

Haptic feedback in robotic teleoperation

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Short Bio

Education

Computer Engineering, special. in Robotics & Automation, **University of Siena**, Italy

- 2011: Laurea magistrale (bac+5)
- **2014**: Dottorato di ricerca (doctorat)

“Cutaneous haptic feedback in robotic teleoperation” - Advisor: Prof. Prattichizzo

National and International Mobility

2013: **University of Padua**, Italy, visiting student (1 month)

Supervisor: Prof. G. Rosati

2013/2014: **University of Twente**, The Netherlands, visiting student (2 months)

Supervisor: Prof. S. Misra

2014: **University of Pennsylvania**, USA, visiting student (7 months)

Supervisor: Prof. K. J. Kuchenbecker

2015: **University of Twente**, The Netherlands, visiting scientist (2 months)

Postdoctoral experience

2015: **University of Siena**, Italy (6 months)

2015-2016: **Istituto Italiano di Tecnologia (IIT)**, Italy (17 months)

From December 2016, CNRS Researcher at **Irisa and Inria Rennes (Lagadic group)**

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hap-tic ('hap-tik)

adj. of or relating to the sense of touch, touch-based.

origins from the Greek *νοιάπτικός* meaning “able to touch or grasp.”

Kinesthesia

Location/configuration
Motion
Force
Compliance

Cutaneous

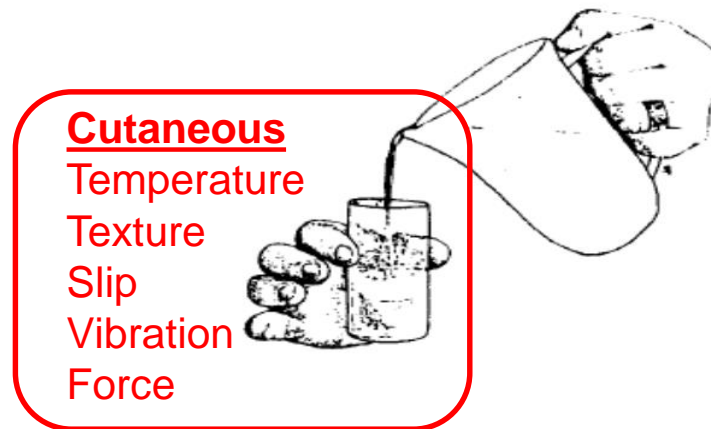
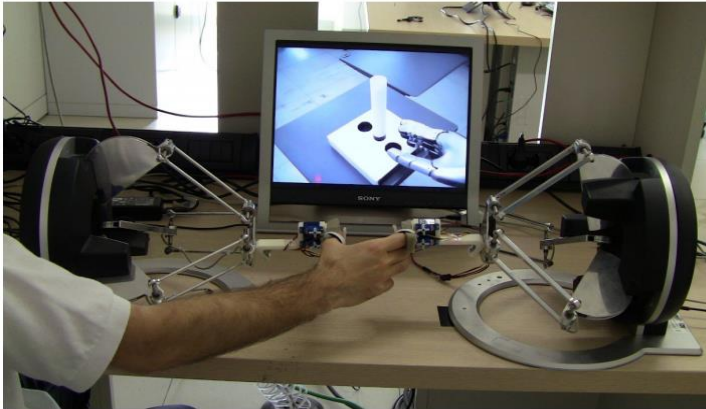
Temperature
Texture
Slip
Vibration
Force



“haptics is to touch as optics is to sight”
(A. M. Okamura), 2008.

Teleoperation

Cutaneous haptic feedback in robotic teleoperation



Delivering ungrounded cutaneous cues to the operator's skin

- (1) conveys **rich information** and
- (2) does not affect the **stability and safety** of teleoperation systems.

