University of BRISTOL

Bristol Robotics Laboratory

Design of dexterous tools with the end-user in mind (healthcare and beyond)

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dexterousrobotlab.com

UCLouvain

Friday, 10th of March 2023


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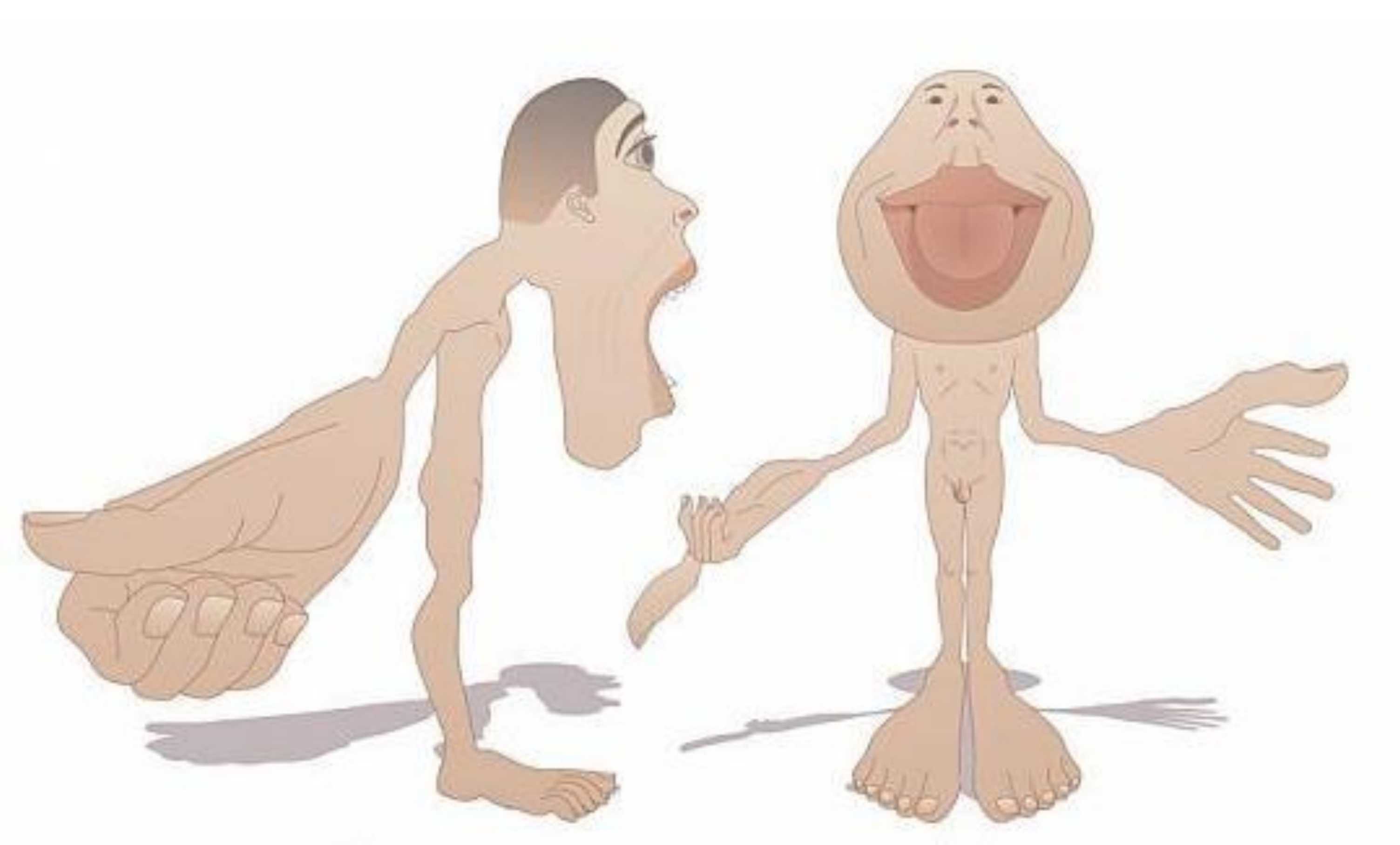
Robotics
Laboratory

Dexterity: moving and sensing

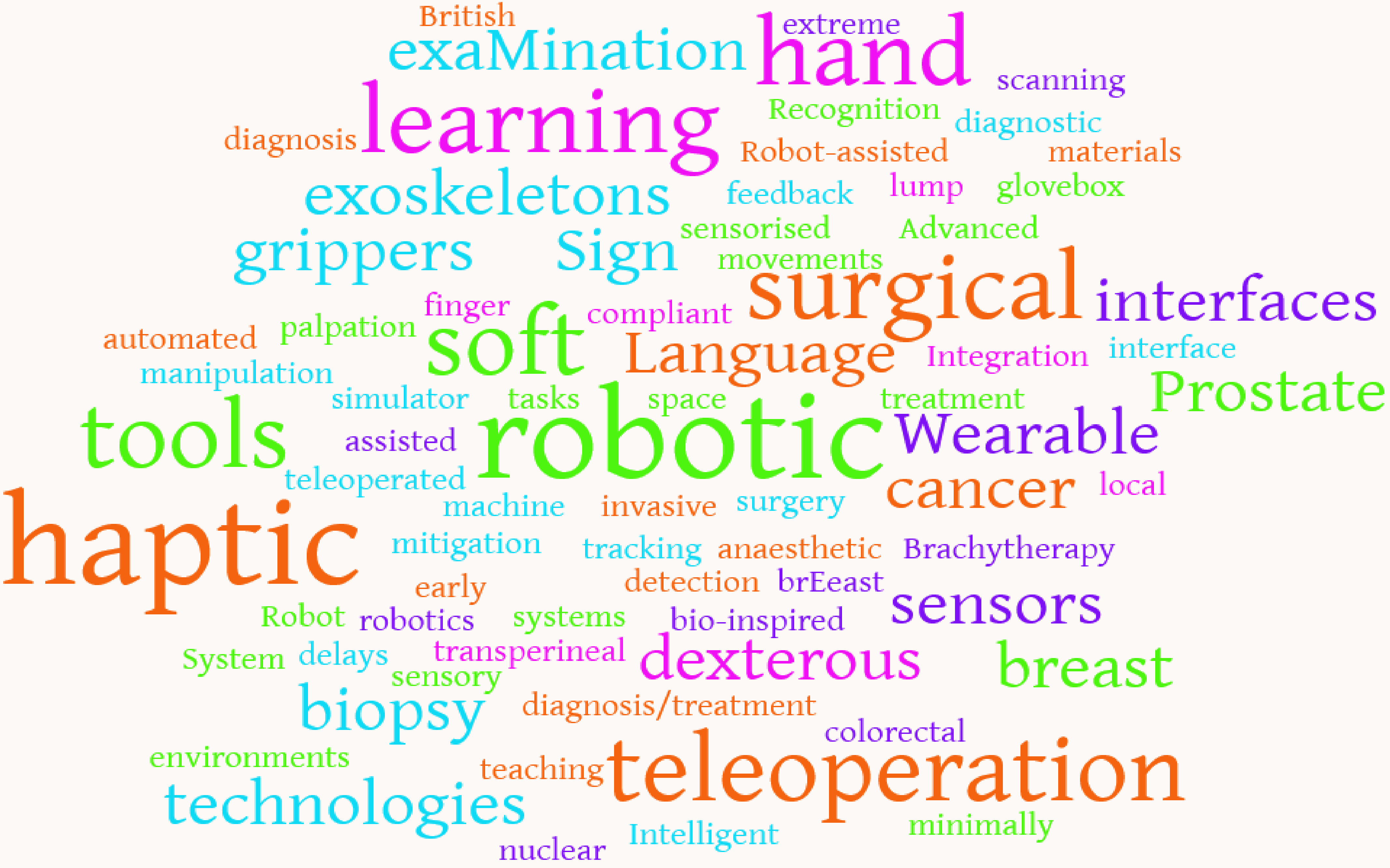


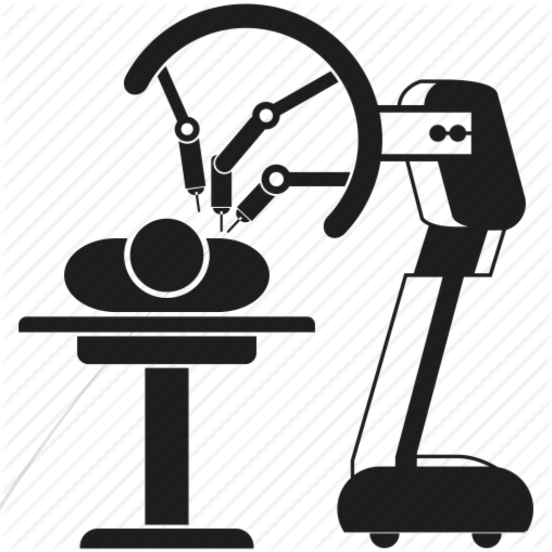
Motor vs Sensory
Homunculus

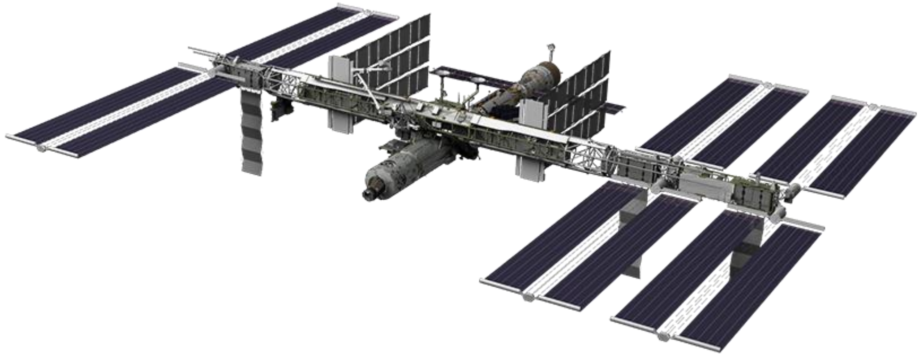
“What can be more curious t
of a man, formed for graspin
for digging, the leg of the ho
the porpoise, and the wing of
be constructed on the sa
should include similar bones, in the same relative
positions?”

Orig

Nakamura et al., 2016


British
extreme
exaMination
hand
scanning
Recognition
diagnostic
diagnosis
learning
Robot-assisted
materials
exoskeletons
feedback
lump
glovebox
sensorised
Advanced
grippers
Sign
movements
surgical
interfaces
finger
compliant
automated
palpation
soft
Language
Integration
interface
manipulation
Prostate
simulator
tasks
space
treatment
tools
robotic
Wearable
assisted
teleoperated
cancer
local
haptic
machine
invasive
surgery
mitigation
tracking
anaesthetic
Brachytherapy
early
detection
brEeast
sensors
Robot
robotics
systems
bio-inspired
System
delays
transperineal
dexterous
breast
sensory
biopsy
diagnosis/treatment
colorectal
environments
teaching
teleoperation
technologies
minimally
Intelligent
nuclear





