ETH zürich

MSRL
Multi-Scale Robotics Lab

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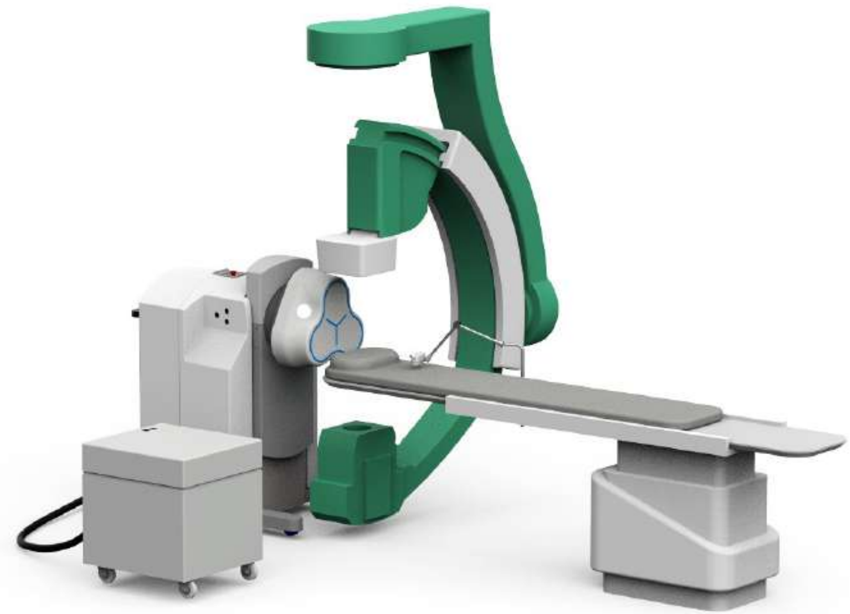
Bridge Discovery Project
“A Submillimeter Minimally Invasive System for Cardiac Arrhythmia Ablations”

Cedric Fischer, PhD candidate ETH Zurich



BRIDGE

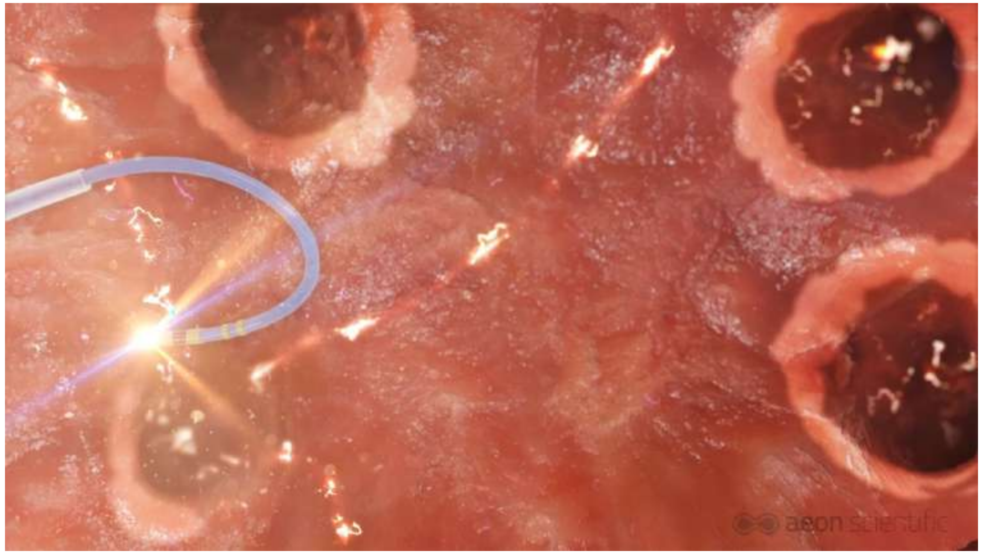
FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

Why Cardiac Arrythmia Ablations?