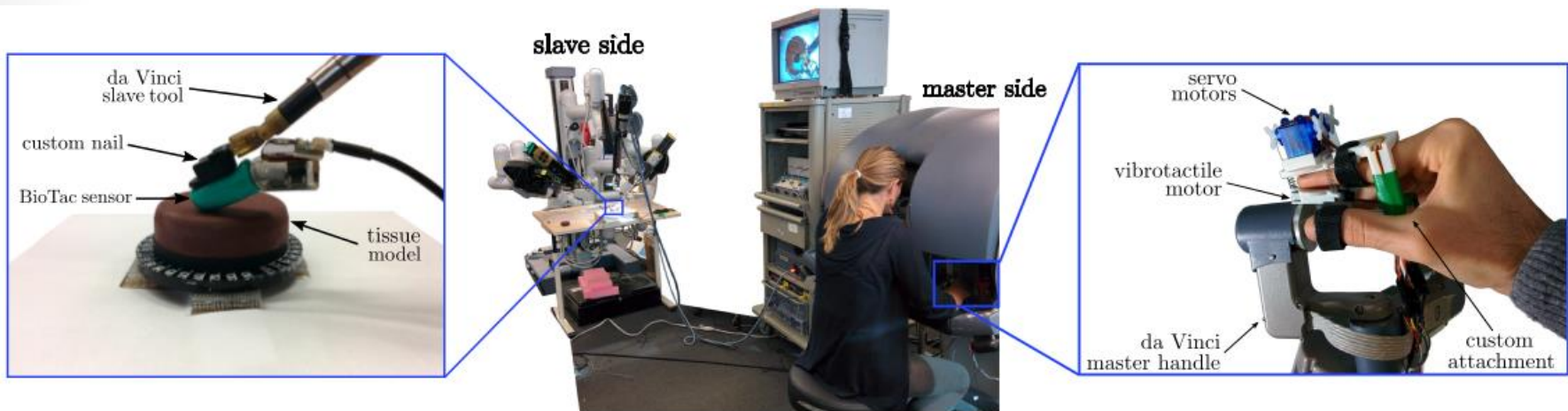
Palpation using the da Vinci Surgical System

The main advantage of using cutaneous-only feedback techniques is a higher degree of **safety**. This is very promising for those scenarios where safety is a paramount and non-negotiable requirement, such as in robot-assisted surgery.



For this reason, we present a novel force feedback system for the da Vinci Surgical System, capable of **providing cutaneous feedback** to the surgeon **while guaranteeing the safety of the teleoperation system**.

Palpation using the da Vinci Surgical System



The haptic system is composed of a

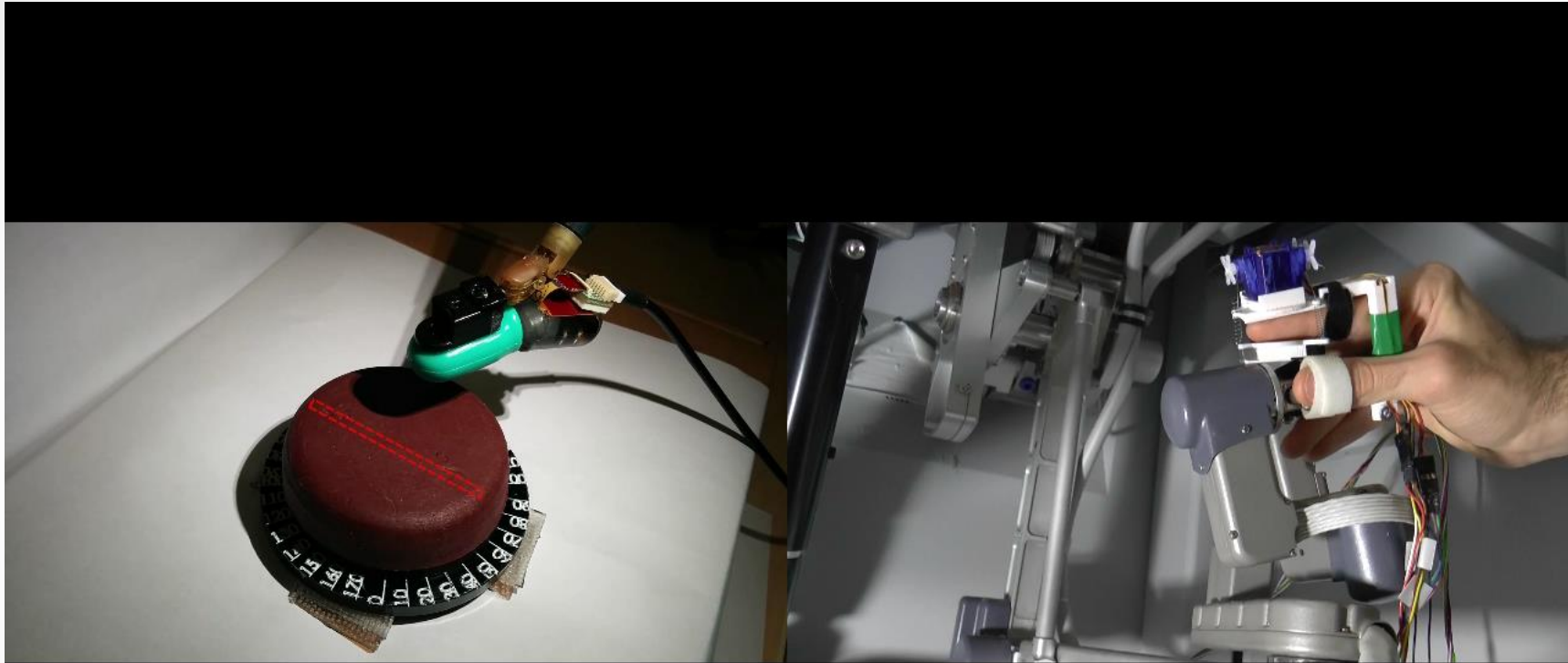
- (1) **BioTac tactile sensor**, in charge of registering contact forces and vibrations at the operating table, and
- (2) **a cutaneous feedback device**, in charge of applying contact forces and vibrations to the surgeon.