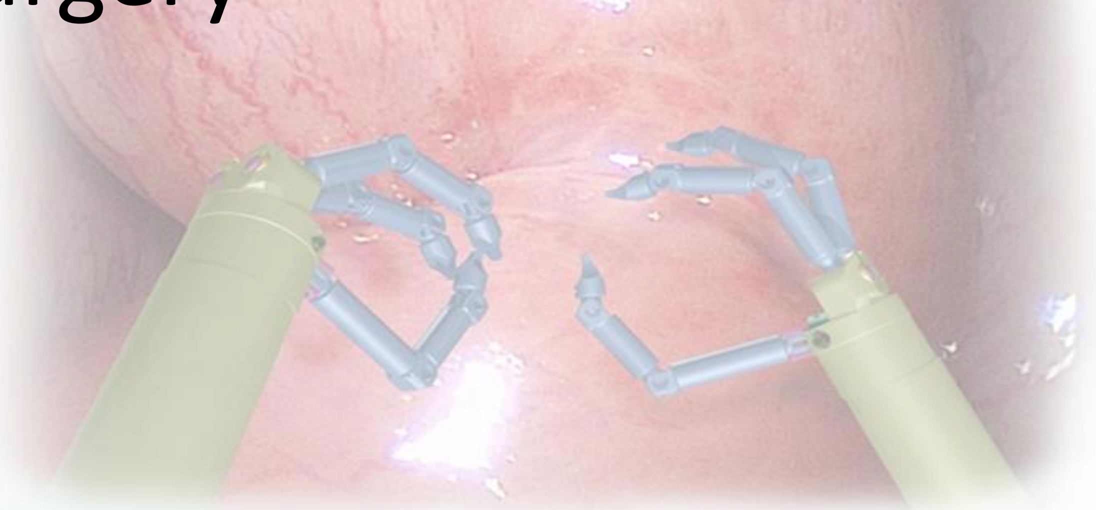

ALPHA

Anthropomorphism in (Robot) Surgery

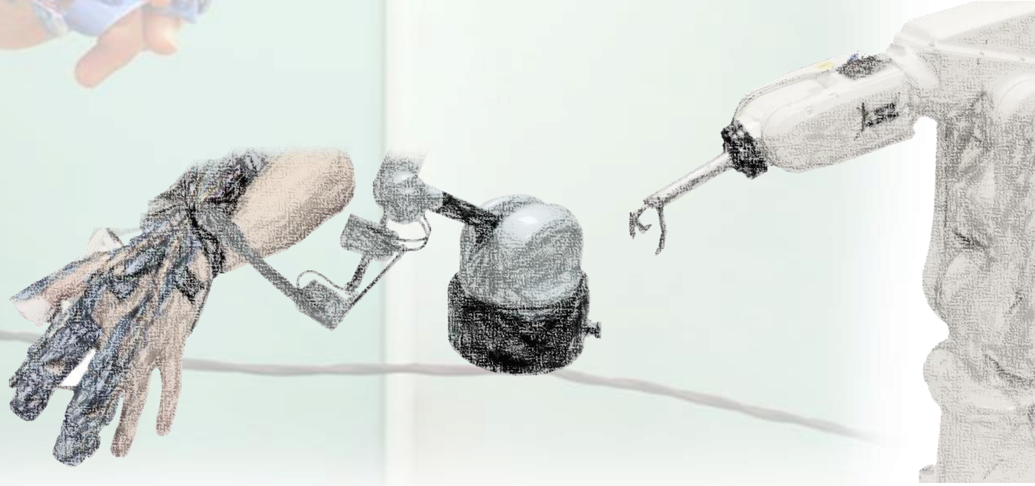
Robot-assisted (Da Vinci) surgery

Anthropomorphic Surgical System for Soft Tissue Robot-Assisted Surgery

μangelo

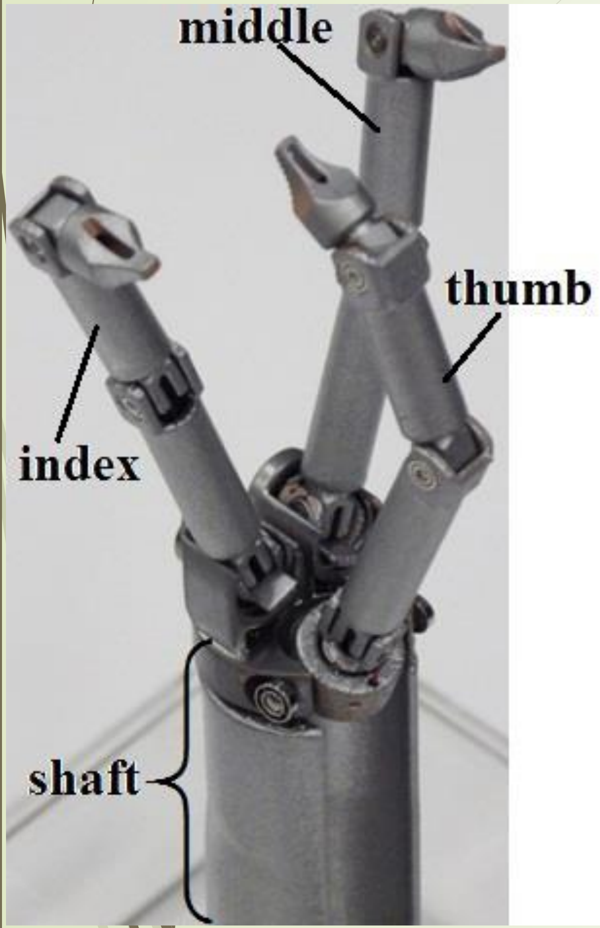


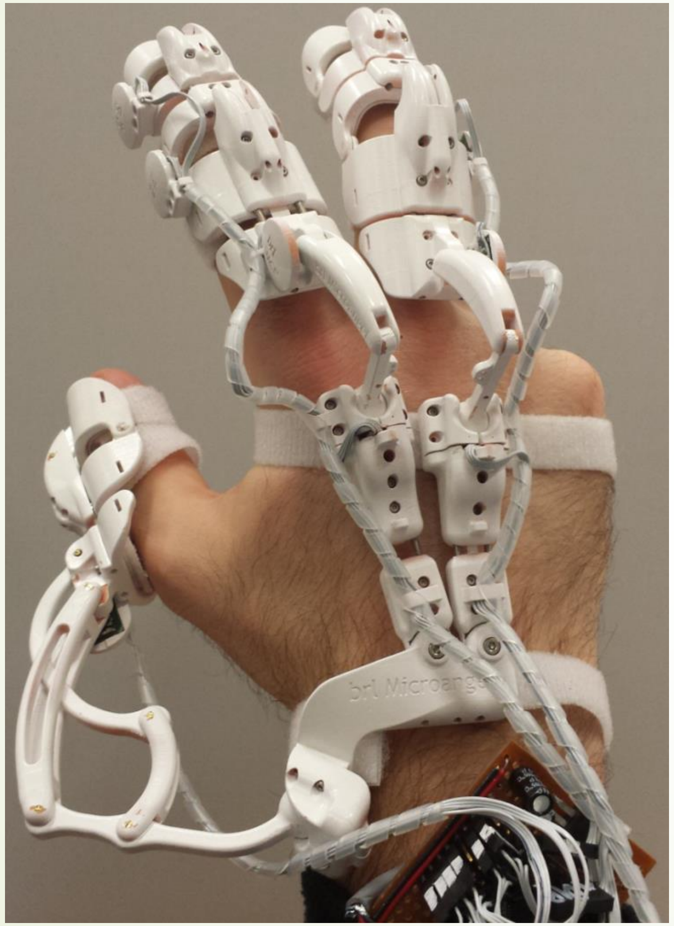
- **Natural tele-operation and manipulation**
- **Dexterity**
- **Portability**
- **Adjustability**
- **Haptic feedback**

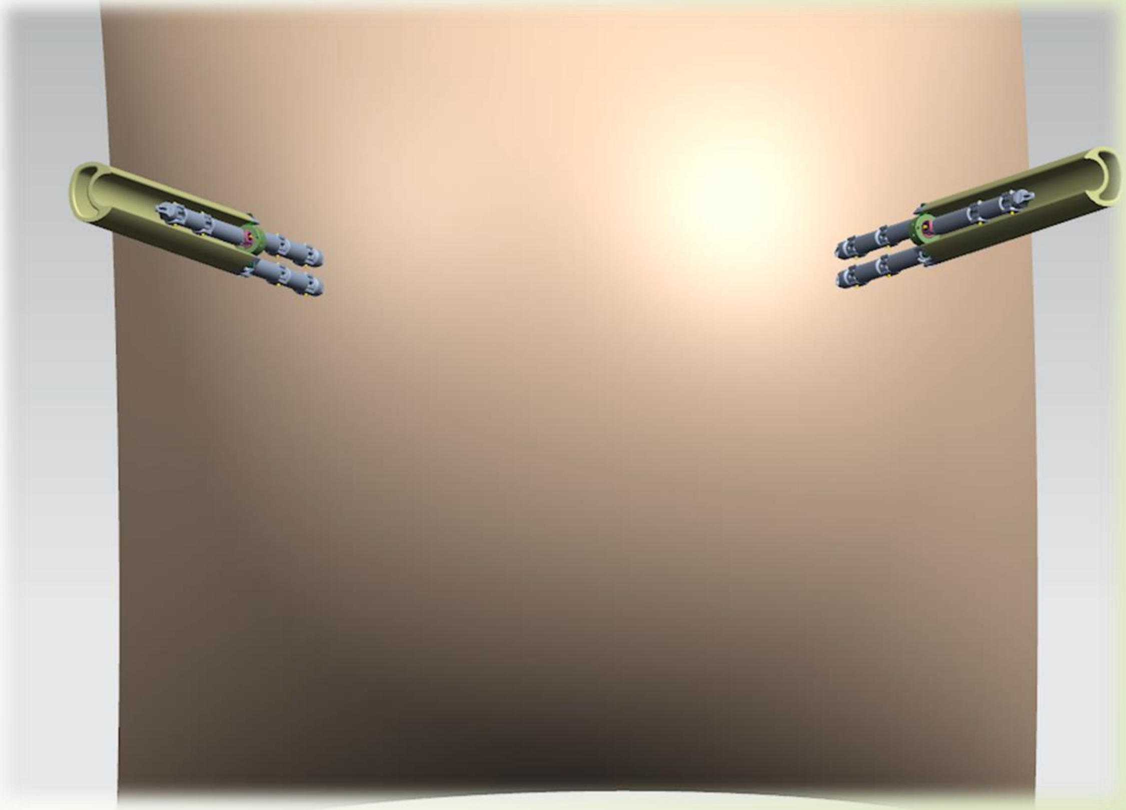


μangelo

Anthropomorphic minimally invasive surgical system







Secondary

18 mm diameter
index/middle: 4 DOF **Thumb:** 5 DOF
Total: 13 DOF

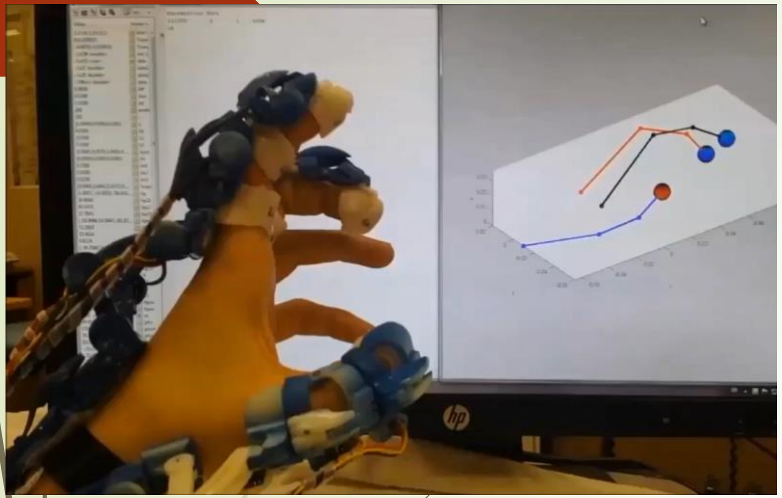
Primary

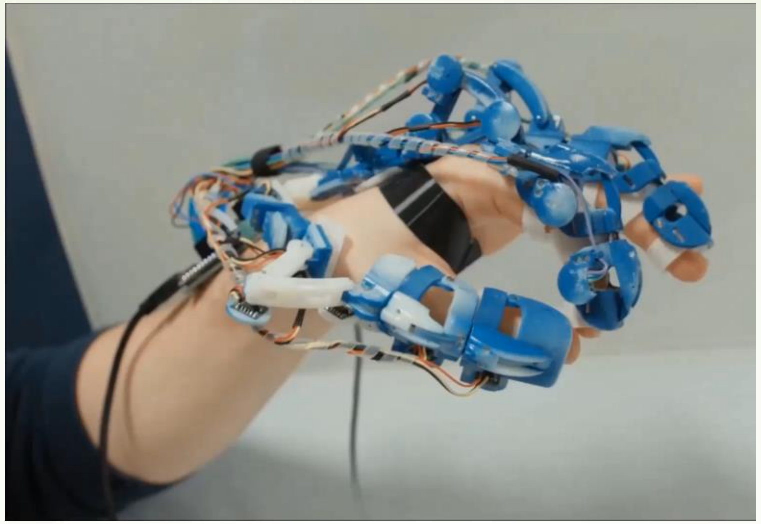
~198 gr, adjustable
index/middle: 6 sensors **Thumb:** 7 sensors
Total: 19 sensors

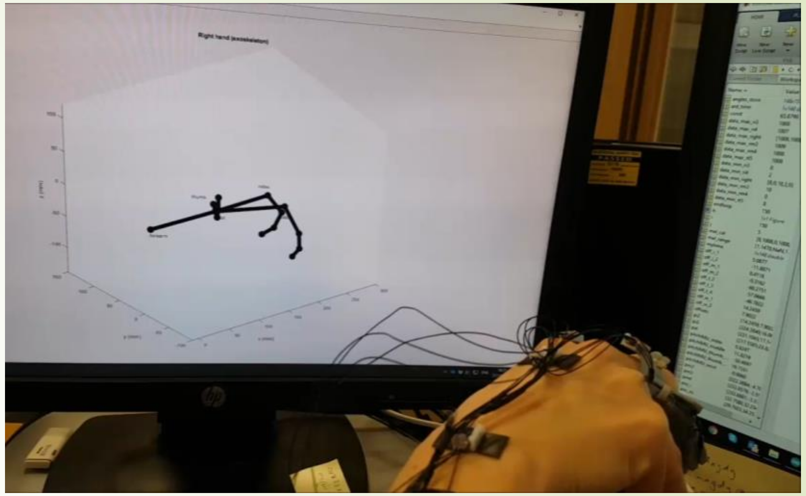
Concept

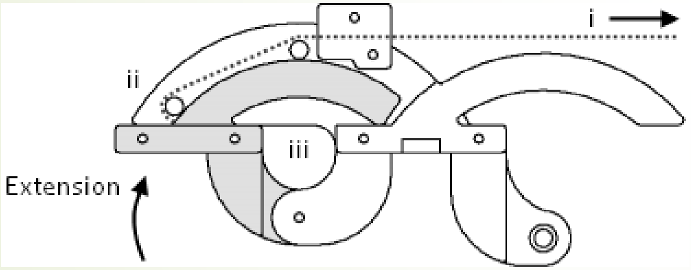
insertion and teleoperation of dexterous instruments into abdominal cavity