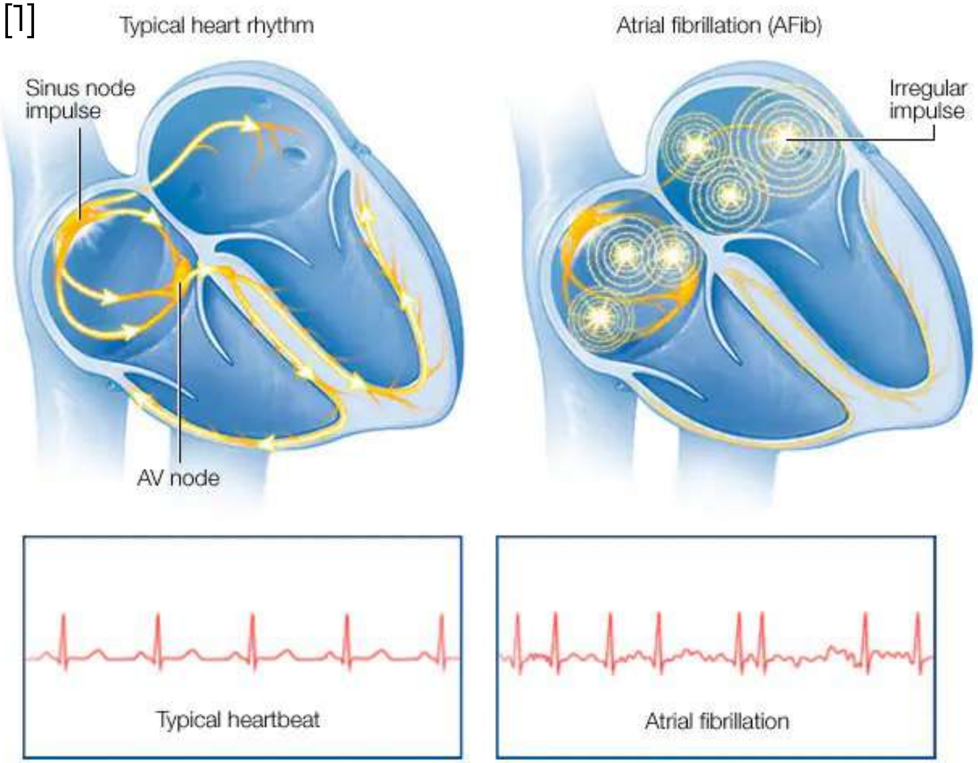
Arrythmias are irregularities in the heartbeat

- Most common case: Atrial fibrillation (0.51% of worldwide population,2017) [1]
- Atrial fibrillation increases risk for ischemic stroke 5-fold [2]

- In severe cases, ablation is required
- Ablation: HF energy is used to "disconnect" pathways of abnormal rhythm



Aeon Scientific AG



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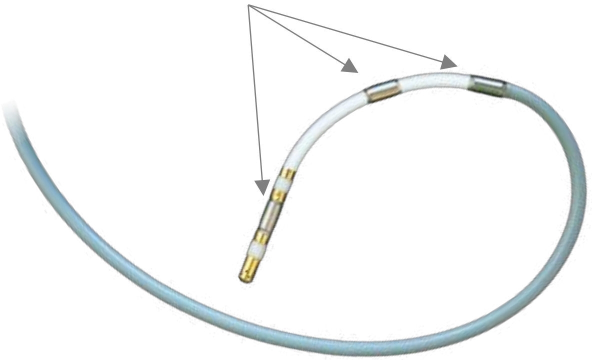
Mayo Clinic