Cutaneous feedback device

TITLE

C. Pacchierotti, D. Prattichizzo, K. J. Kuchenbecker

Experiment



Condition SV

The servo motors move the platform, and the vibrotactile motor outputs vibrations (played here as audio).

C. Pacchierotti, D. Prattichizzo, K. J. Kuchenbecker. "Cutaneous feedback of fingertip deformation and vibration for robotic surgery." **IEEE Transactions on Biomedical Engineering**, In Press, 2015.

C. Pacchierotti, K. J. Kuchenbecker, D. Prattichizzo. "A general approach to displaying sensed tactile cues with a fingertip haptic device." **IEEE Transactions on Haptics**, 8(4):397-409, 2015.

C. Pacchierotti, D. Prattichizzo, K. J. Kuchenbecker. "A data-driven approach to remote tactile interaction: from a BioTac sensor to any fingertip cutaneous device." **Proc. EuroHaptics**, 2014.

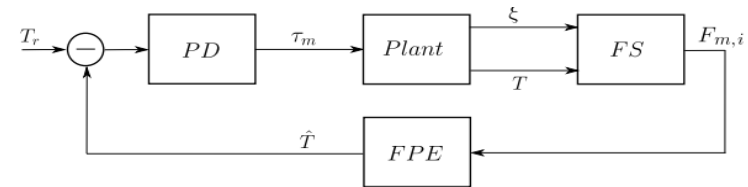
Wearable haptics

Wearable haptics systems



- Small, compact, and lightweight designs.
- Underactuation and undersensing.
- Force and position closed-loop control