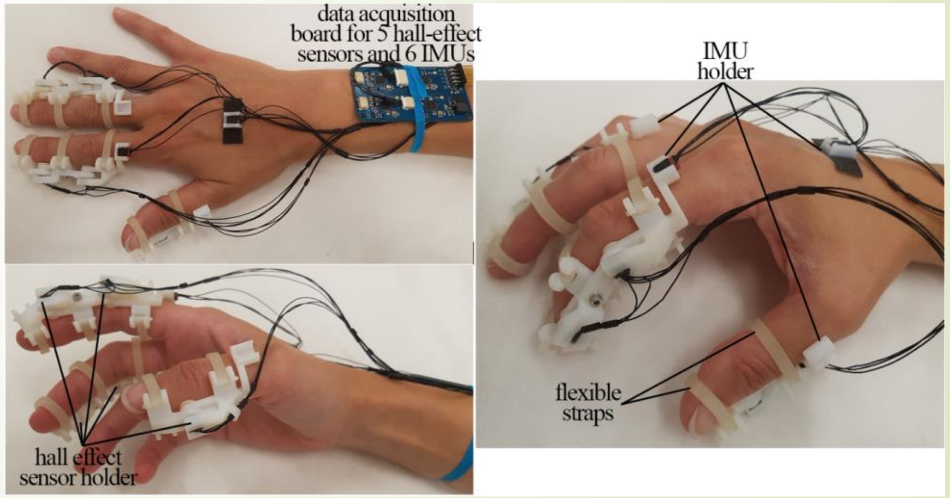
Sensory exoskeleton



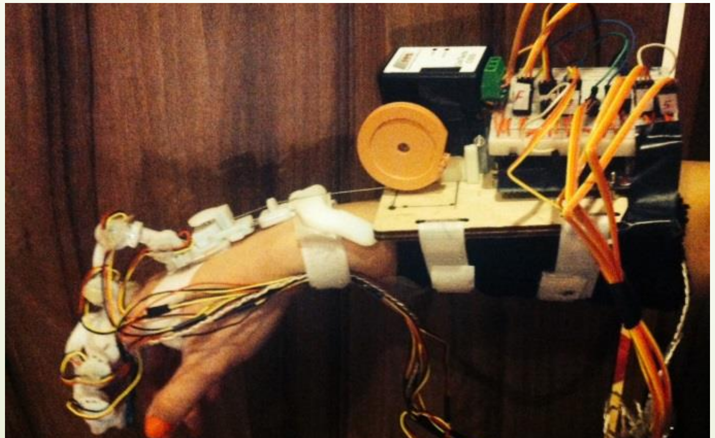




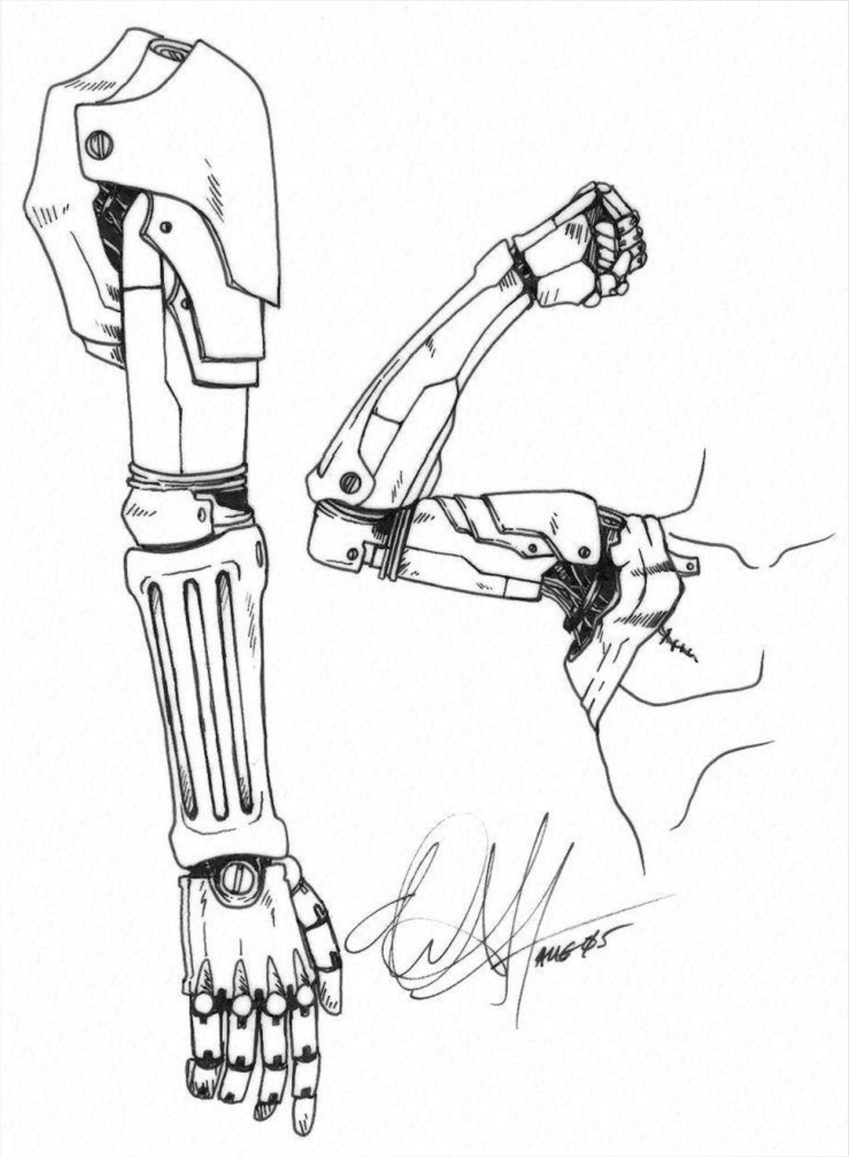




Haptic Feedback



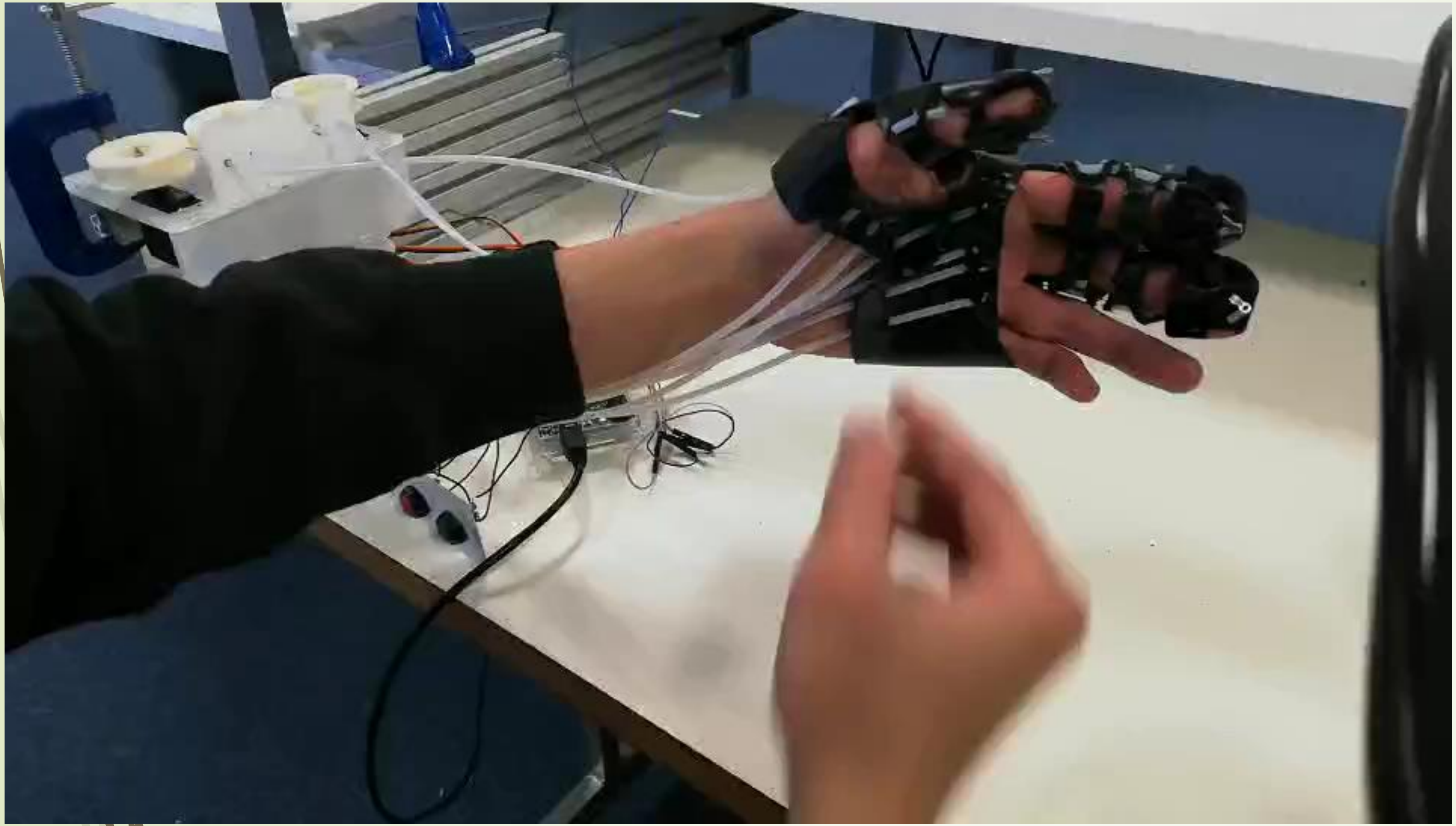
Robotics in Hand Rehabilitation



Soft robotic hand exoskeleton:
rehabilitation/assistance on activities

- Portable domestic solution
- complementary treatment
- Help with activities of daily life

Soft robotic hand exoskeleton:
rehabilitation/assistance on activities



Robotics in Diagnosis

Breast examination/screening – time for automation?

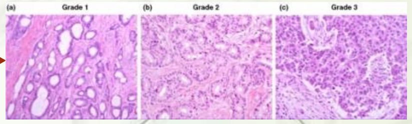
Home/community | **Hospital**

Current

Self examination

GP consultation

Imaging



Tissue biopsy

Aims

- New approach to routine monitoring
- Rapid response to identification of high risk – *maintaining breast health*
- Combine smart sensing robotics and actuation
- Increase accessibility to breast cancer screening and diagnosis using automation
- Examine diversification of technologies, setting the user at its centre
- Comfortable to use multimodal robotic system

Target group:

women at high risk of breast cancer and who are not normally included in screening programmes

ARTEMIS: Advanced RoboTic brEeast exaMination Intelligent System

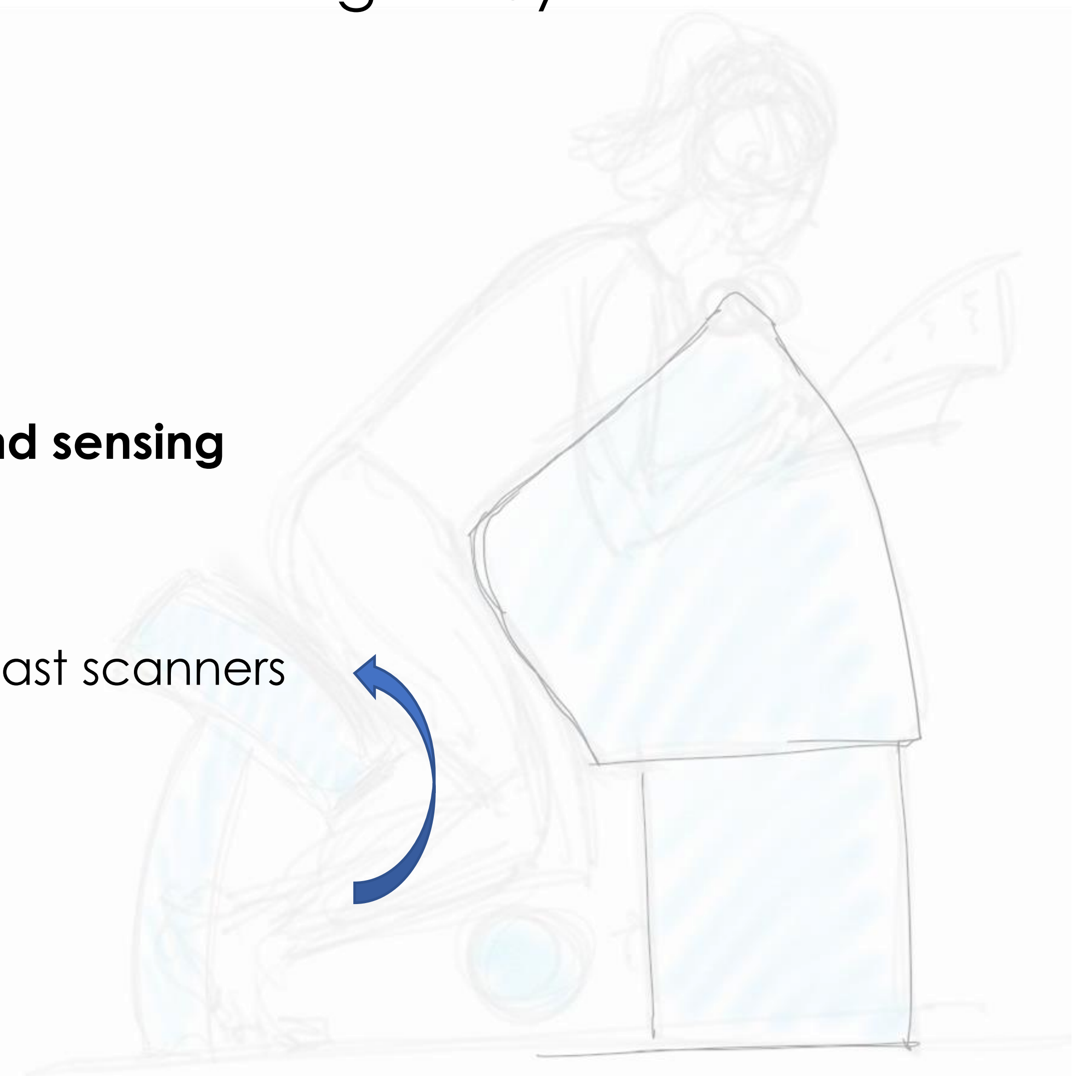
End-user requirements exploration
User Questionnaires

A soft robotic system for simultaneous palpation and sensing

Soft sensors for palpation

Sensor ‘holders’/ breast scanners

End-user requirements exploration and feedback
Patient and Public Involvement (PPI) in research



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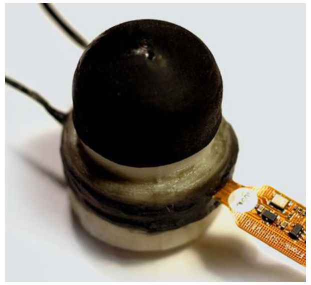
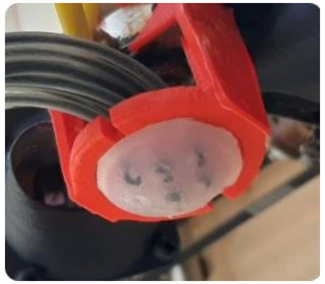
ARTEMIS: Advanced RoboTic brEeast exaMination Intelligent System

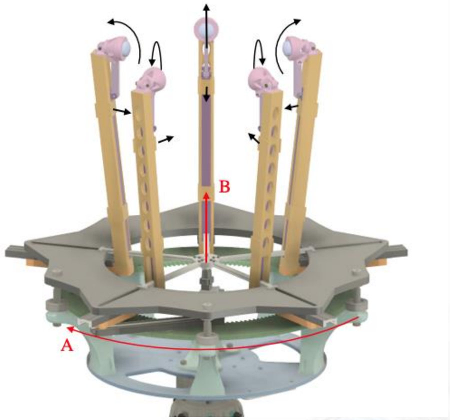


Pneutip



Espress.0

Soft sensors for palpation



IRIS

Lotus

Sensor 'holders'/ breast scanners

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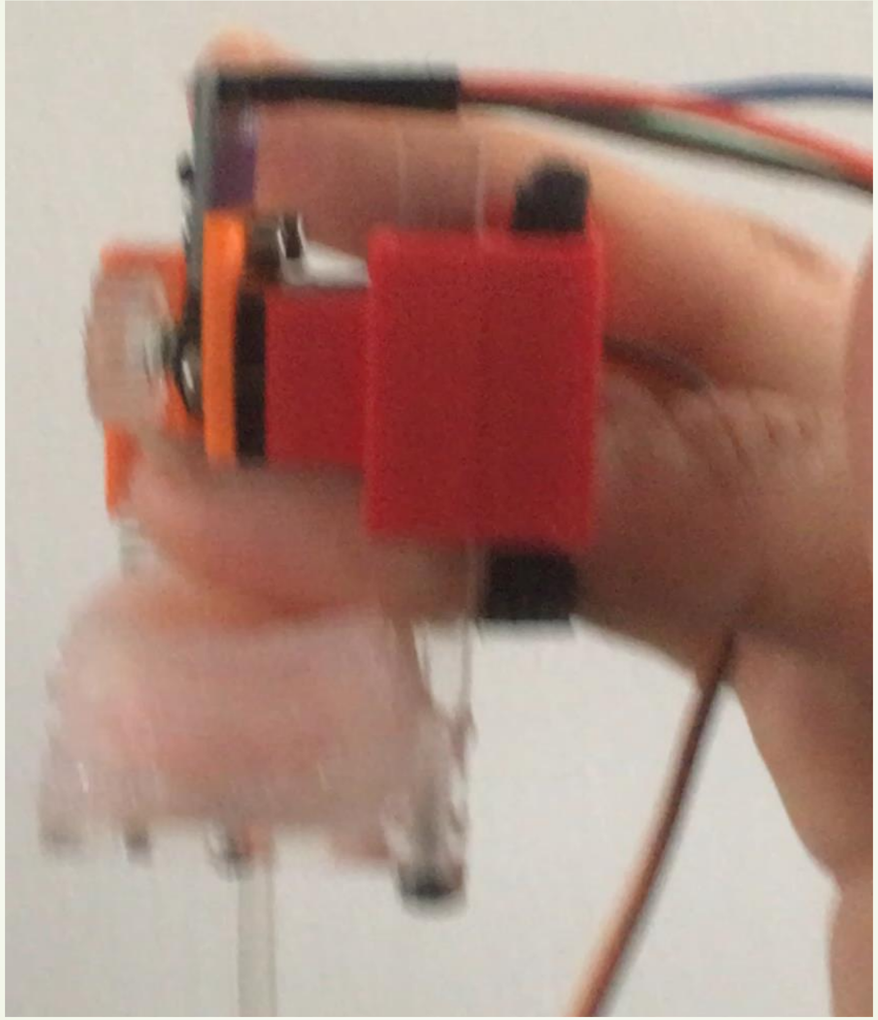
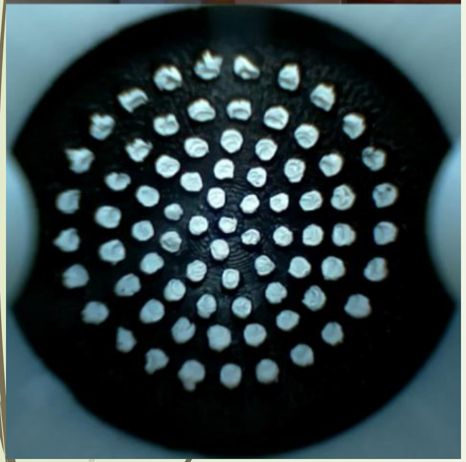
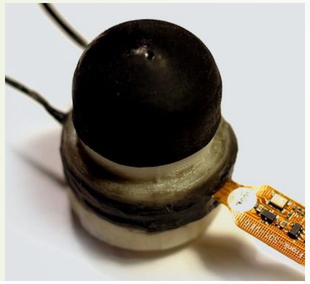
Variable Stiffness Fingertip Haptic Device

