MRS Nearlab thesis presentation

www.nearlab.polimi/medical

@MRSNealab

elena.demomi@polimi.it

@USA

In-Loop Electromagnetic Tracker

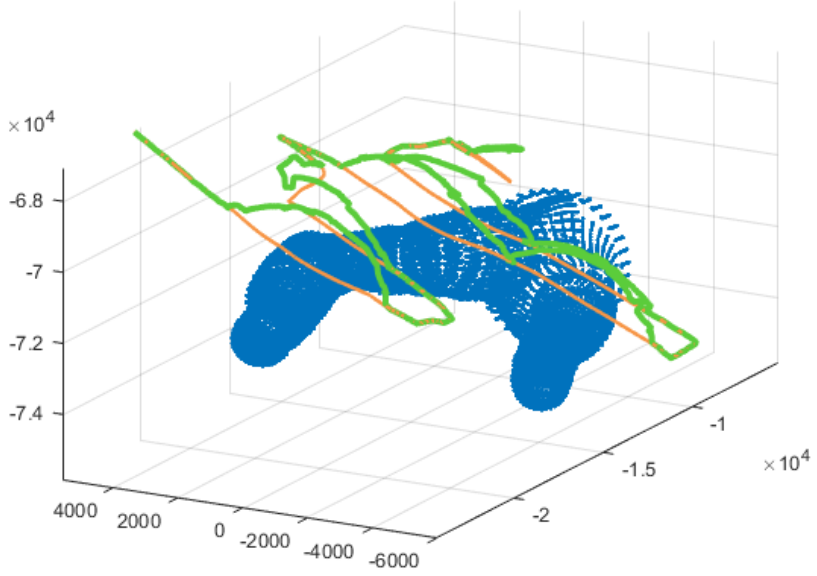
to obviate tracking sightlines for handheld surgical robotics

- Carnegie Mellon University
- Prof. Cameron Riviere: camr@ri.cmu.edu
- https://zapdf.com/multirate-kalman-filter-rejects-impulse-noise-in-frequency-d.html
- Thesis can be completed ½ in Milan and ½ in Pittsburgh

Virtual fixture for safer microneurosurgery

Carnegie Mellon
THE ROBOTICS INSTITUTE

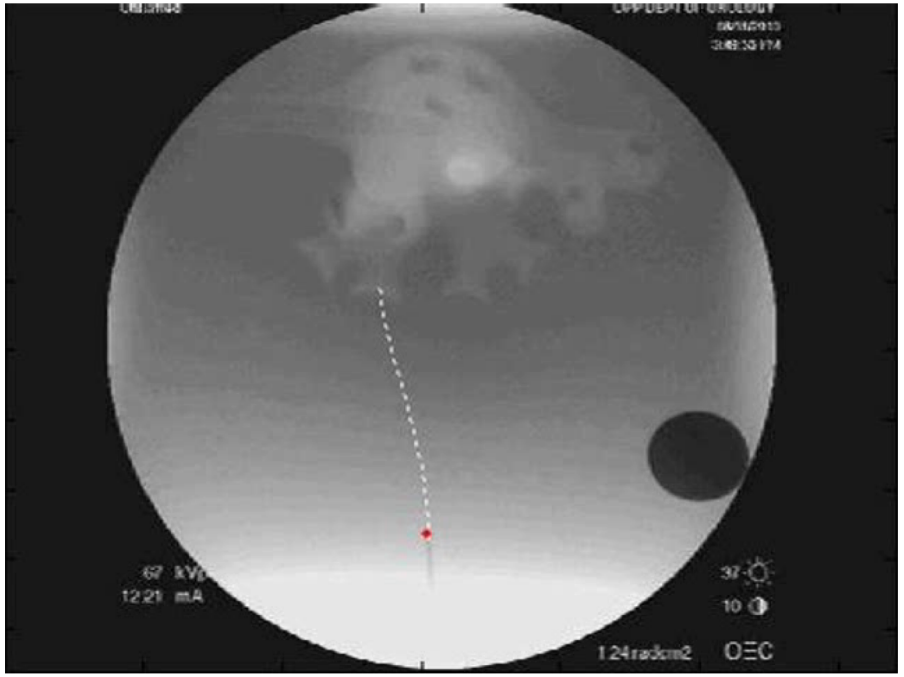
- Carnegie Mellon University
- Prof. Cameron Riviere: camr@ri.cmu.edu
- https://www.researchgate.net/publication/326432668_Toward_Improving_Safety_in_Neurosurgery_with_an_Active_Handheld_Instrument
- Thesis can be completed ½ in Milan and ½ in Pittsburgh