$$\xi = \mathbf{K}^{-1} \mathbf{w}_p,$$



Challenges & Outcome

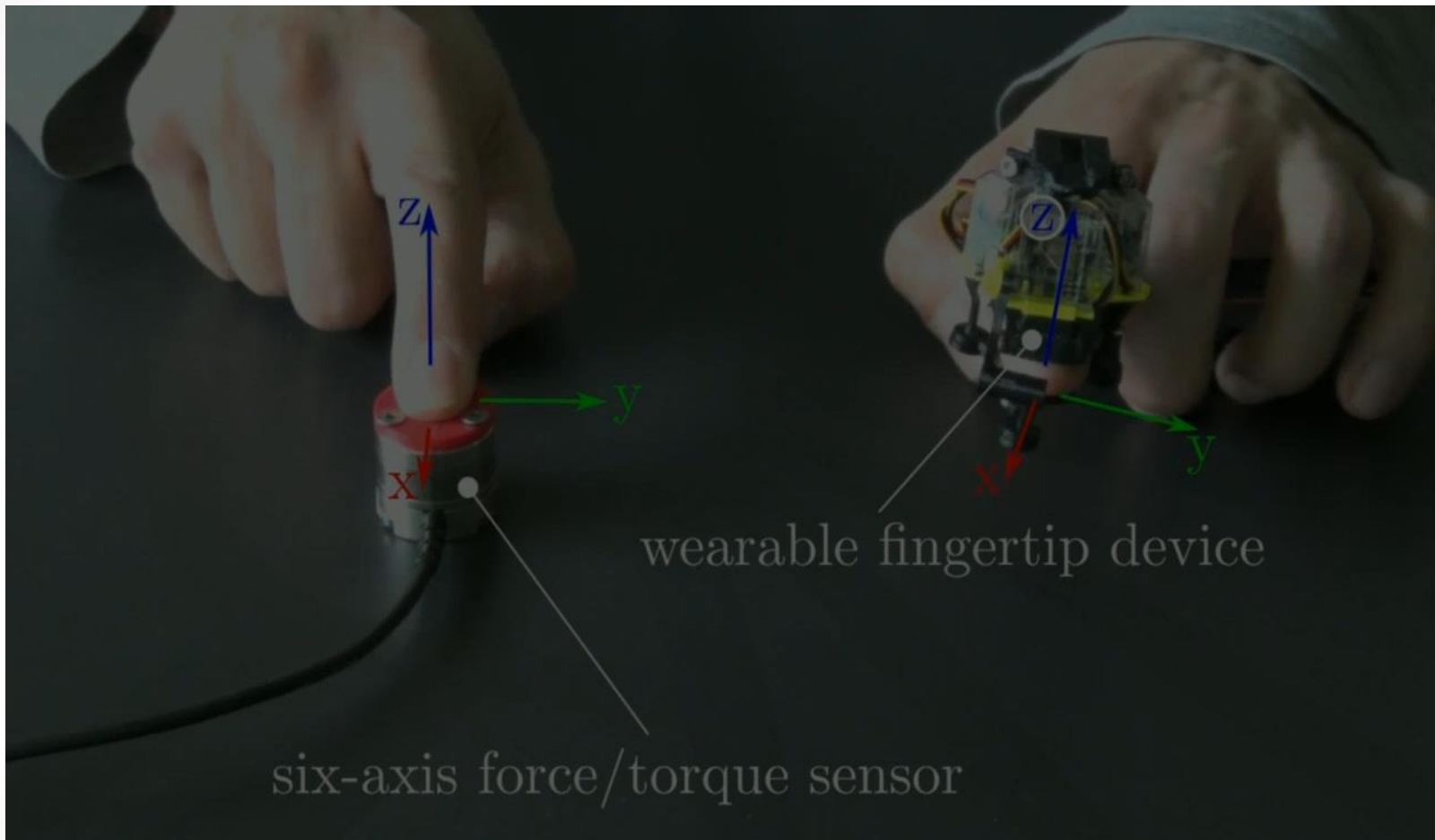
- Redistributable designs and APIs.
- Applications in medical robotics, rehabilitation, and gaming.



D. Prattichizzo, F. Chinello, C. Pacchierotti, M. Malvezzi. Towards wearability in fingertip haptics: a 3-DoF wearable device for cutaneous force feedback. **IEEE Transactions on Haptics**, 6(4):506-516, 2013.