[1] Lippi, Int. J Stroke, 2021
[2] Lakshminarayan, Neurologist, 2008

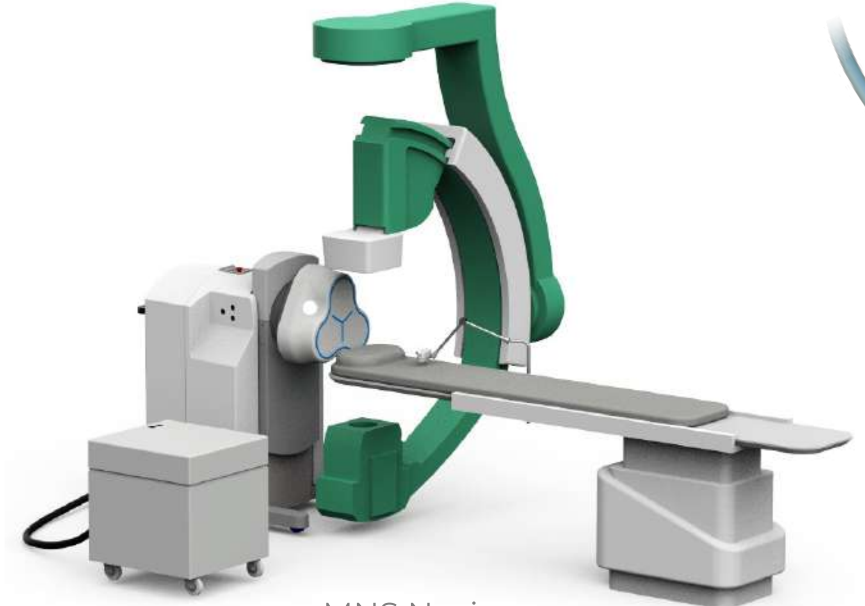
Remote magnetic navigation (RMN)

RMN utilizes external magnetic field to remotely manipulate magnetic catheters

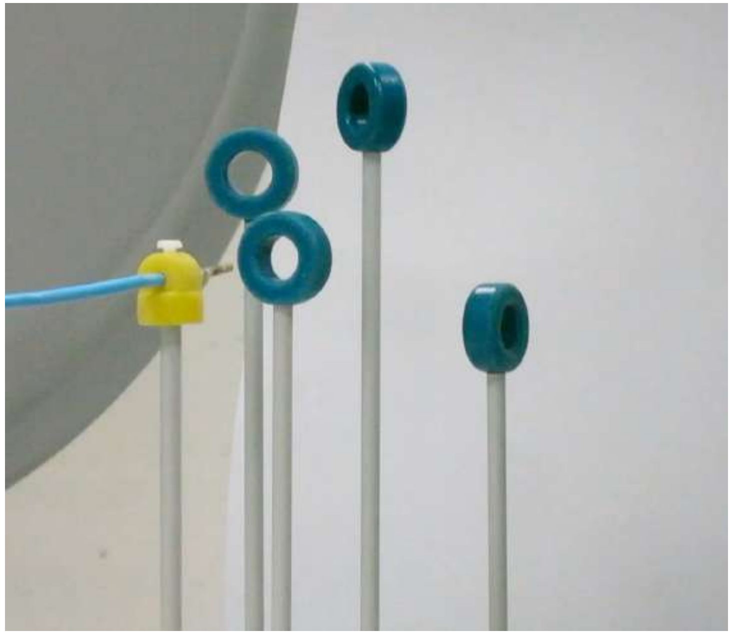
Magnetic field is generated by (electro-)magnetic navigation system (eMNS)



Acutus Medical



eMNS Navion



Advantages of magnetic catheters:

