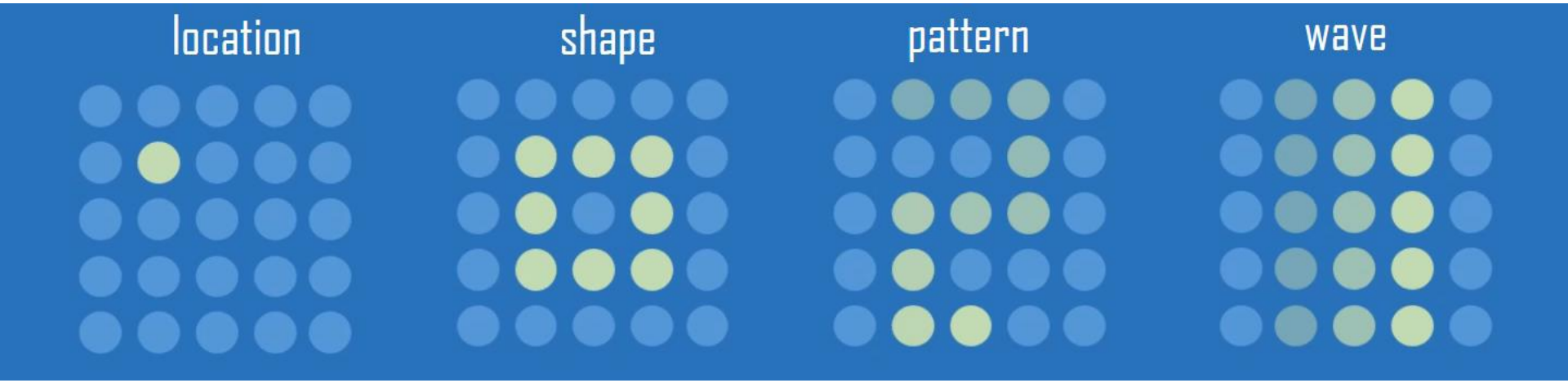
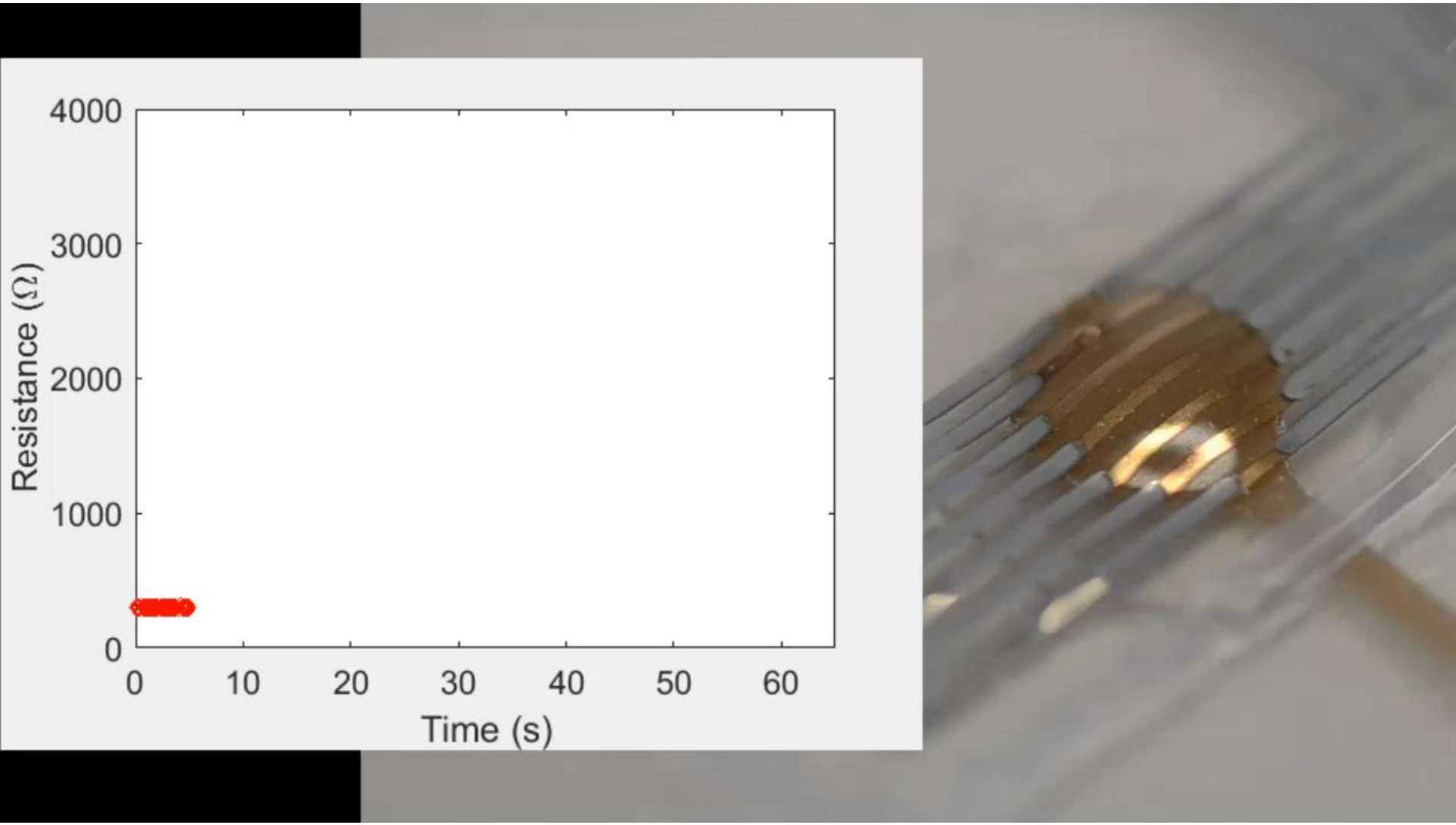