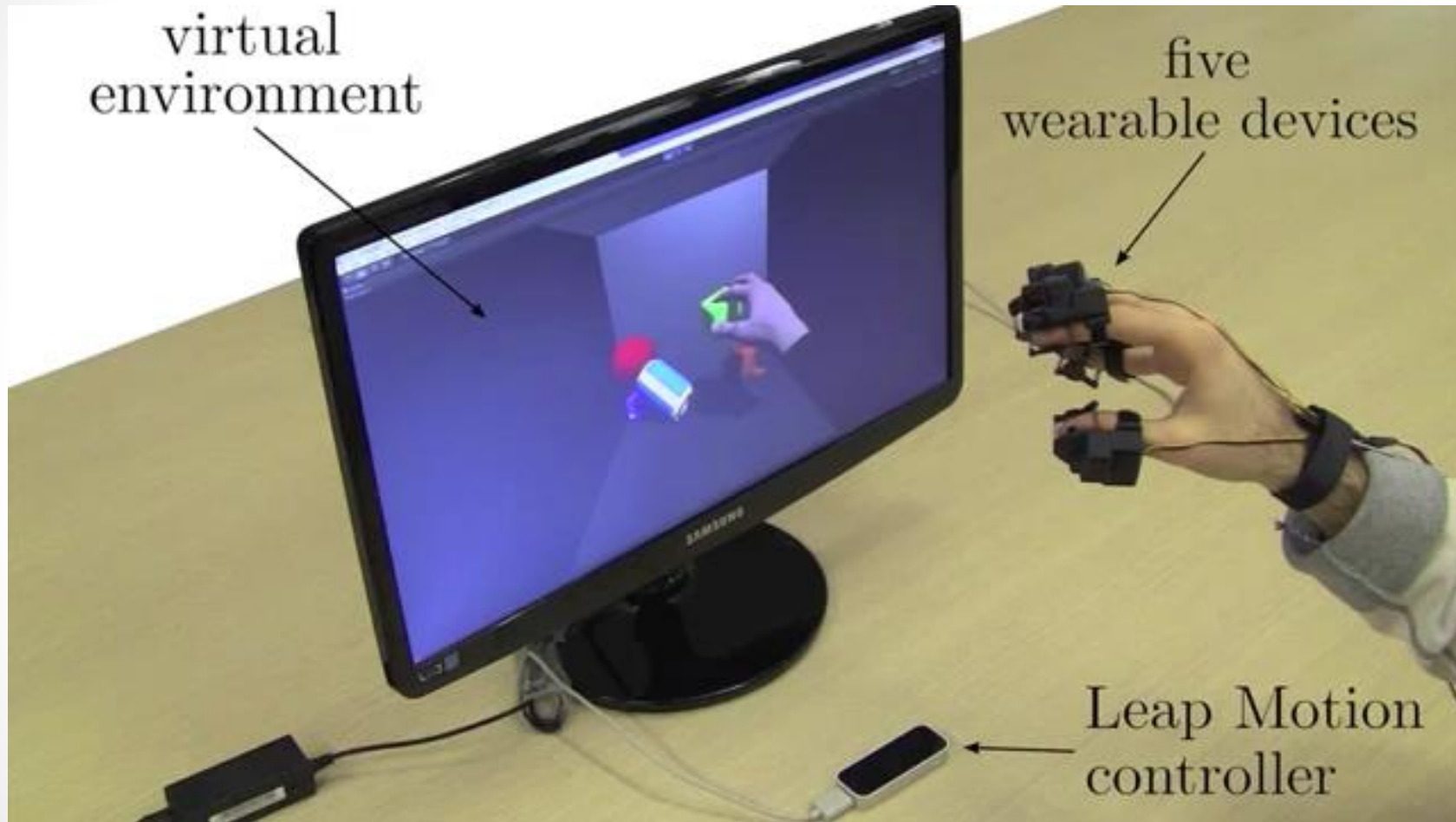
F. Chinello, M. Malvezzi, C. Pacchierotti, D. Prattichizzo. "Design and development of a 3RRS wearable fingertip cutaneous device." **Proc. IEEE/ASME International Conference on Advanced Intelligent Mechatronics**, Busan, Republic of Korea, 2015.

Demonstration



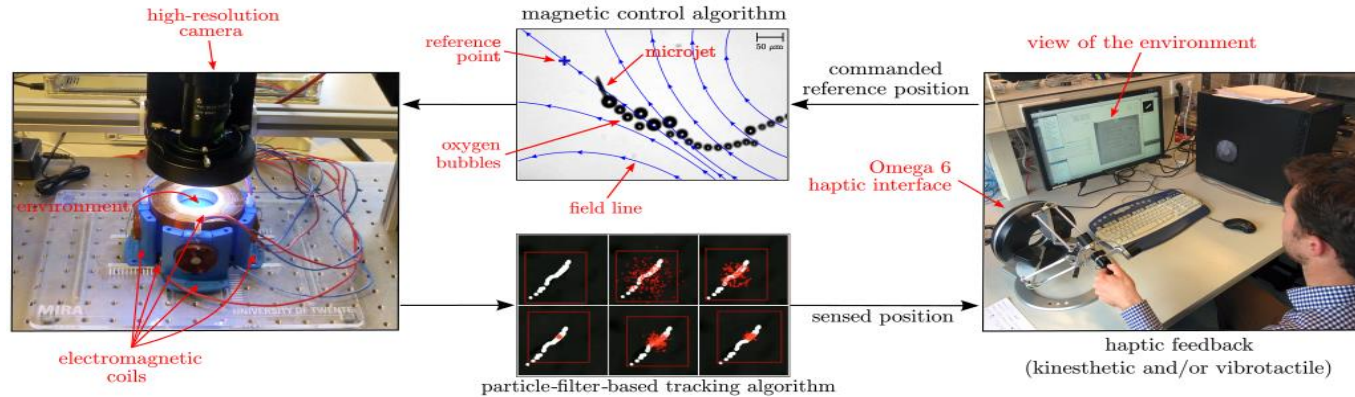
The wearable fingertip devices replicates the force pattern applied by the user on the sensor. 16