- High flexibility and dexterity
- Precise tip control
- Part of robotic system

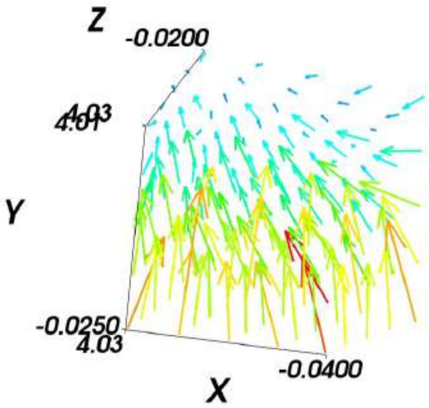
Project collaboration

Goal: *Expand capabilities of magnetically actuated catheters*

Variable stiffness

Magnetic field mapping

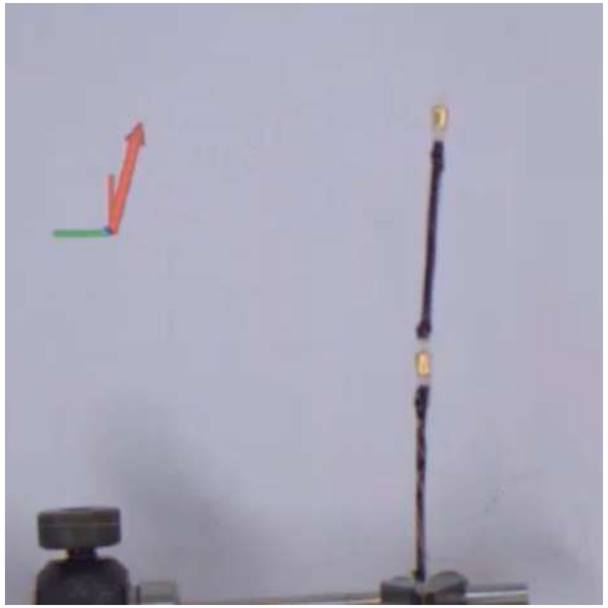
Control and localization algorithms



Variable Stiffness technology

Material changes properties with increasing temperature → becomes softer

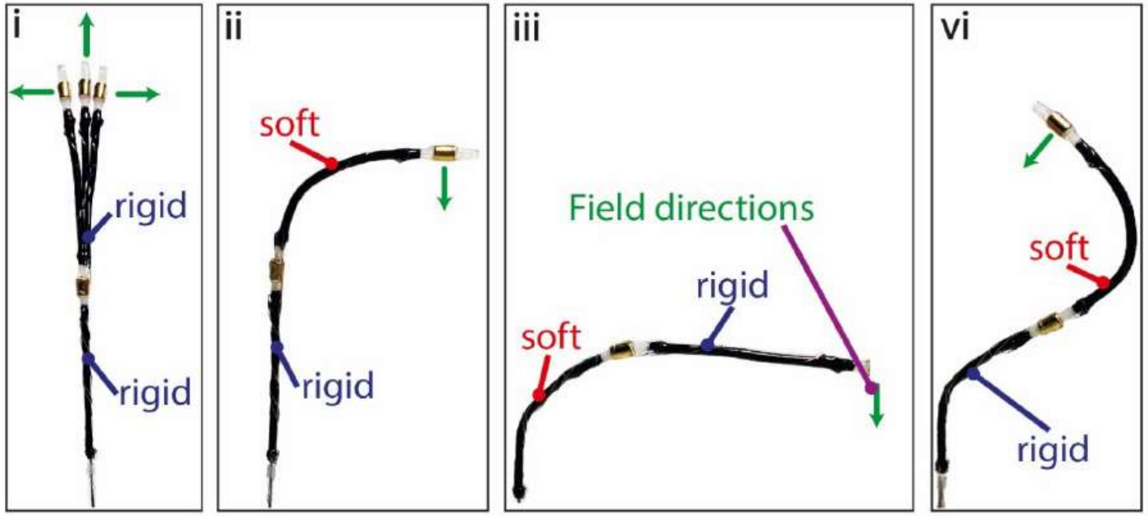
- *Increased dexterity with multiple segments*
- *Improved control and precision*
- *Higher forces can be applied*



Y. Piskarev, Adv. Funct. Mater., 2022

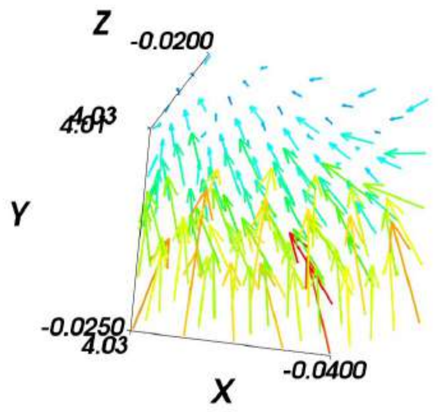
Advances during project

- Small scale integration
- Fast stiffness changes
- Moving towards bio-compatible materials
- Large stiffness range