3D path-following control of steerable needles

Carnegie Mellon
THE ROBOTICS INSTITUTE

- Carnegie Mellon University
- Prof. Cameron Riviere: camr@ri.cmu.edu
- https://pdfs.semanticscholar.org/acc1/cc0450115cc982b66532e9b8f2779f9bc82e.pdf
- Thesis can be completed ½ in Milan and ½ in Pittsburgh



Mechanical optimization of soft hydrogels for biomimicking applications

Harvard University, Boston US

antonio.forte10@imperial.ac.uk
aeforte@seas.harvard.edu

Forte, Antonio E., et al. "A composite hydrogel for brain tissue phantoms." *Materials & Design* 112 (2016): 227-238.
Leibinger, A., Forte, A. E., Tan, Z., Oldfield, M. J., Beyrau, F., Dini, D., & y Baena, F. R. (2016). Soft tissue phantoms for realistic needle insertion: a comparative study. *Annals of biomedical engineering*, *44*(8), 2442-2452.
Tan Z, Parisi C, Di Silvio L, Dini D, Forte AE. Cryogenic 3D printing of super soft hydrogels. Scientific reports. 2017 Nov 24;7(1):16293.

@EU

Thesis title: **Virtual fixtures for haptic guidance in robotized teleoperated craniotomy**

Partner institution: University of Poitiers, PPRIME Institute (Poitiers, France)

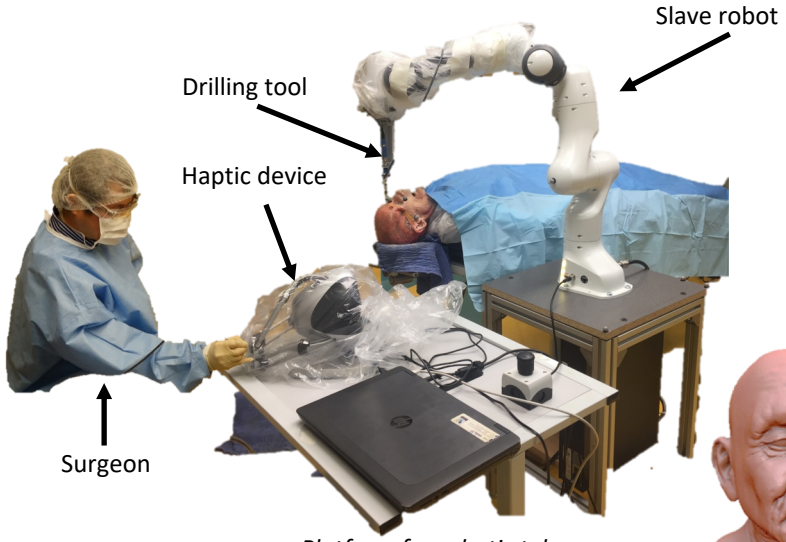
Description:

During craniotomy procedures, hand-held drilling is commonly used to remove a section of the skull. Nevertheless, drilling torsion and hand shaking may lead to potential deviation from targeted drilling region, producing hemorrhage and other neurological problems. To mitigate these risks, a teleoperated craniotomy platform is proposed.

The aim of this MSc thesis is to develop haptic guidance strategies to constraint the drilling tool movements into a desired region. Forbidden-region virtual fixtures should be defined based on a 3D reconstruction of the patient's skull. Moreover, a control strategy is expected to be implemented to prevent meninges damage (three membranes enveloping the brain), through the measures provided by the force sensor placed at the drilling tool.

The proposed thesis can be performed half-time in Milan and half-time in Poitiers, where it is expected to perform experimental tests.