Application



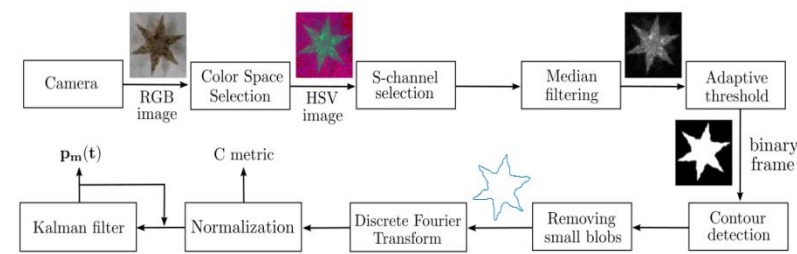
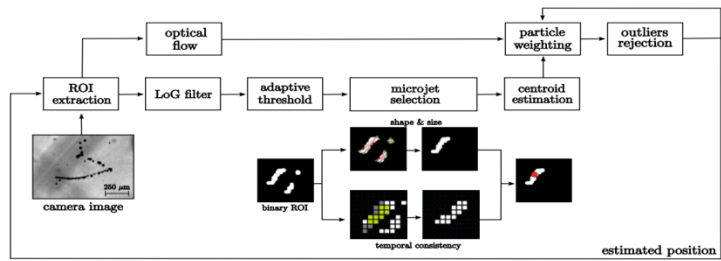
Wearable devices provide the user with the compelling sensation of **touching** the virtual environment

Haptic feedback for microrobotics applications

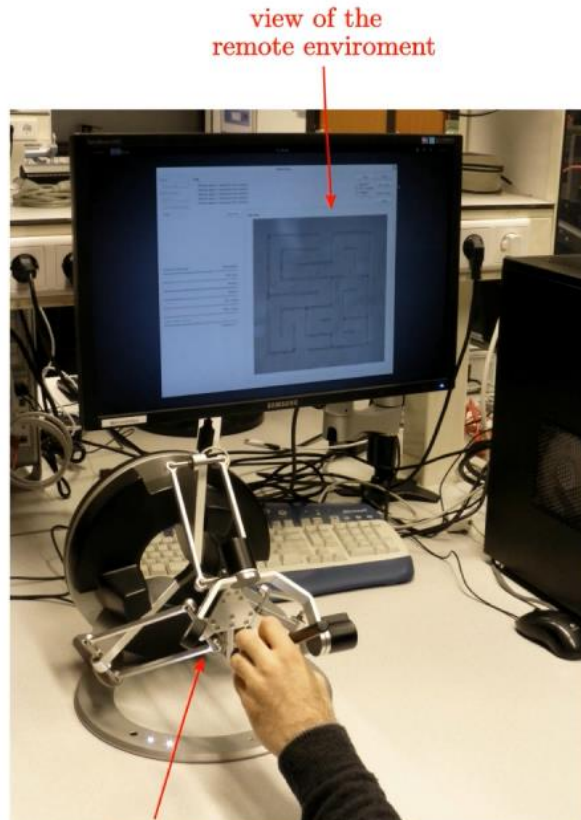


Challenges & Outcome

- Biocompatible, biodegradable, **soft robots**.
- Tracking using **particle-based approaches**.
- **Wireless magnetic control**.

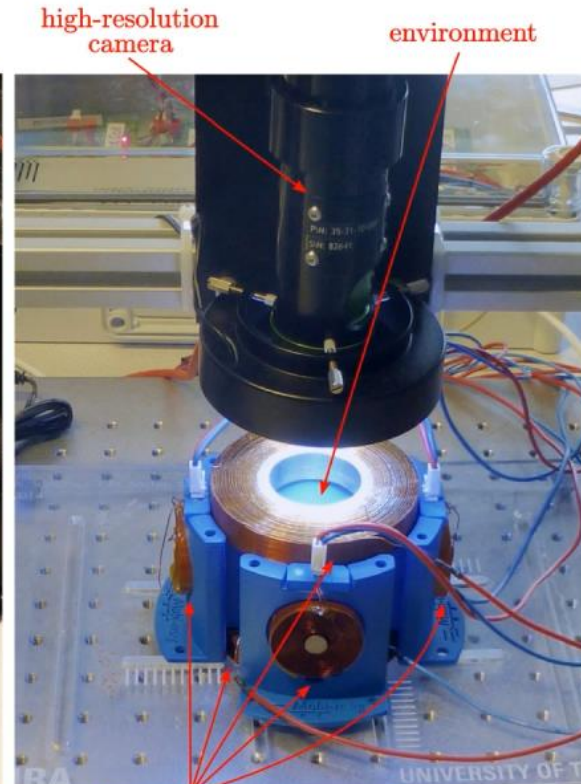


- Applications in **medical diagnosis**.



view of the remote environment

Omega 6 haptic interface



high-resolution camera

environment

electromagnetic coils