Haptic Feedback: Soft kinesthetic assistance



Soft kinesthetic assistance



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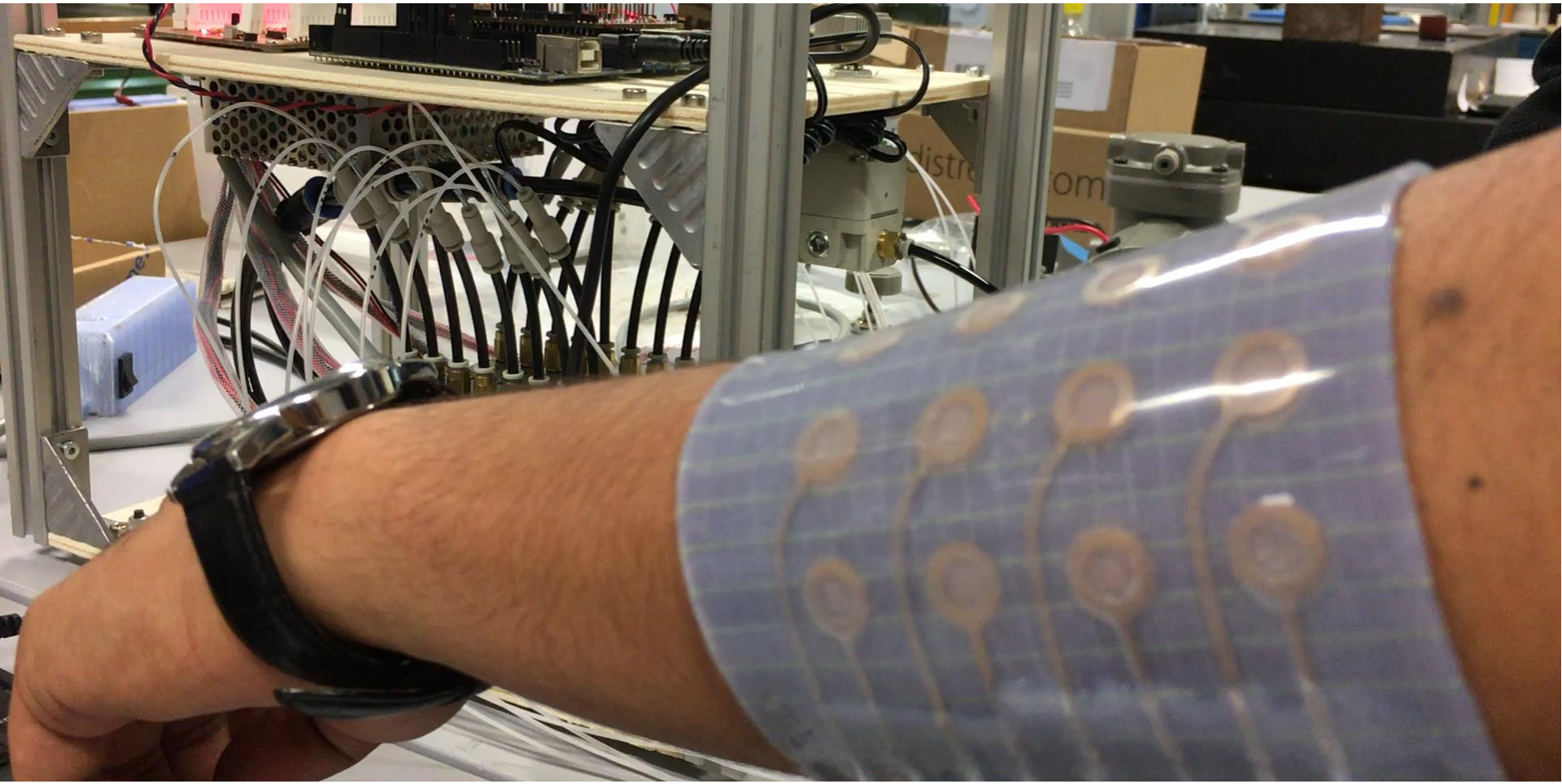
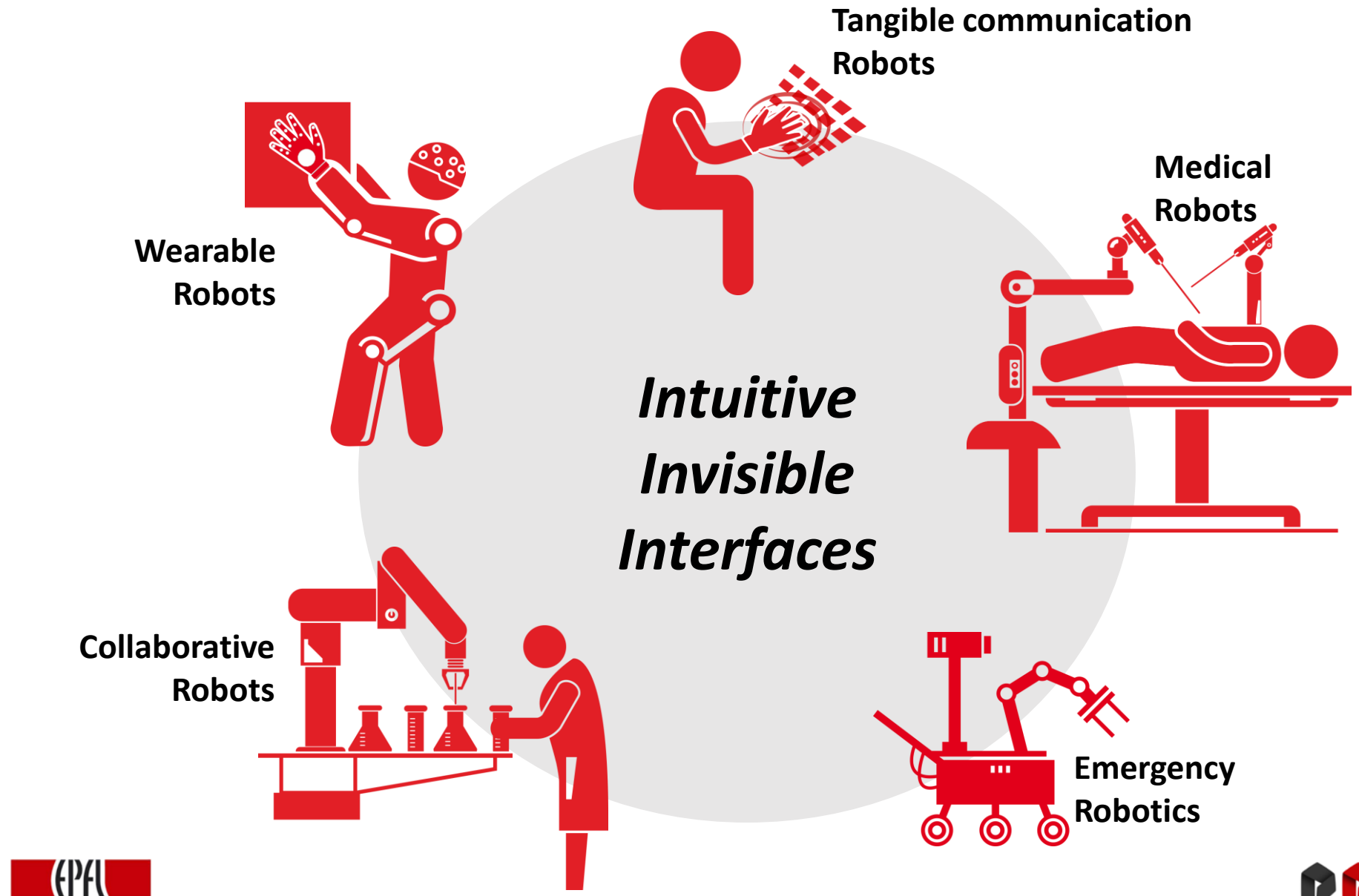