Available equipments: Franka robot, Falcon interface, 3D scan, Motion Capture system, etc.
Proposed software: Robot Operating System (ROS), Matlab Simulink, Vrep



Platform for robotic telesurgery (experiments on cadaver)

3D reconstructed cadaver's skull

Bibliography:

[1] Lin, C.-C.; Lin, H.-C.; Lee, W.-Y.; Lee, S.-T.; Wu, C.-T. (2017). Neurosurgical robotic arm drilling navigation system, The International Journal of Medical Robotics and Computer Assisted Surgery, Vol. 13, No. 3, Paper e1790, DOI:10.1002/rcs.1790

[2] M. Li, M. Ishii, R. H. Taylor, Spatial motion constraints using virtual fixtures generated by anatomy, IEEE Transactions on Robotics, vol. 23, no. 1, pp. 4-19, 2007, DOI: 10.1109/TRO.2006.886838

Further information:

Juan Sebastián Sandoval Arévalo, Ph.D.
Assistant Professor
juan.sebastian.sandoval.arevalo@univ-poitiers.fr

September 24th, 2018

Bristol Robotics Laboratory

UWE Bristol University of the West of England

University of BRISTOL

Investigation of hand and finger motions using a robotic hand exoskeleton interface

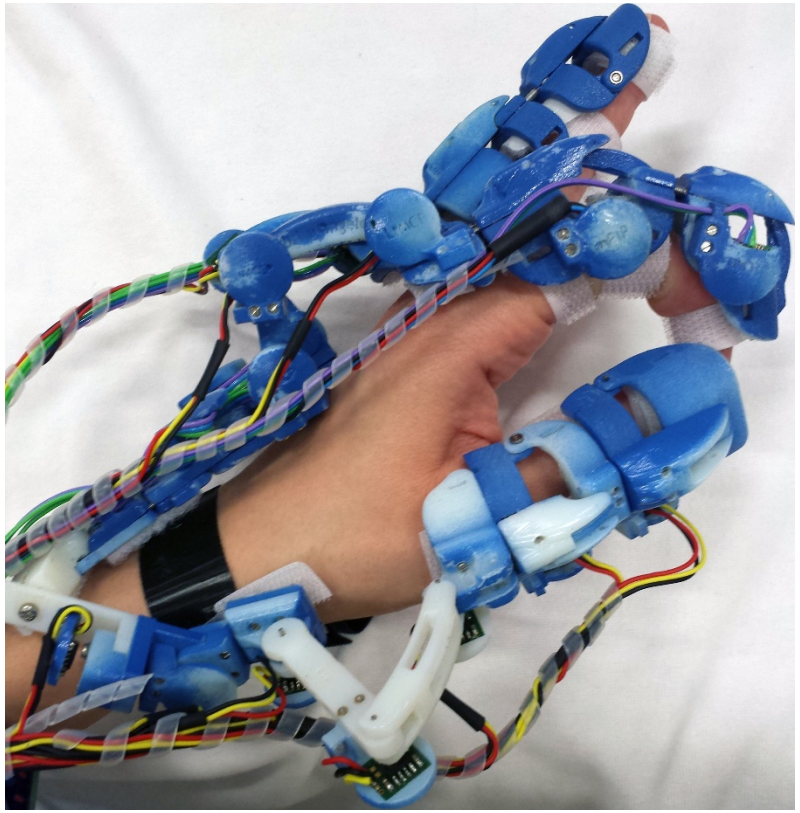
- Scope:

Develop algorithms for hand motion tracking and recording and compare a custom-made robotic hand exoskeleton with other methods of tracking (e.g. Leap motion). This can be used in investigating hand motions of users when attempting various grasping tasks, varying from every-day objects to surgical suturing.

- Contact:

Dr Antonia Tzemanaki, Antonia.Tzemanaki@brl.ac.uk

Prof. Sanja Dogramadzi, Sanja.Dogramadzi@brl.ac.uk



Bristol Robotics Laboratory

UWE Bristol University of the West of England

University of BRISTOL

Are 3 better than 2? Mapping between human and robot hands for surgical tele-operation

- Scope:

Investigate, develop and implement one or more algorithms that map a human hand and its fingers to those of a robotic end-effector. Examples of end-effectors can vary between robot grippers, hand or even surgical instruments. The ultimate goal would be to use the developed algorithms in a series of tests that compare two-finger and three-finger grasping and manipulation.