Magnetic field mapping

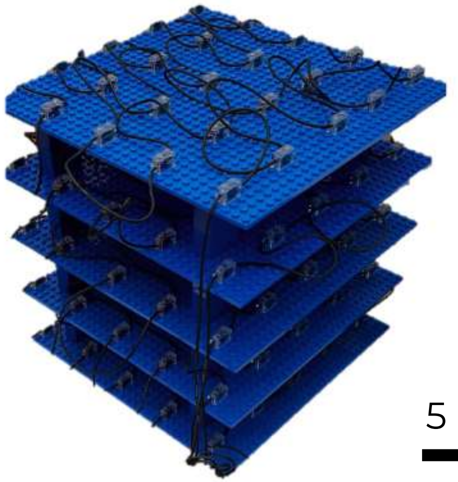
Precise knowledge of magnetic fields needed for control and localization tasks



How do we map the fields?

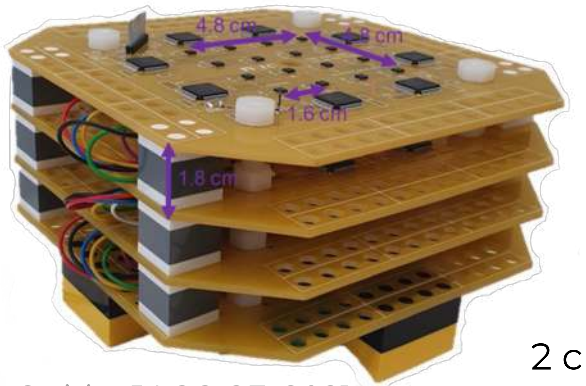
- Magnetometer arrays
- Different sensor grid spacings
- Different mounting systems

125 sensors (2019)



5 cm

64 sensors (2021)



T. Quirin, JACC CE, 2021

2 cm

80 sensors (2022)