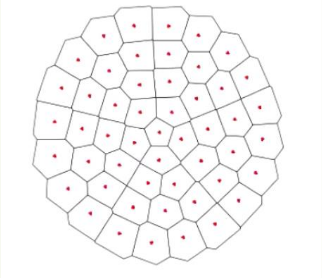


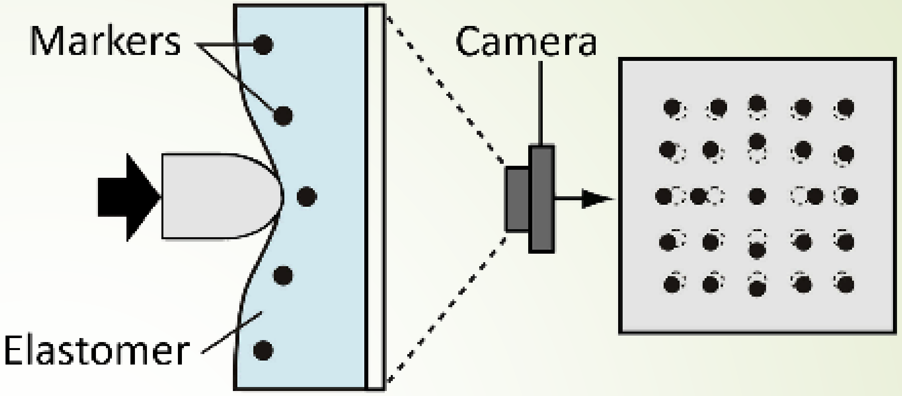
- Tzemanaki, A., Al, G.A., Melhuish, C. and Dogramadzi, S., 2018. Design of a wearable fingertip haptic device for remote palpation: Characterisation and interface with a virtual environment. *Frontiers Robotics and AI*.

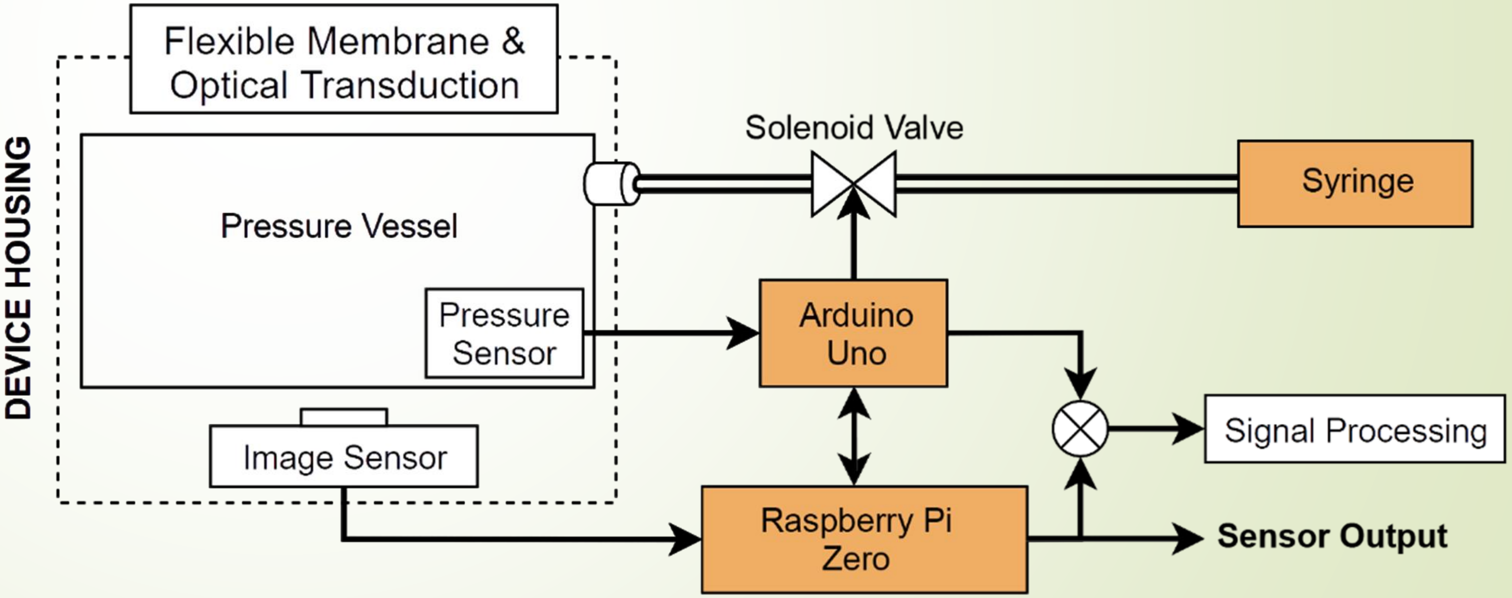
Optical-Tactile sensor with Pneumatic Control (Pneutip)





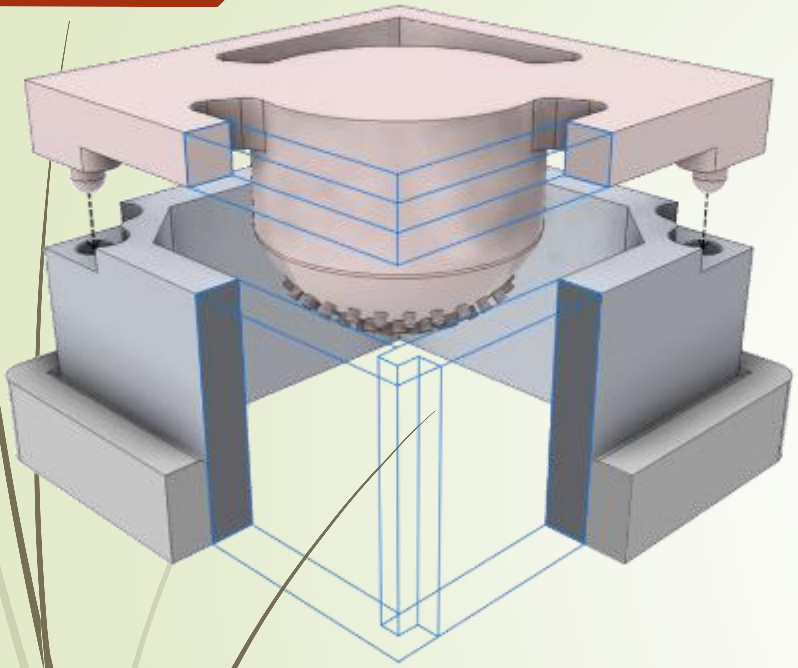


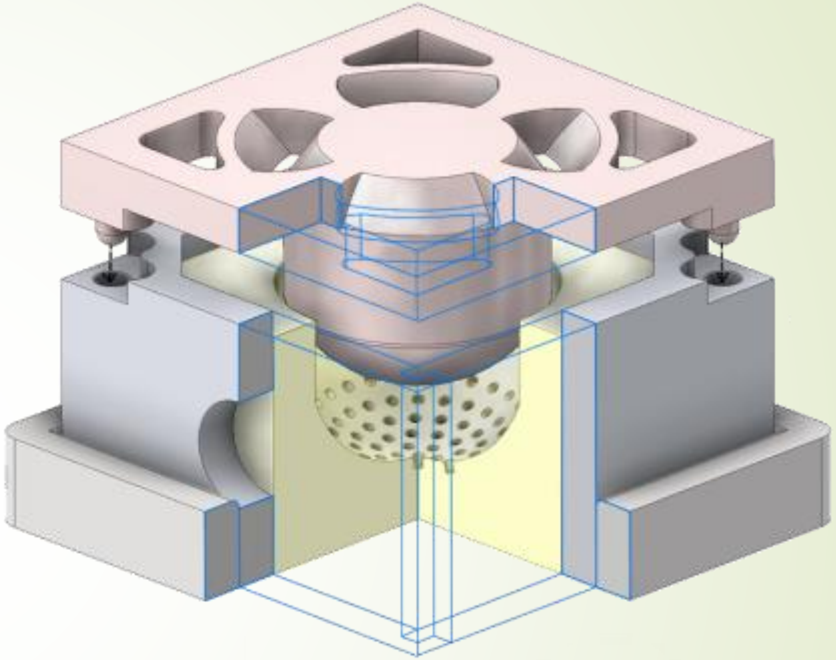


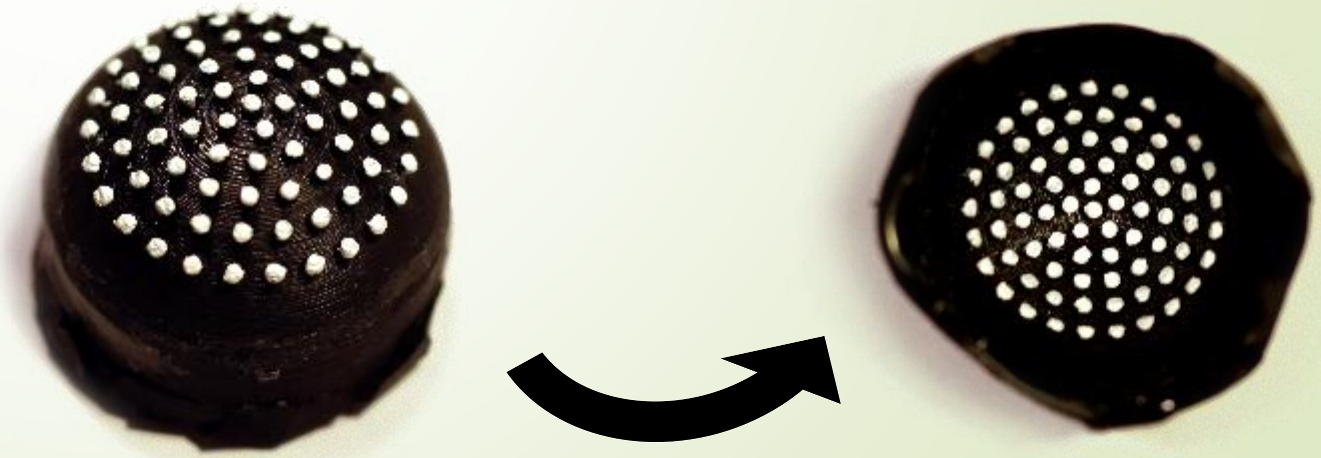


- Bewley J, Jenkinson GP and Tzemanaki A (2021) Optical-Tactile Sensor for Lump Detection Using Pneumatic Control. Front. Robot. AI 8:672315. doi: 10.3389/frobt.2021.672315

Tactile Membrane

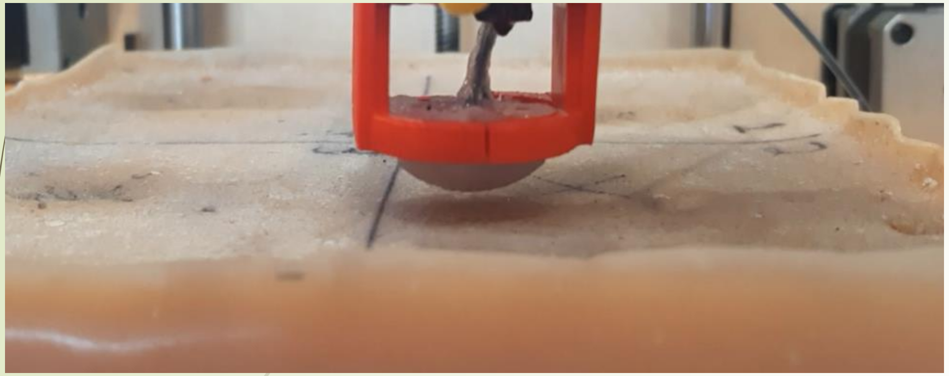


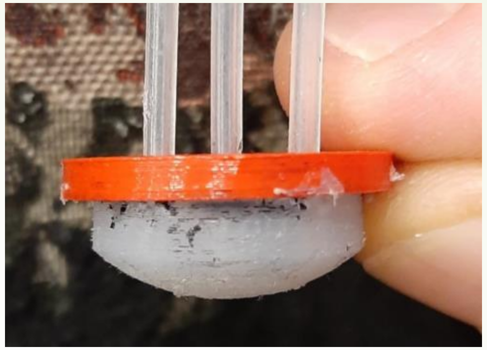


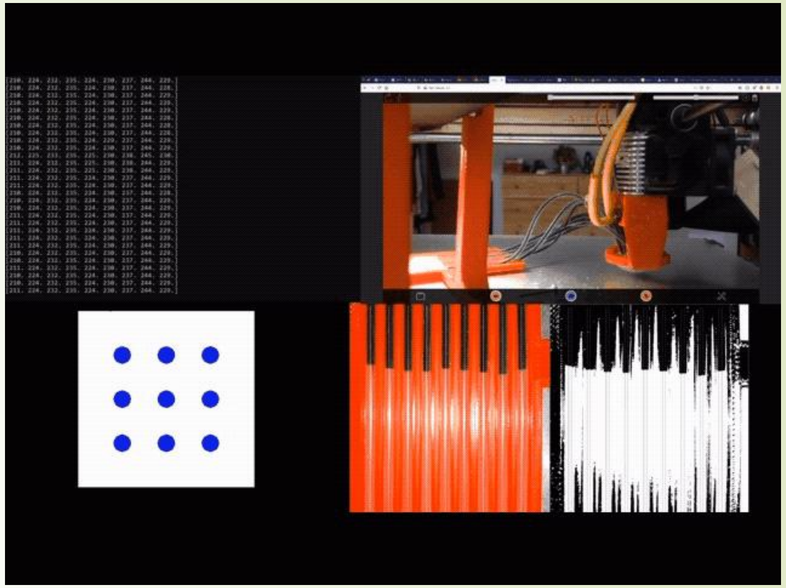


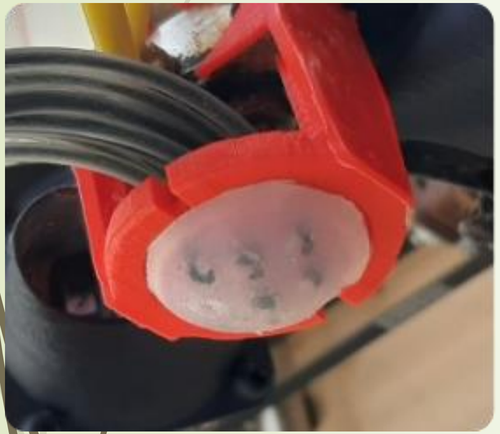
Device Assembly

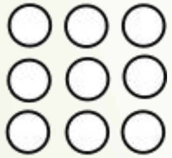
Eustachian tube-inspired Tactile Sensor (Espress.0)