- Contact:

Dr Antonia Tzemanaki, Antonia.Tzemanaki@brl.ac.uk

Prof. Sanja Dogramadzi, Sanja.Dogramadzi@brl.ac.uk

Bristol Robotics Laboratory

UWE Bristol University of the West of England

University of BRISTOL

Implementation and control of an elbow joint of a surgical instrument in a Virtual Surgical Environment

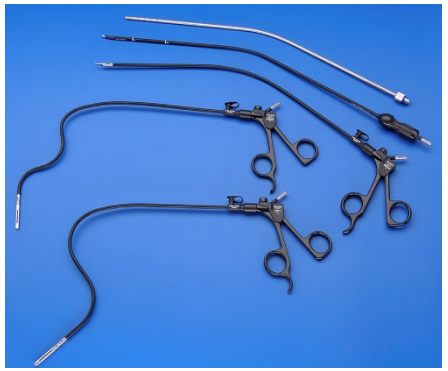
- Scope:

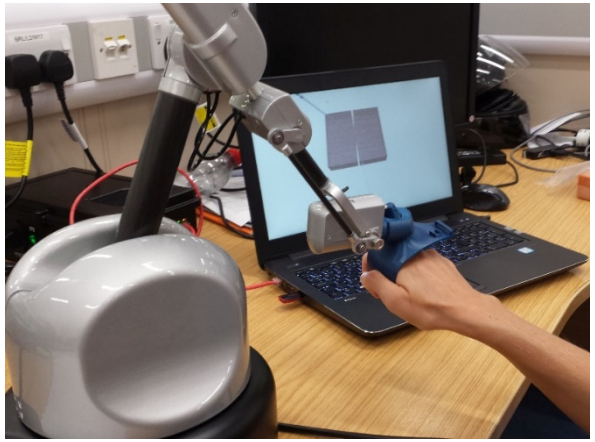
Investigate requirements for added dexterity in minimally invasive surgical (MIS) instruments. This can be achieved by creating a virtual surgical environment (e.g. Unity or CHAI3D) and a surgical instrument with an added joint (elbow). The required number of degrees of freedom of the joint can be determined in the project with testing. The position and orientation of the virtual instrument will be controlled by a user operating a robotic haptic arm (e.g. Virtuose 6d desktop, HAPTION), which will help test if the additional joint is beneficial in avoiding collisions with (virtual) abdominal walls.

- Contact:

Dr Antonia Tzemanaki, Antonia.Tzemanaki@brl.ac.uk

Prof. Sanja Dogramadzi, Sanja.Dogramadzi@brl.ac.uk





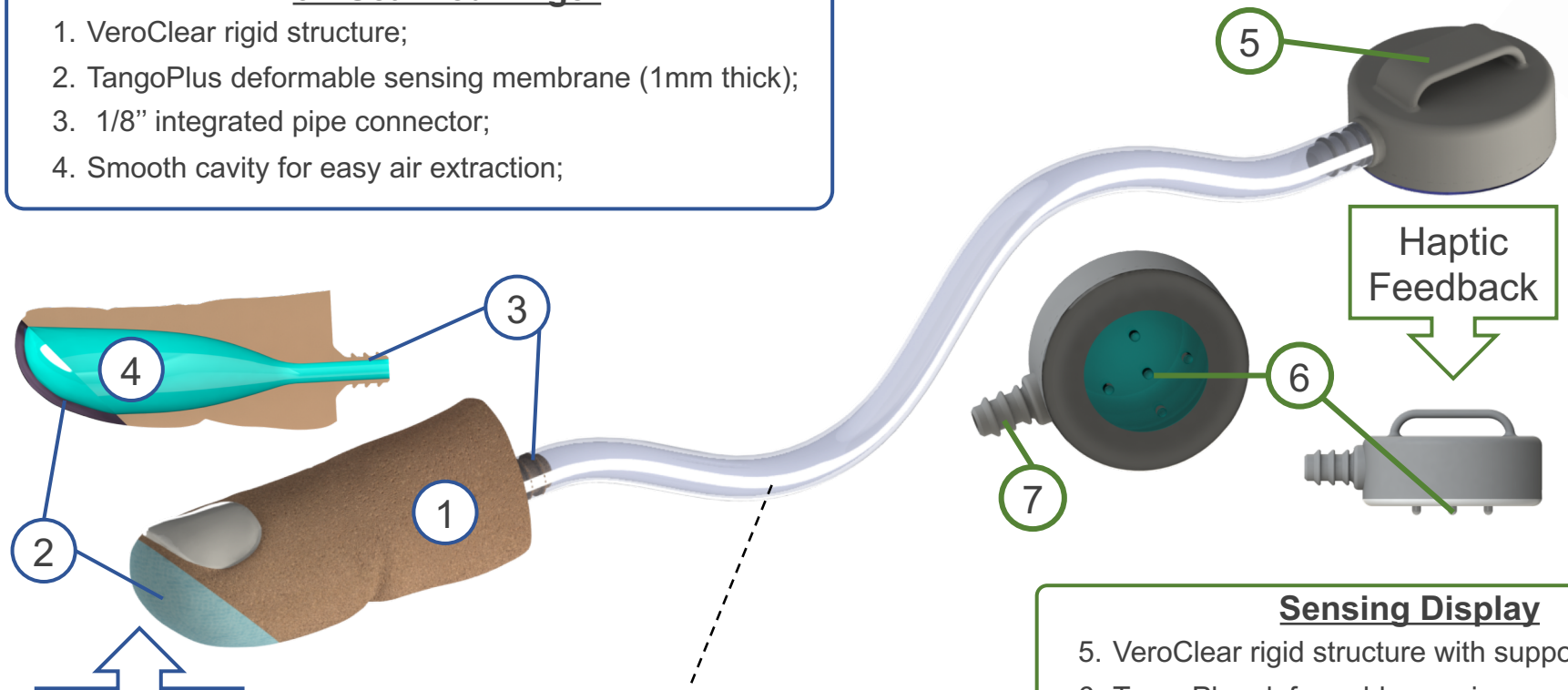
Hydraulic haptic feedback for prosthetic upper limb