T. Quirin, IEEE MeMeA, 2022

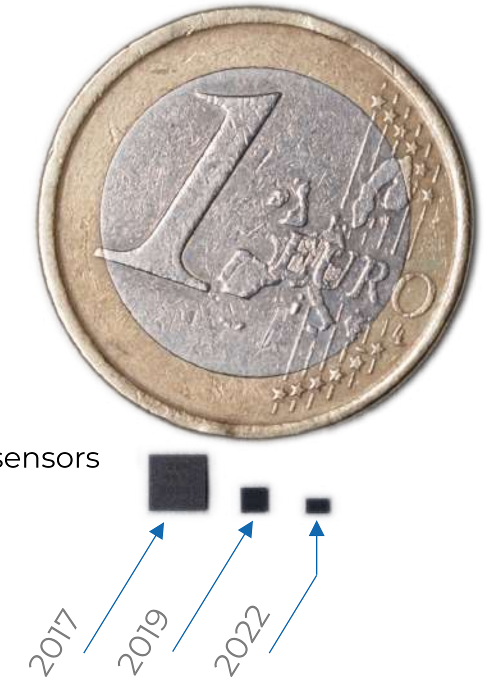
2 cm

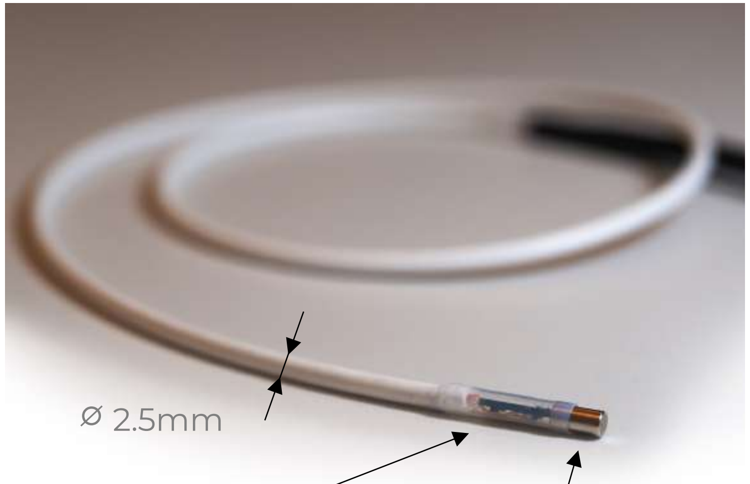
Catheter localization

Our aim: Use eMNS for *both* navigation *and* localization

→ Expand capabilities of eMNS: 2-in-1 system

→ Integrate magnetic sensors into catheters



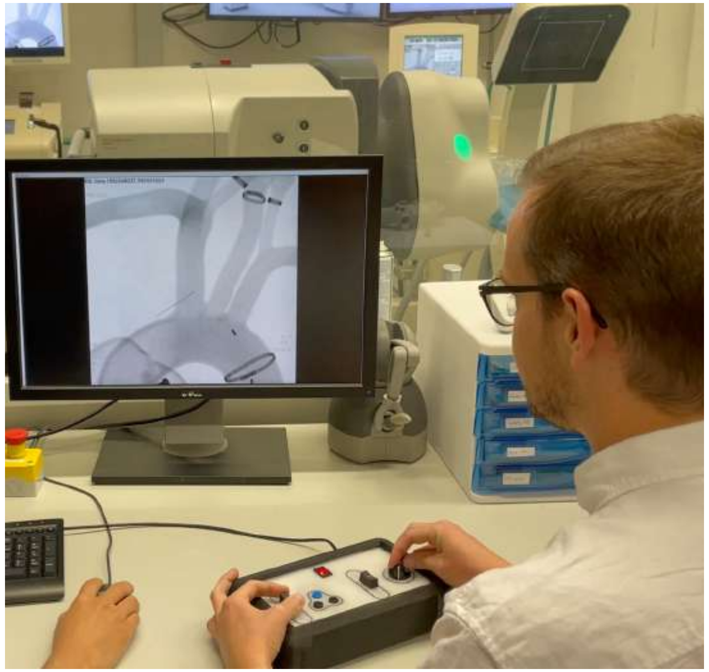


Catheter Control

- Simplify magnetic navigation with control algorithms
- An eMNS is a robotic system → Automation