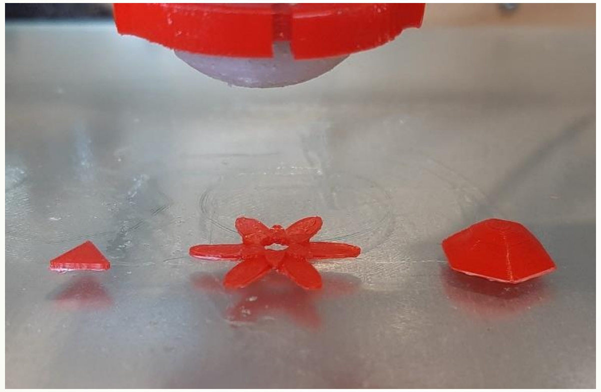


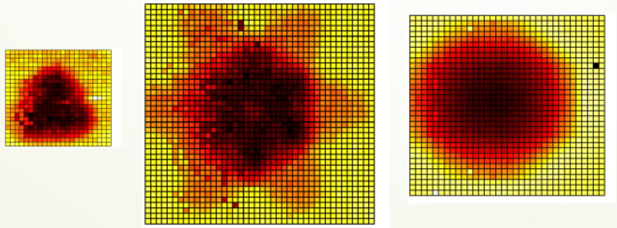




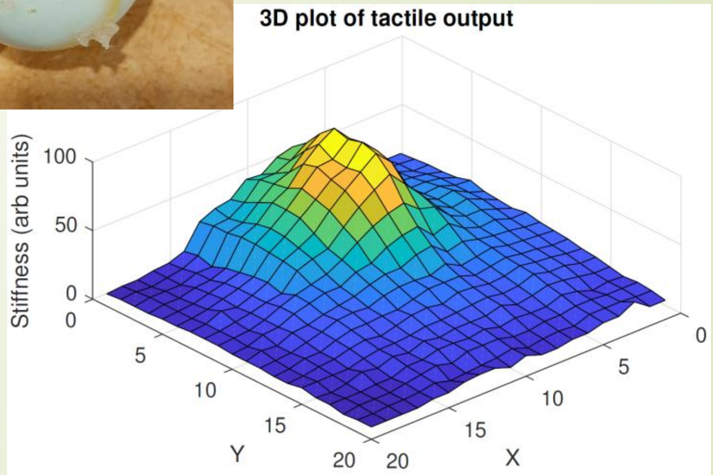






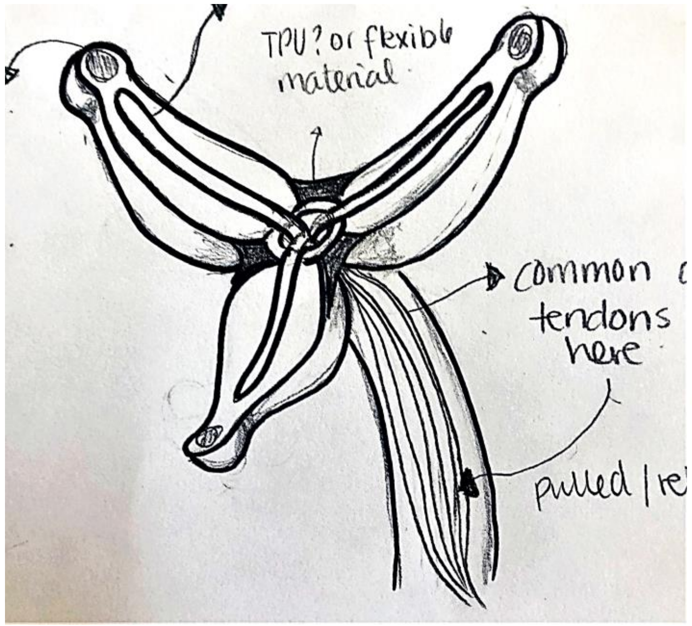


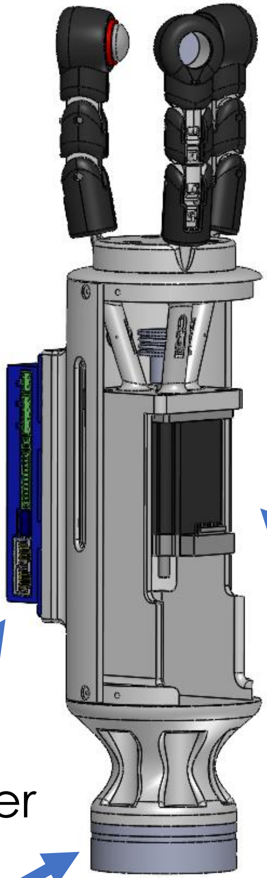
Height: 0.6mm 1mm 4mm

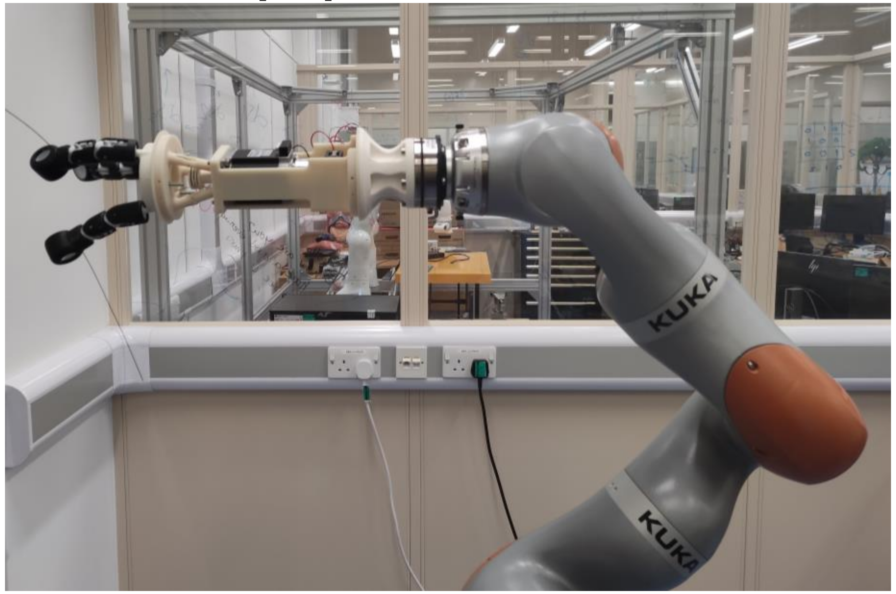


- ➢ Jenkinson, G.P., Conn, A.T. and Tzemanaki, A. (2023). ESPRESS.0: Eustachian Tube-Inspired Tactile Sensor Exploiting Pneumatics for Range Extension and SenSitivity Tuning. Sensors, 23(2), p.567

An Adaptable, Biomimetic Robotic Gripper – LOTUS







Motor controller

Force-Torque Sensor

2.3Nm Hybrid Stepper motor with brake and encoder

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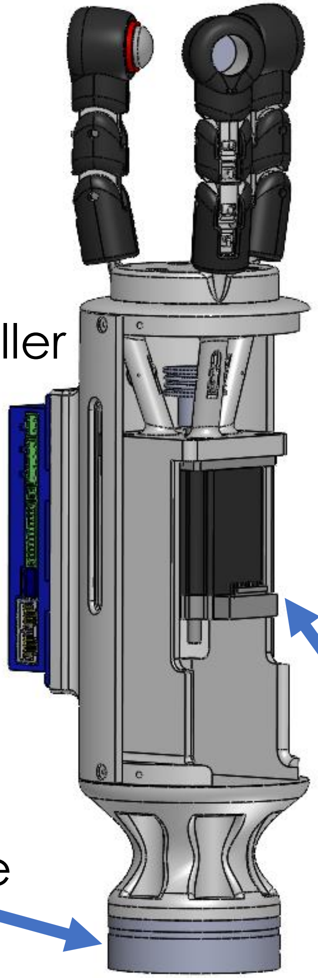
LOTUS

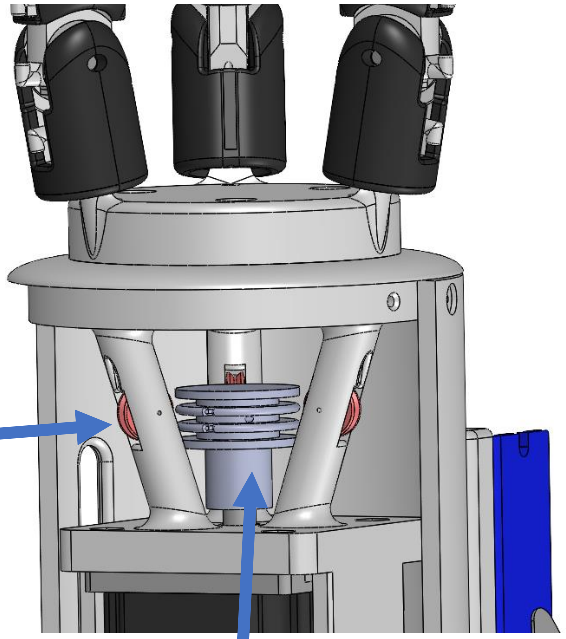


Motor controller

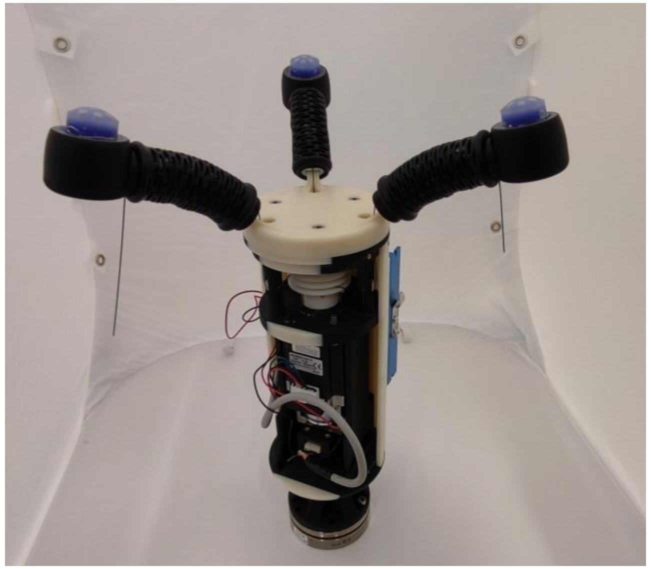
Force-Torque Sensor

2.3Nm Hybrid Stepper motor with brake and encoder

Pulley and cable guide



Triple cable spool



- Length = 415mm
- Diameter = 110mm
- Open diameter ~ 225mm
- Mass = 3277g

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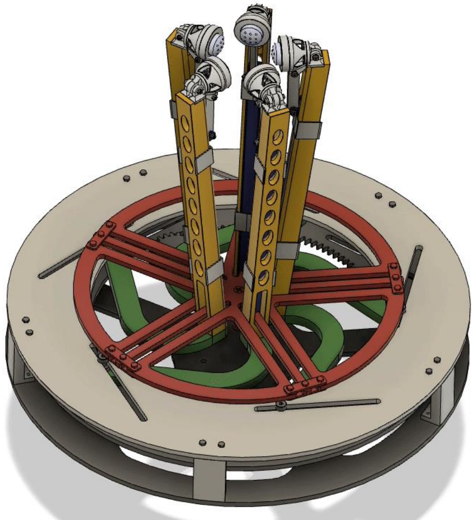
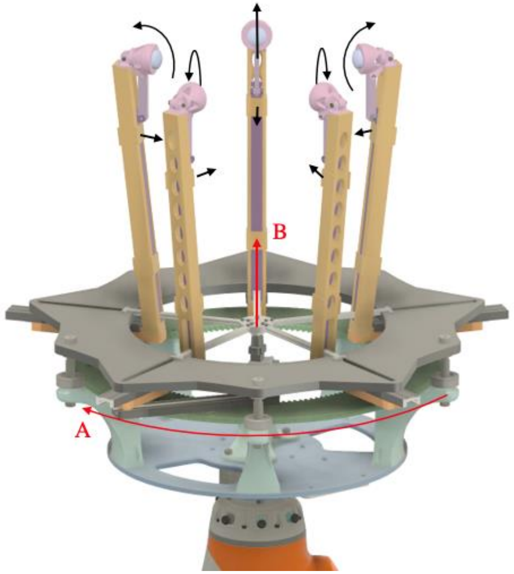
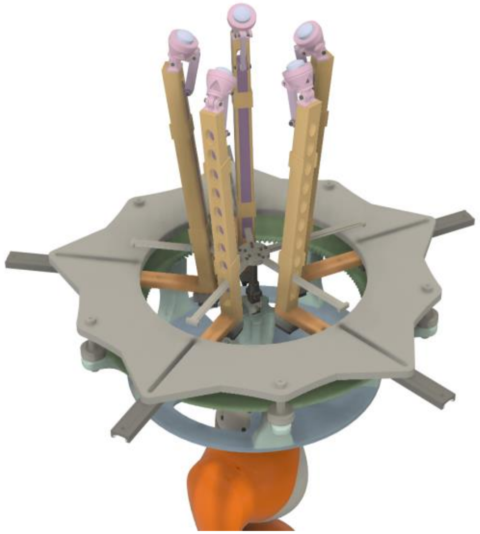
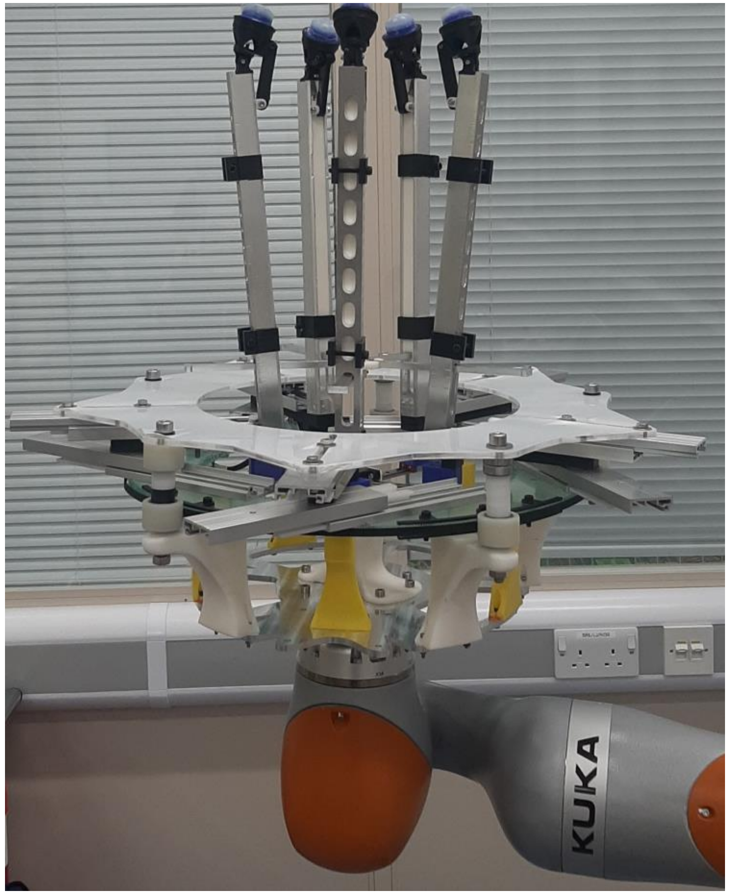
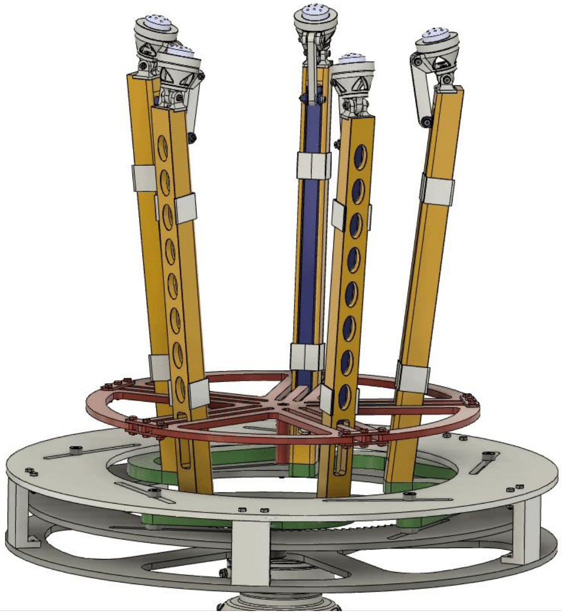
IRIS: roboti**I**c **R**adial palpat**I**on mechani**S**m