Soft Robotic Applications



RRL Members & Fundings

PhDs
PostDocs

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Strategic Focus Area Advanced Manufacturing
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Origami Robots

Soft-Material Robots

Design Methodology & Model

Novel actuators & Control

Integration & Fabrication

Alumni

Assist. Prof. Acer @ Istanbul Technical Univ.
Assist Prof. Song @ Missouri State Univ.
Assist. Prof. Fomin @ Siberian State Univ.
Dr. Florez, Senior R&D engineer @ Liebherr
Dr. Agarwal, Senior R&D researcher @ Tesla
Dr. Firouzeh, PostDoc @ SNU

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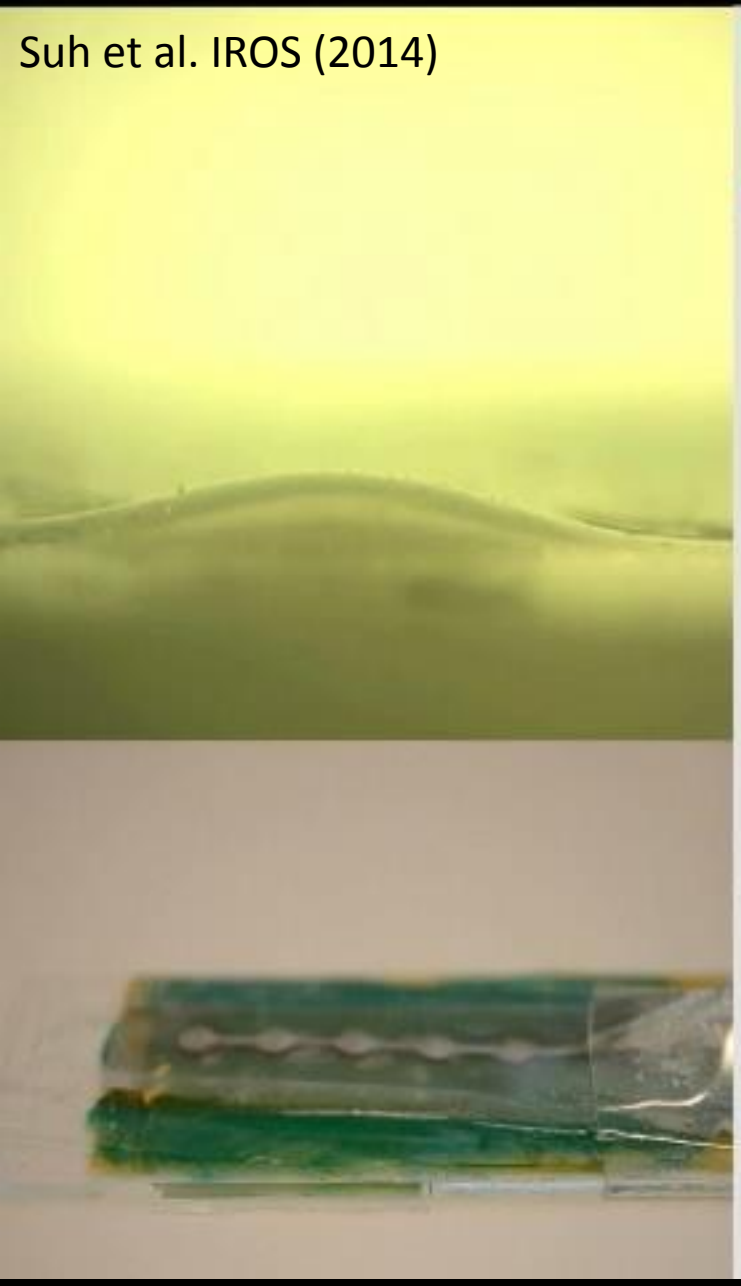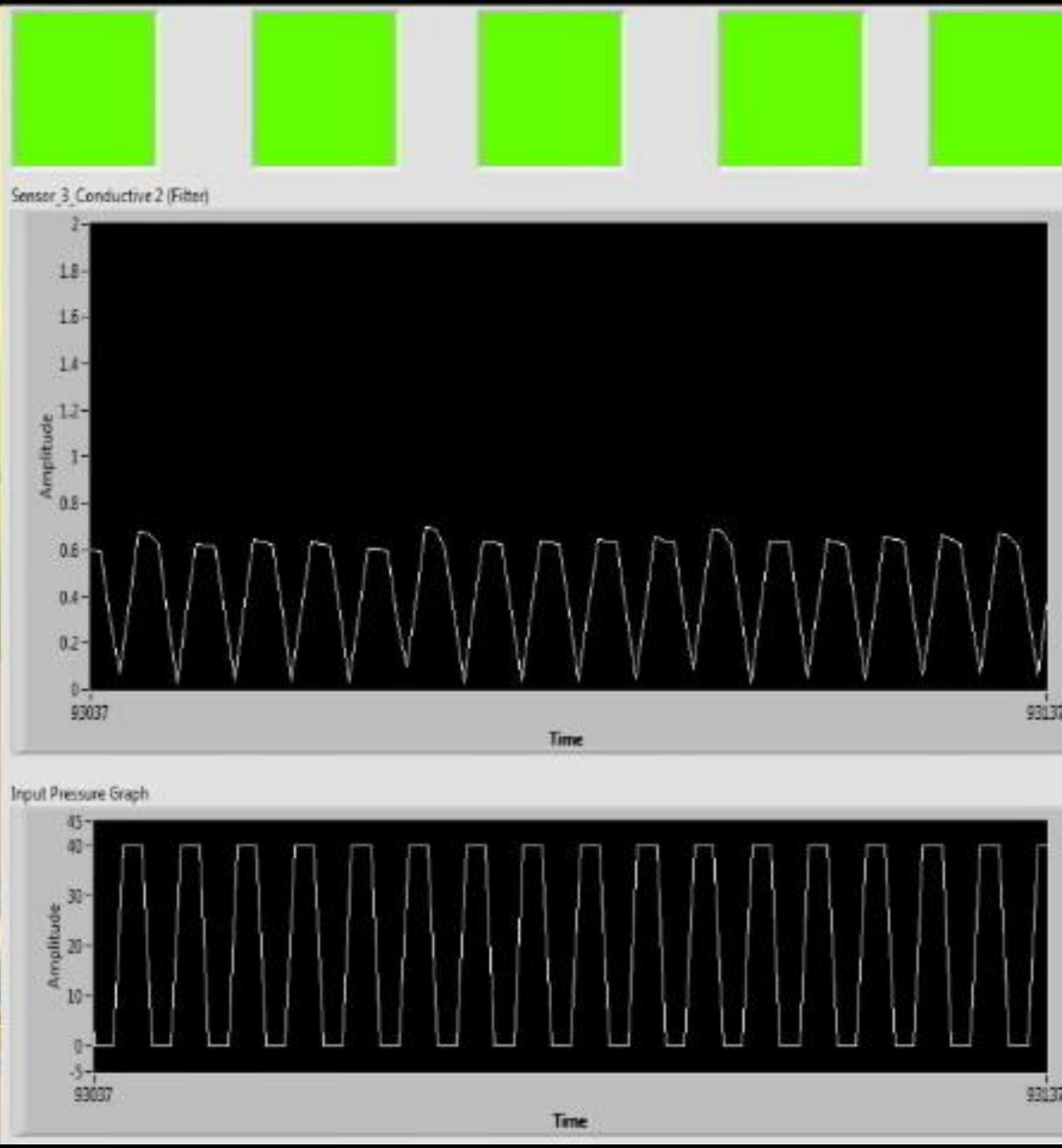
Suh et al. IROS (2014)