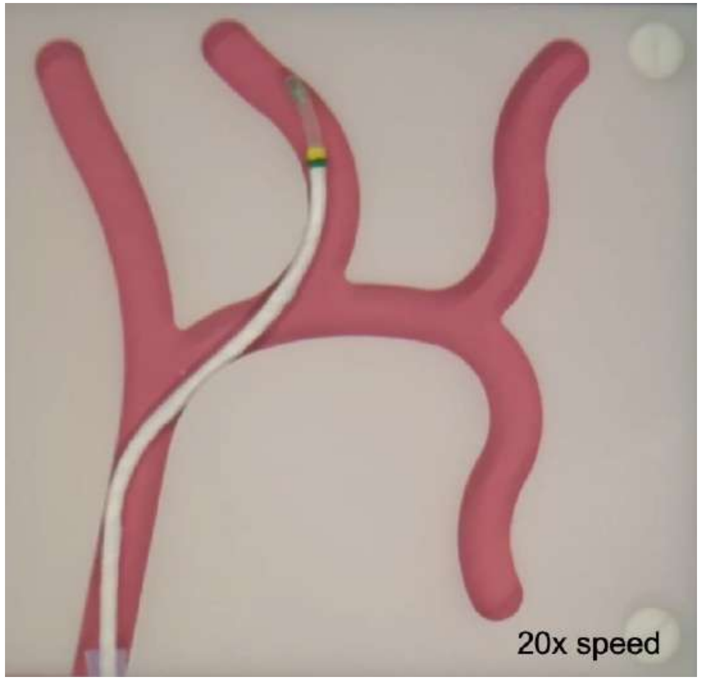
eMNS Navion

Choice of ideal user input device



R. Dreyfus, Hamlyn Symp., 2022

Towards autonomous steering

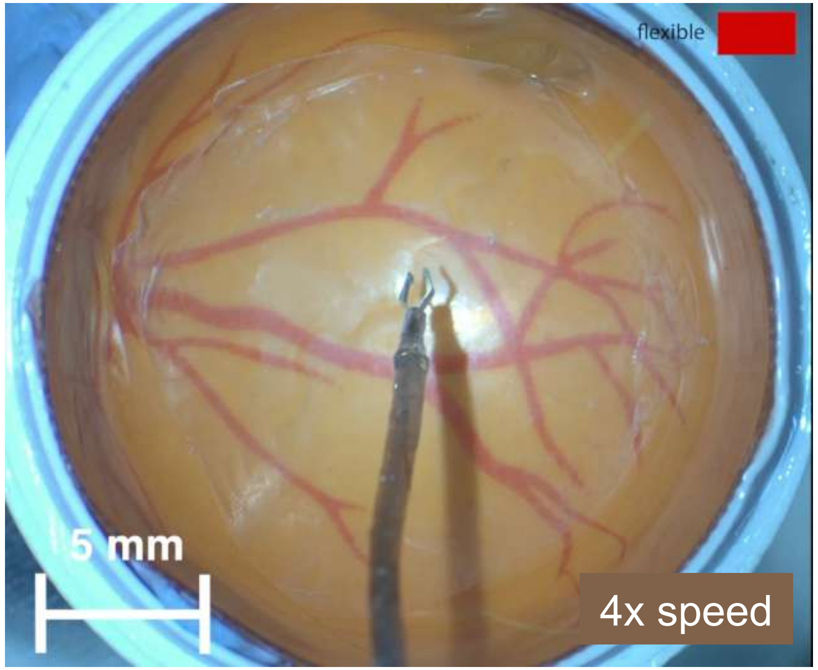


Beyond cardiac surgeries …

Expanding technologies to other surgical applications

Eye surgeries

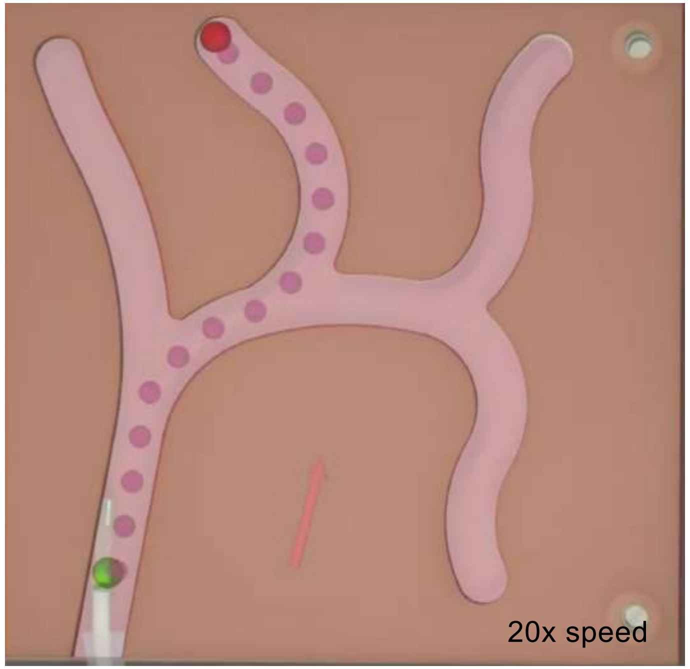
Submilimeter variable stiffness catheter



J. Lussi, Adv. Science, 2021

Endoluminal surgeries

Automated navigation through known geometry with magnetic sensor localization



C. Fischer, IEEE RA-L, 2022

Fetal surgeries

Visual servoing: Automated endoscope control

J. Lussi, Adv. Int. Sys, 2022

Publications

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- Fischer, C., et al., *Using Magnetic Fields to Navigate and Simultaneously Localize Catheters in Endoluminal Environments.* IEEE Robotics and Automation Letters, 2022.
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- Féry, C., et al., Magnetic Field Measurements of Portable Electronic Devices: The Risk Inside Pockets for Patients With Cardiovascular Implantable Devices. Circ. Arrhythm. Electrophysiol. 15., 2022
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- Vergne, C., et al., Millirobot magnetic manipulation for ocular drug delivery with sub millimeter precision, in: IEEE Sensor, Dallas, United States, November 2022.

Thank you for your attention!