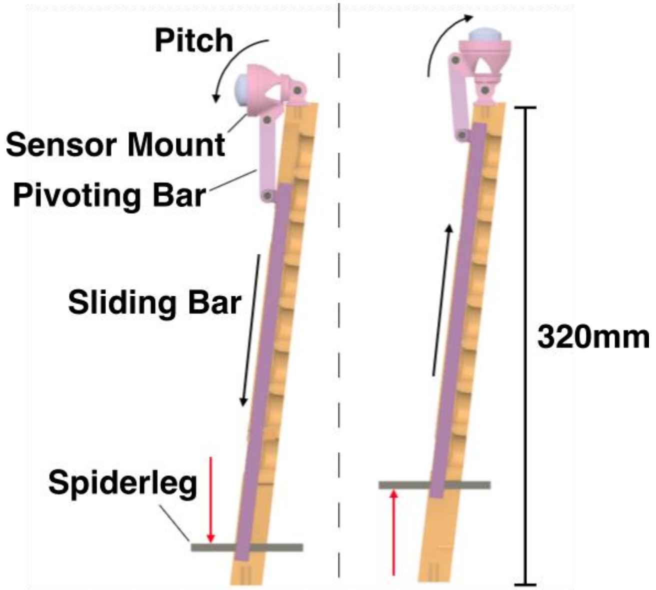




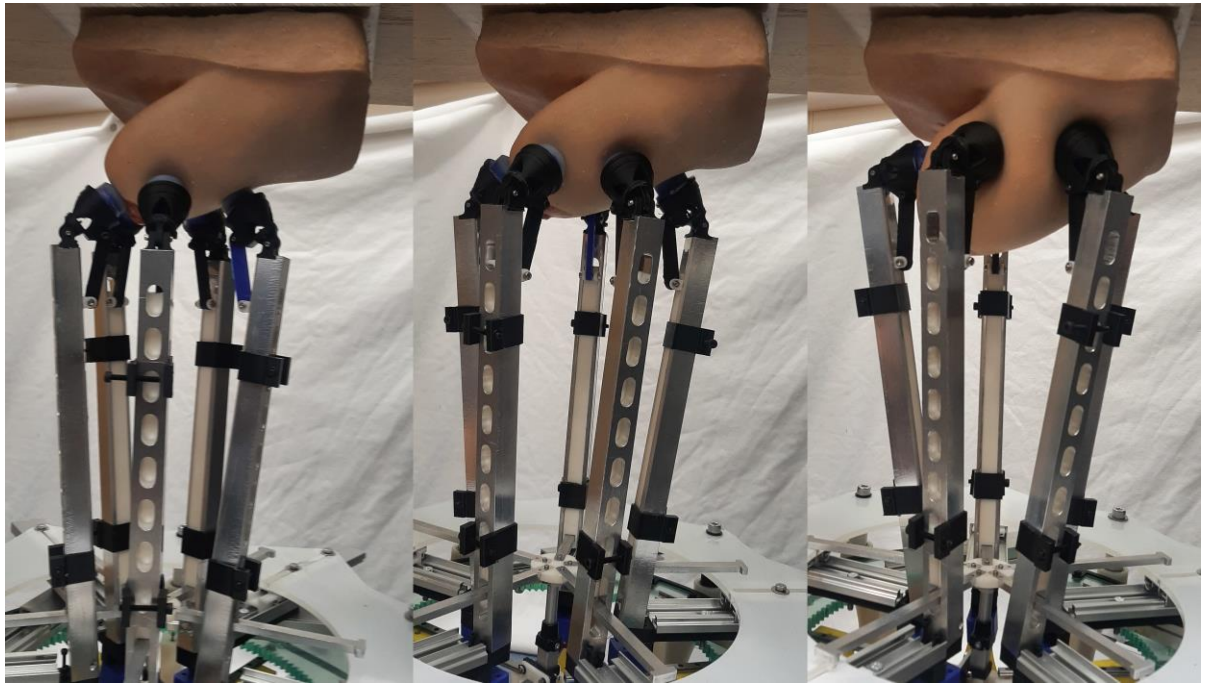


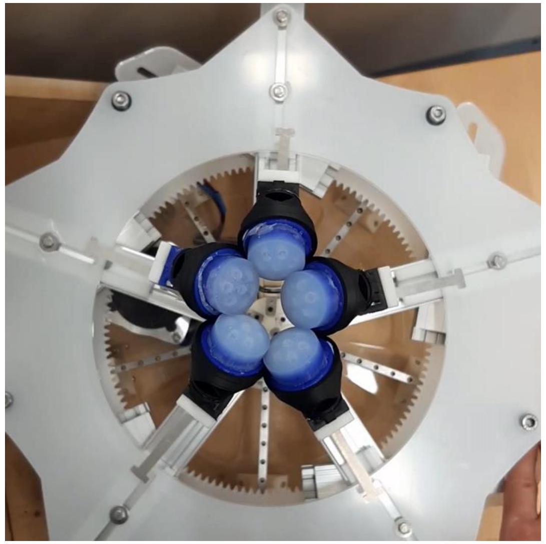


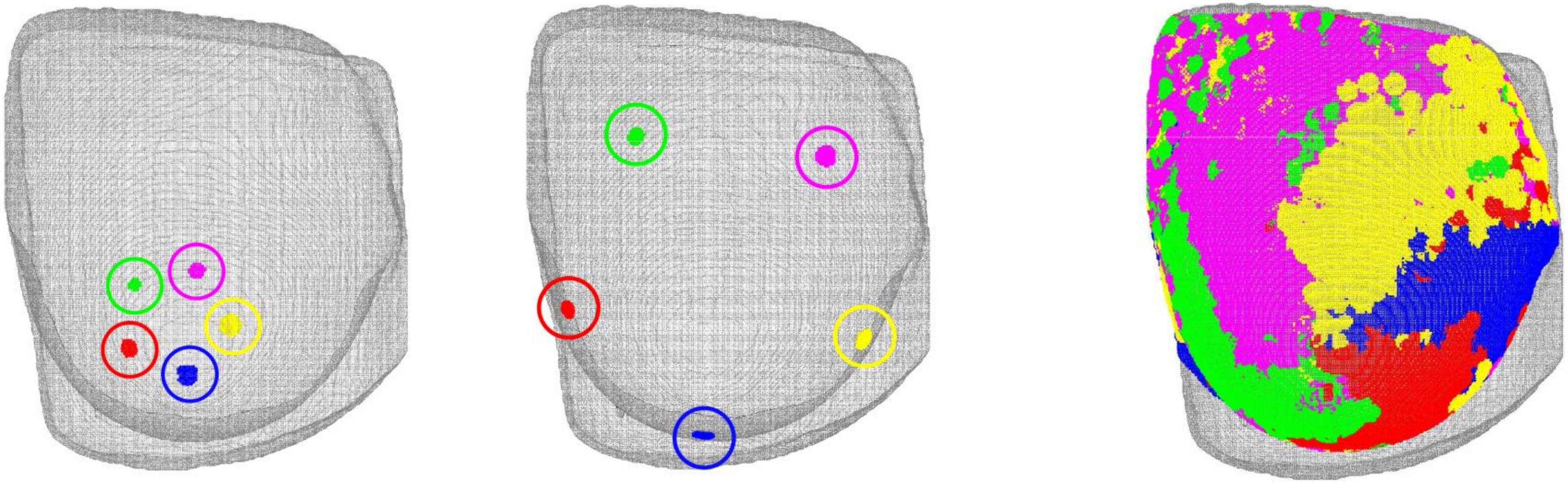




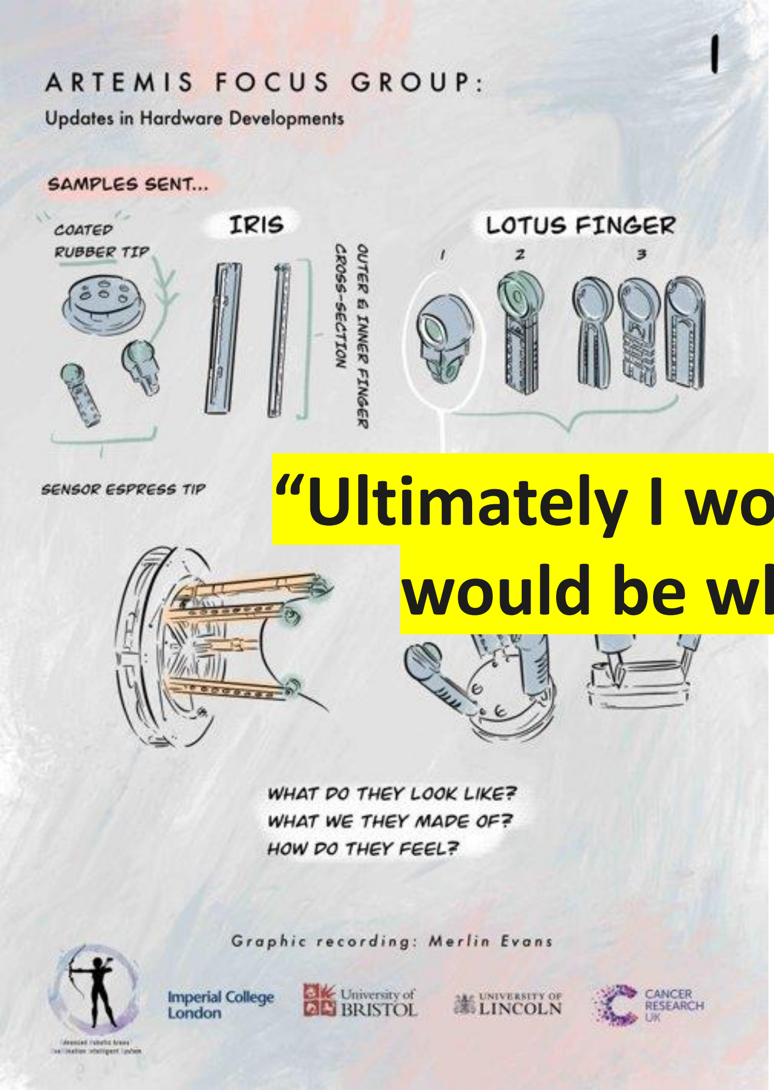
IRIS: palpation of breast

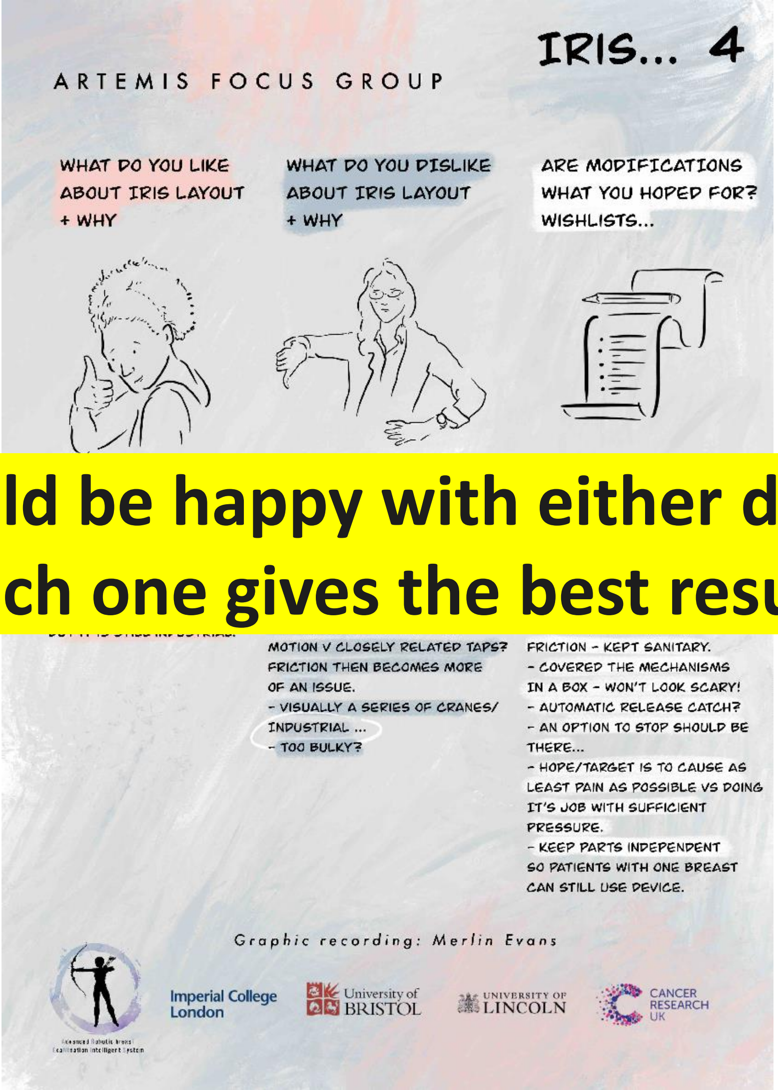






PPI Feedback





"Ultimately I would be happy with either design, my priority would be which one gives the best results clinically"

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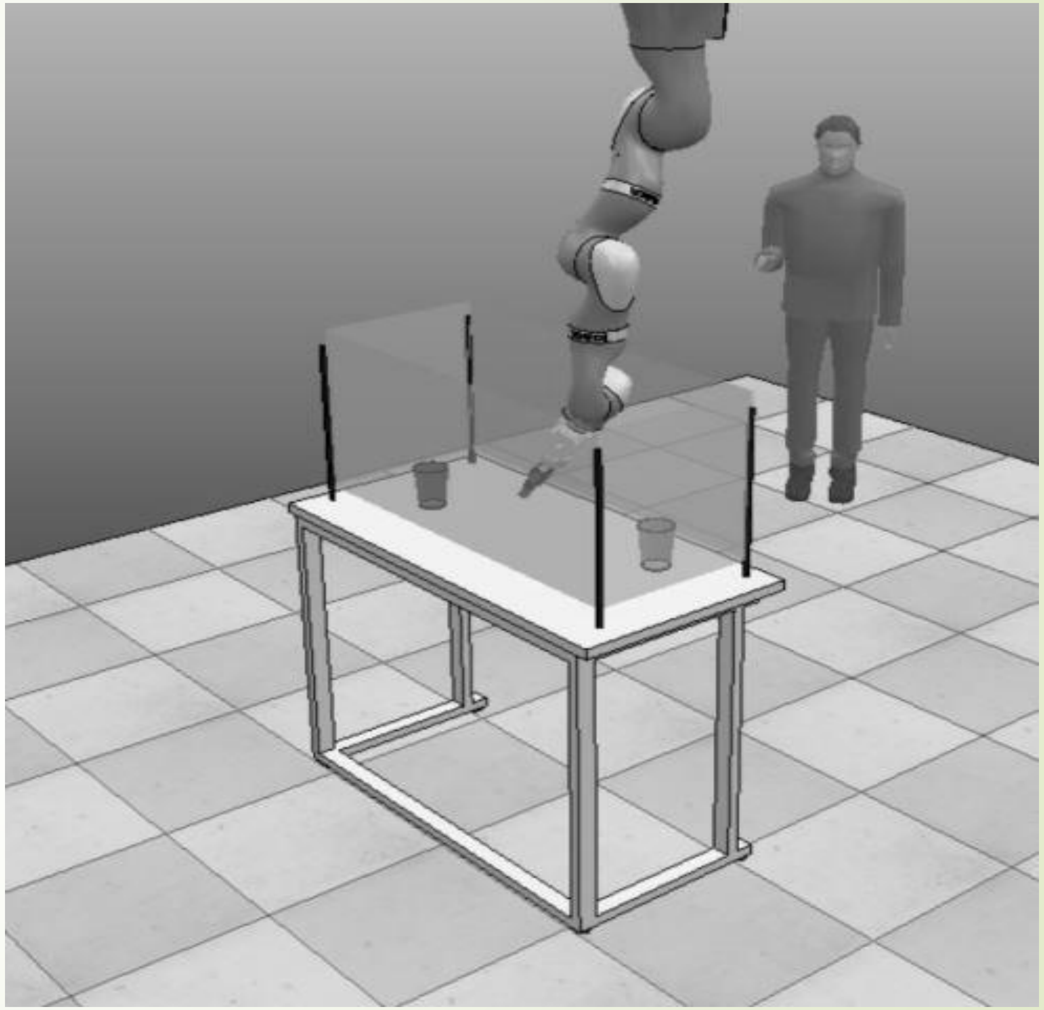
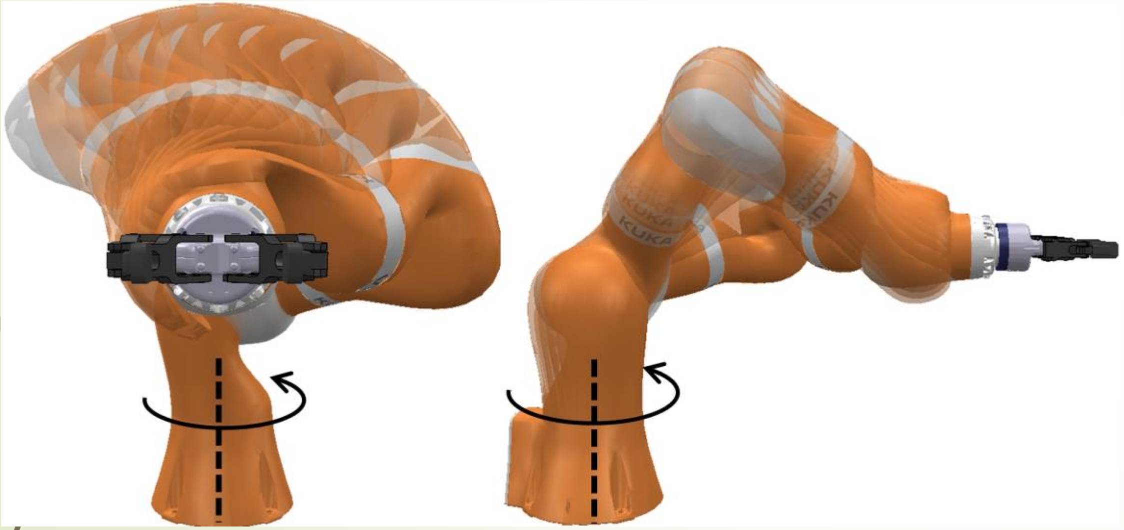
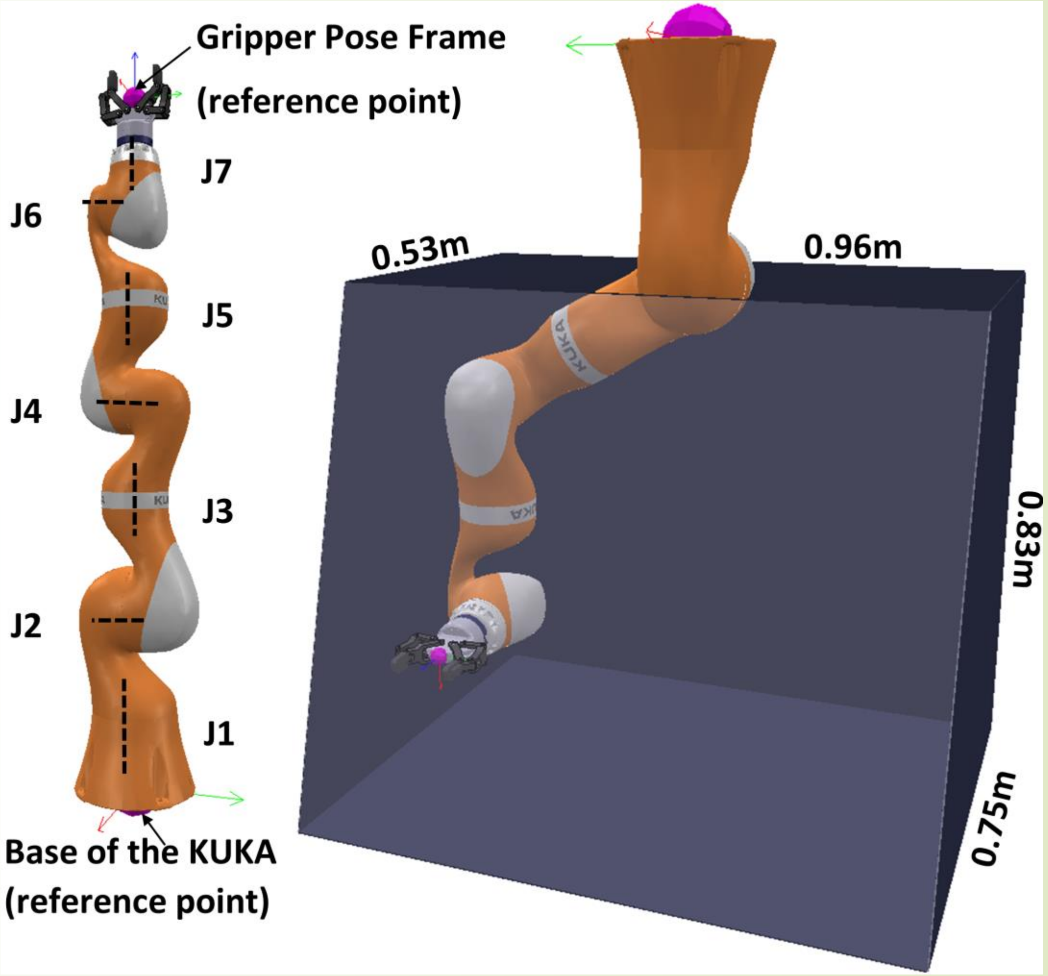
Redundant manipulators in confined spaces

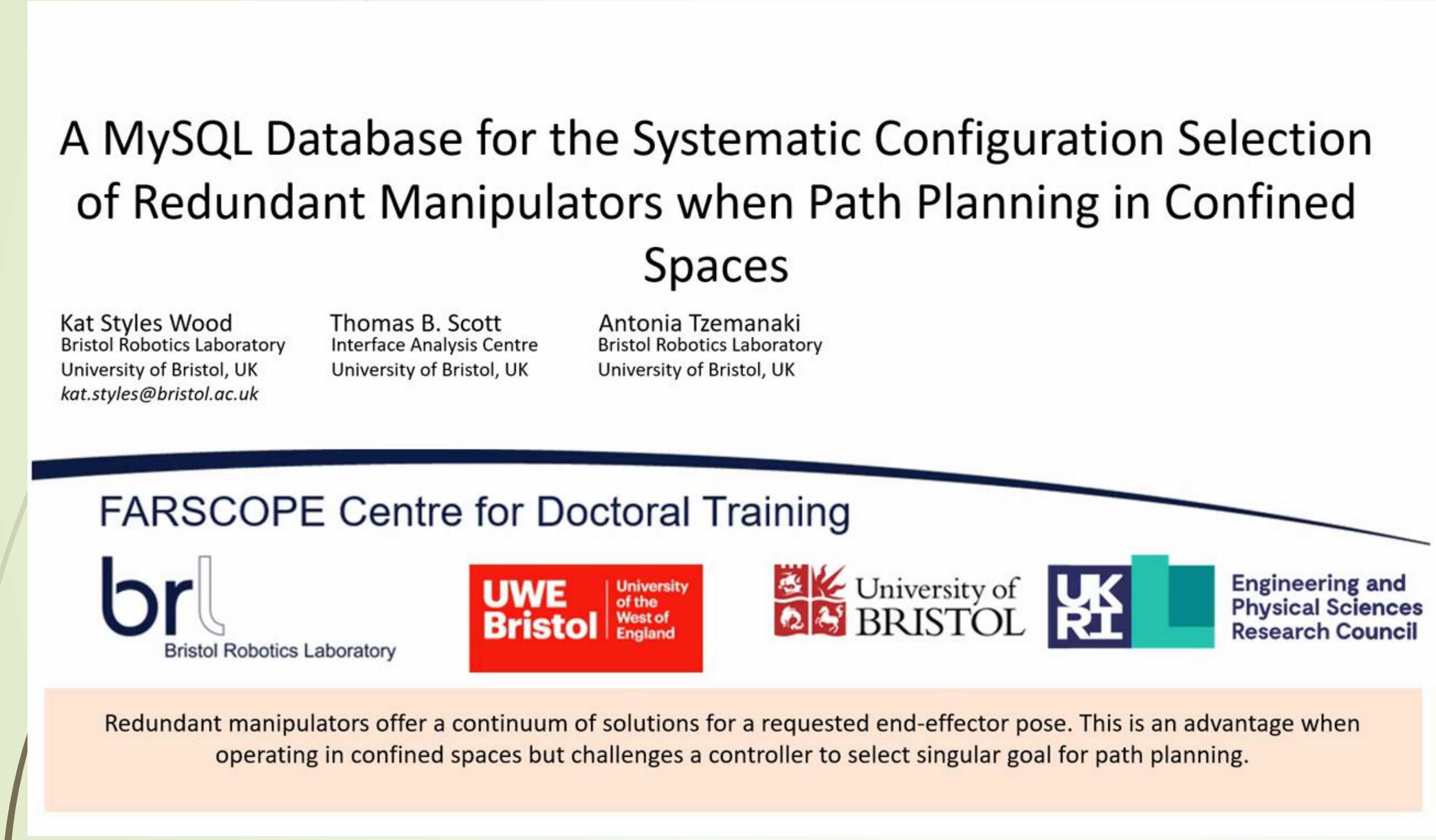


Path Planning for Redundant Manipulators in Confined Spaces





Path Planning for Redundant Manipulators in Confined Spaces: A database method


A MySQL Database for the Systematic Configuration Selection of Redundant Manipulators when Path Planning in Confined Spaces

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University of Bristol, UK

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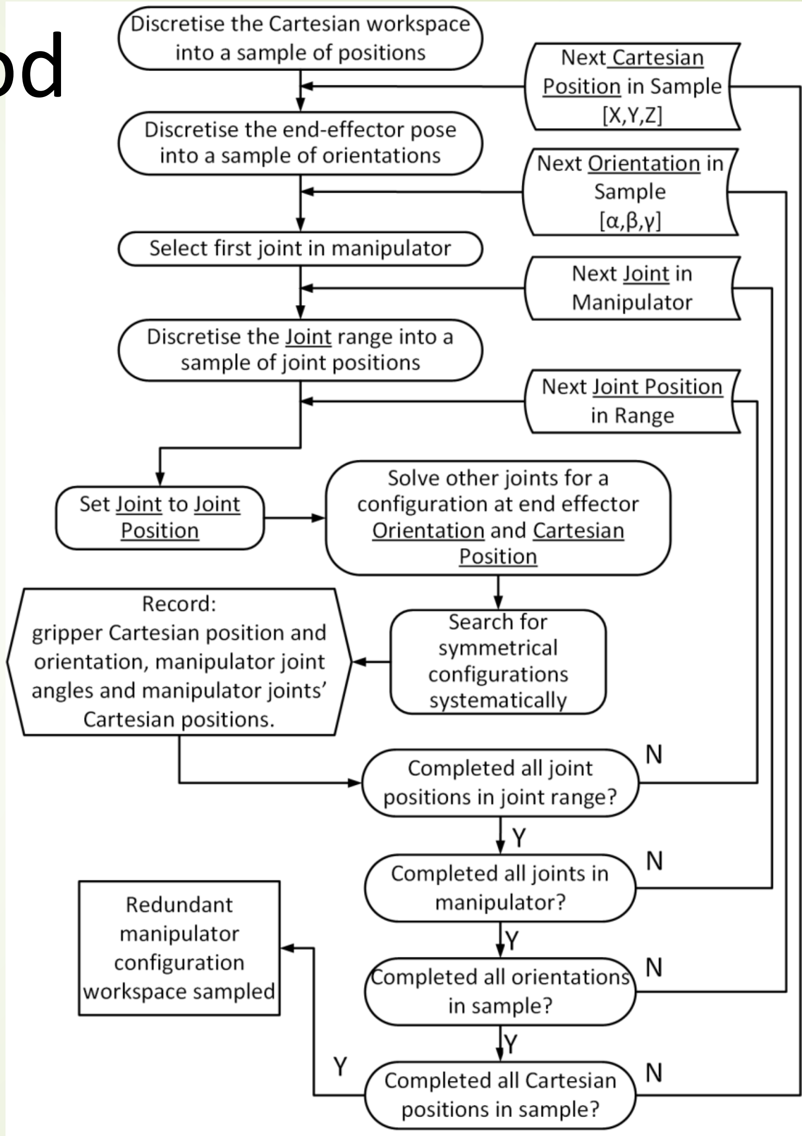
University of Bristol, UK

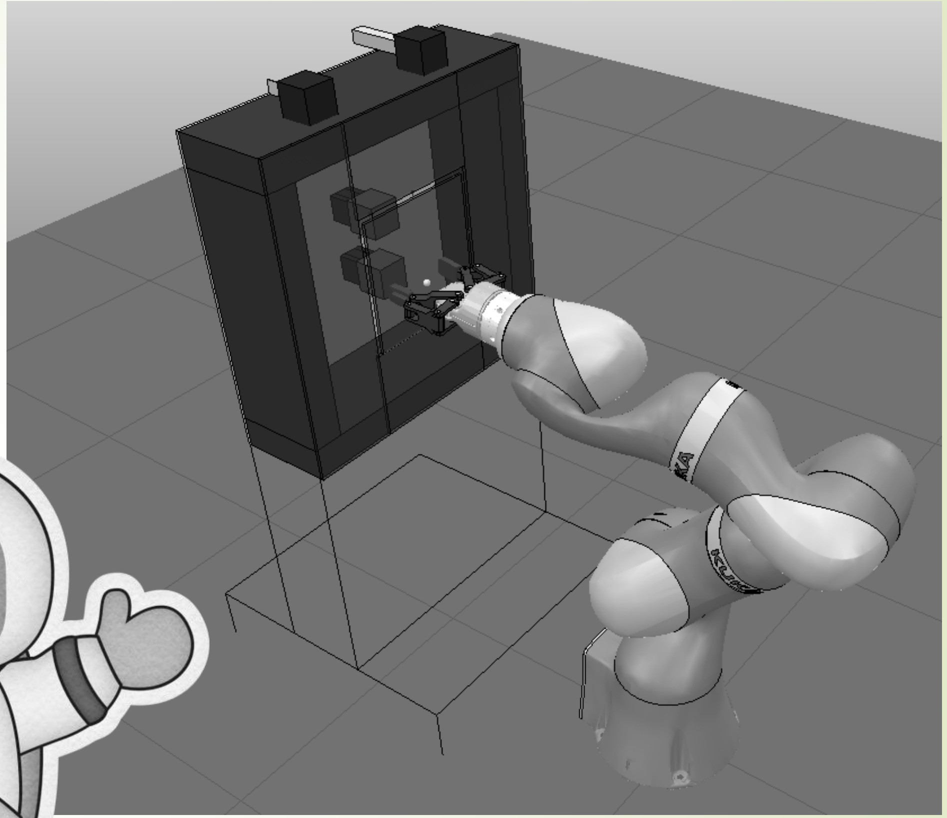
FARSCOPE Centre for Doctoral Training

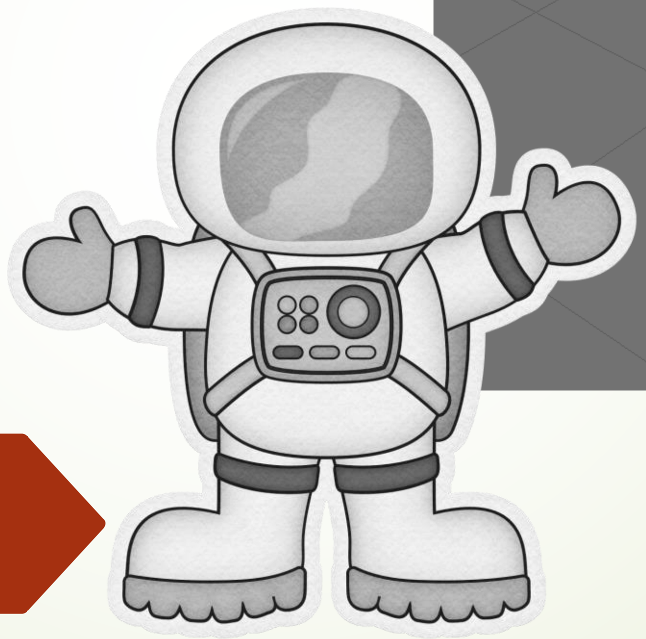
Redundant manipulators offer a continuum of solutions for a requested end-effector pose. This is an advantage when operating in confined spaces but challenges a controller to select singular goal for path planning.



- Wood Styles K., Scott B. T. and Tzemanaki A. (2023). A MySQL Database for the Systematic Configuration Selection of Redundant Manipulators when Path Planning in Confined Spaces. *2023 IEEE International Conference on Robotics and Automation (ICRA)* (accepted).

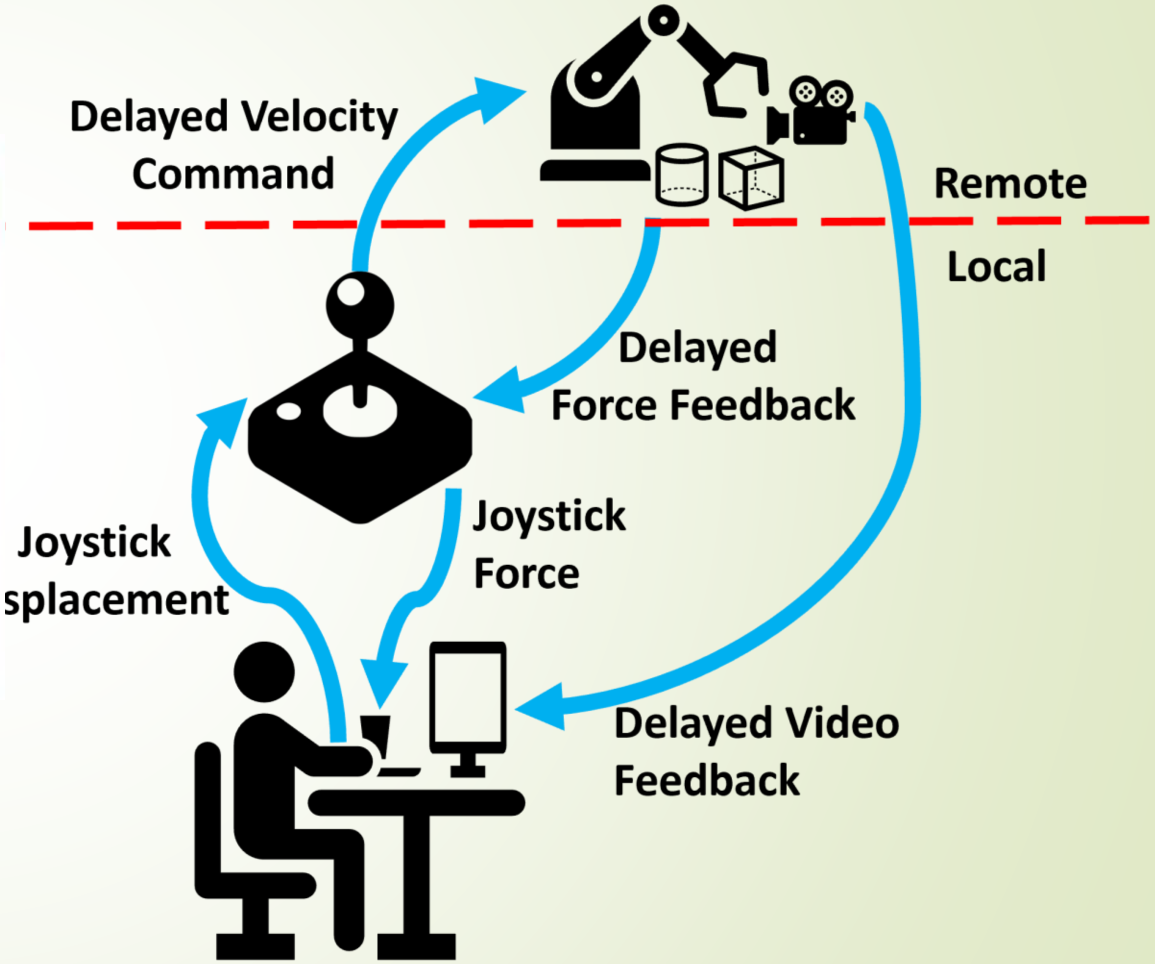
(Trustworthy) Robotics in Space



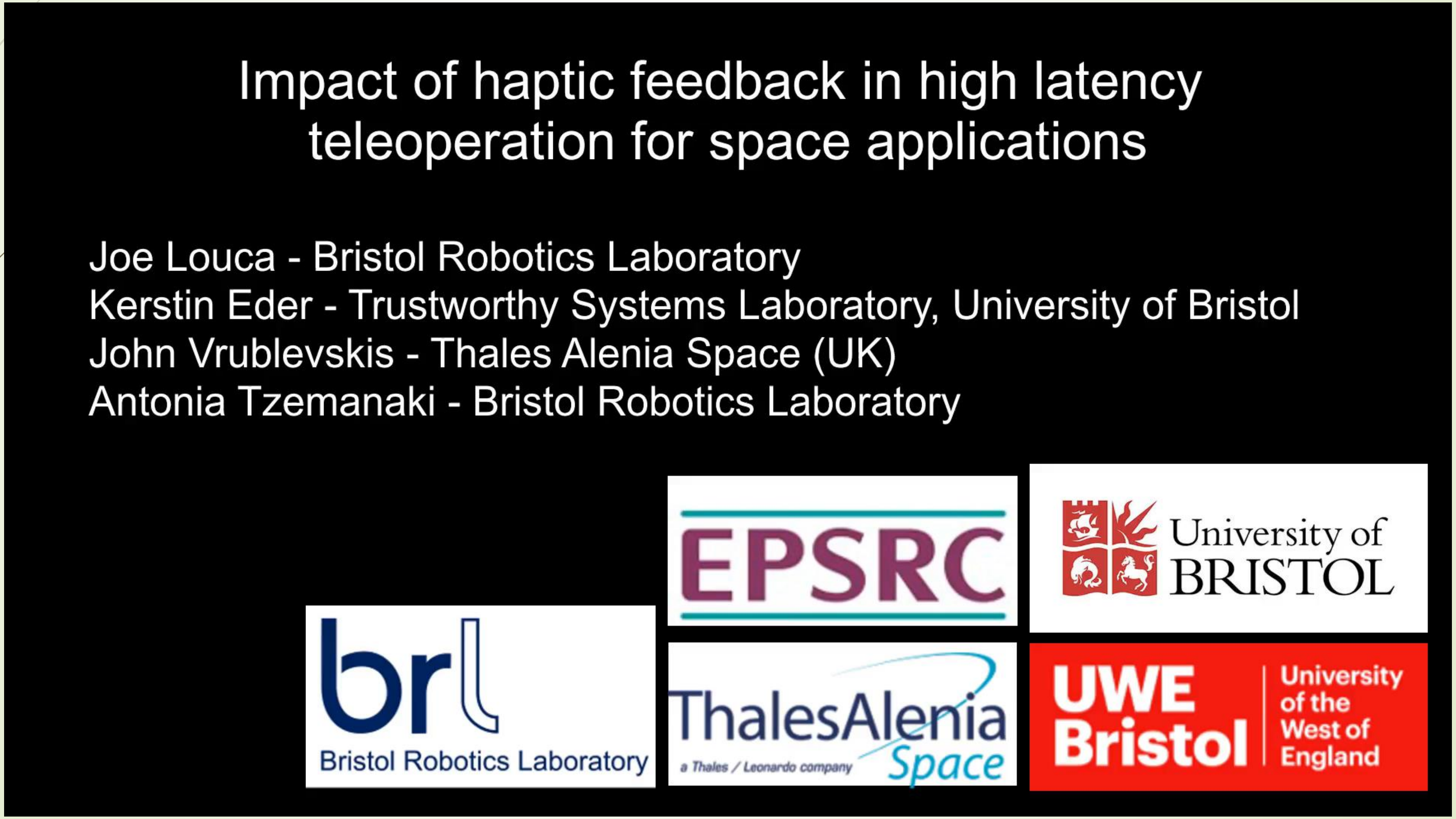


Haptic feedback in high latency teleoperation

2-Way Delay	Between Points
130 ms	Opposite sides of the Earth
130 ms	Deimos to Mars
240 ms	Earth to Geostationary Orbit (GEO)
410 ms	Earth-Moon L1/L2 to Moon surface Lunar Gateway aposelene to Moon surface
2.6 sec	Earth to Moon
6-44 mins	Earth to Mars



Haptic feedback in high latency teleoperation: *a user study*



Haptic feedback in high latency teleoperation: *elicitation of trustworthiness requirements*

12 interviews in 4 target application areas

- 4 nuclear reactor maintenance
- 3 underwater exploration and maintenance
- 3 robotic explosive ordnance disposal
- 2 surgeons (robot-assisted surgery)

“Will not have” requirements

- System is controlled via a virtual representation
- Operator uses a VR headset
- System is capable of changing the end-effector tool automatically
- System provides haptic feedback (in delayed systems)

Haptic feedback in high latency teleoperation: *elicitation of trustworthiness requirements*

High priority requirements

- Comprehensive understanding of the system's capabilities and limitations
- Combination of fixed viewpoints, an overview from a constant perspective, and variable cameras, which can move and/or zoom to provide detail on specific aspects of the scene
- System health monitoring systems must clearly communicate the cause and effect of faults
- Systems must be tested and trained upon with gradually increasing risk and realism, first in simulation, then on a physical mock up, and eventually in-situ in the real environment.
- Long practice and experience (low frequency of faults and uncontrolled movements)
- Safety systems must trigger in a fail-safe mode.
- Operators must have clear lines of communication with their support team to spread out responsibilities beyond the operator.

Thank you!

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