Dr Helge Wurdemann, University College London
h.wurdemann@ucl.ac.uk | helge-wurdemann.com

- purely mechanically-driven
  (no need for batteries or other electronic components)
- ➢ extremely light and low-cost

3D Scanned Finger

1. VeroClear rigid structure;
2. TangoPlus deformable sensing membrane (1mm thick);
3. 1/8'' integrated pipe connector;
4. Smooth cavity for easy air extraction;

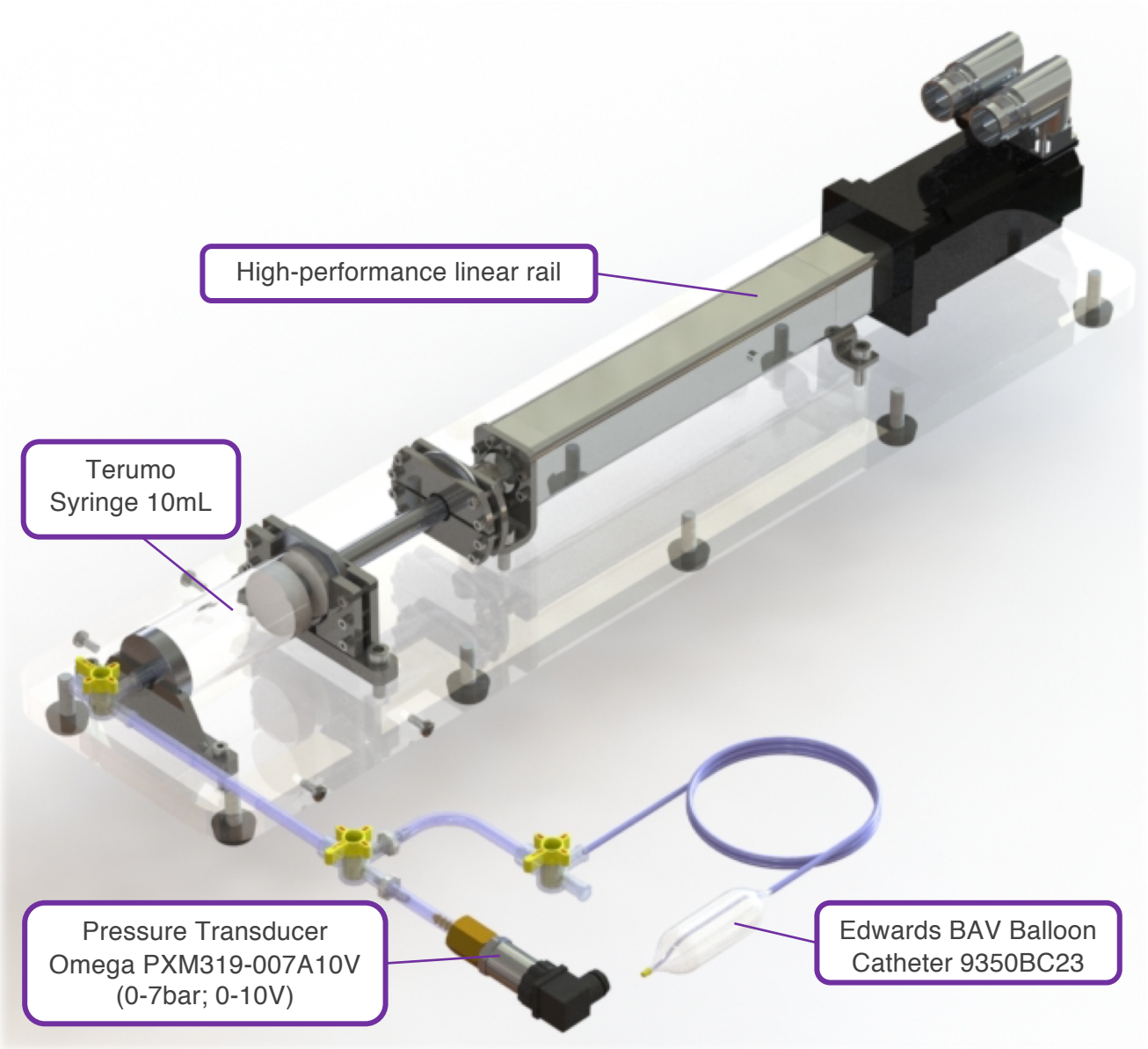


Sensing Display

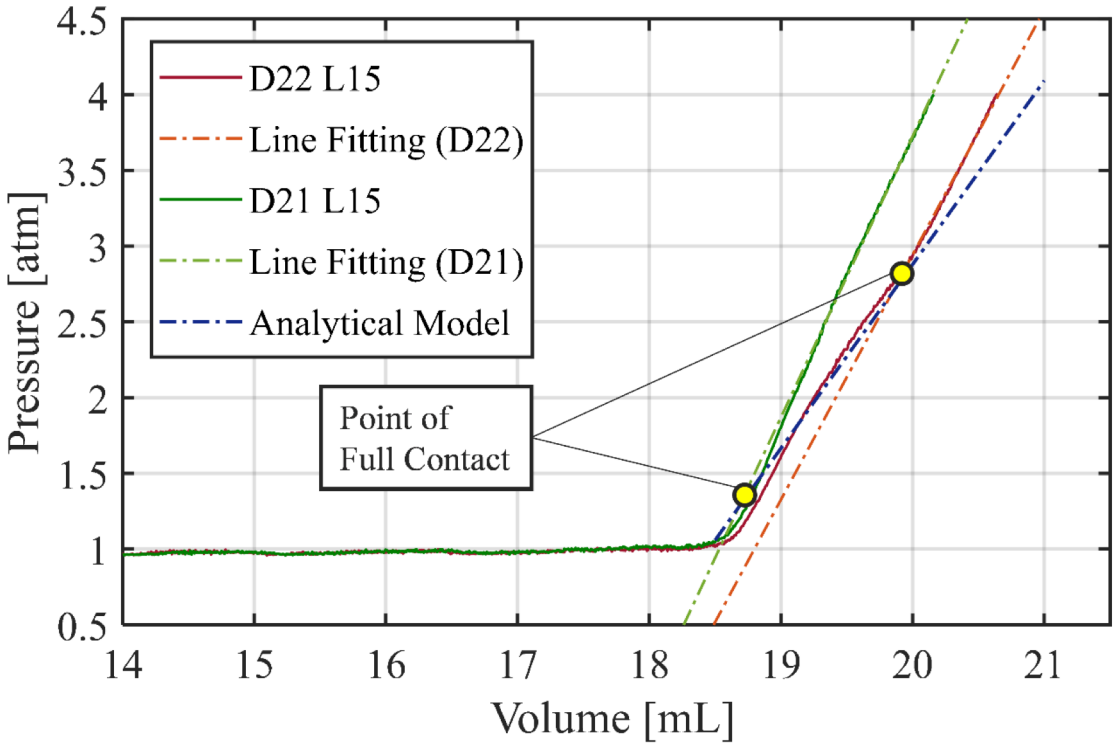
5. VeroClear rigid structure with support for velcro;
6. TangoPlus deformable sensing membrane (0.8mm thick) with pins for enhanced sensation;
7. 1/8'' integrated pipe connector;

Understanding vessel properties from p-v curves

Dr Helge Wurdemann, University College London
h.wurdemann@ucl.ac.uk | helge-wurdemann.com

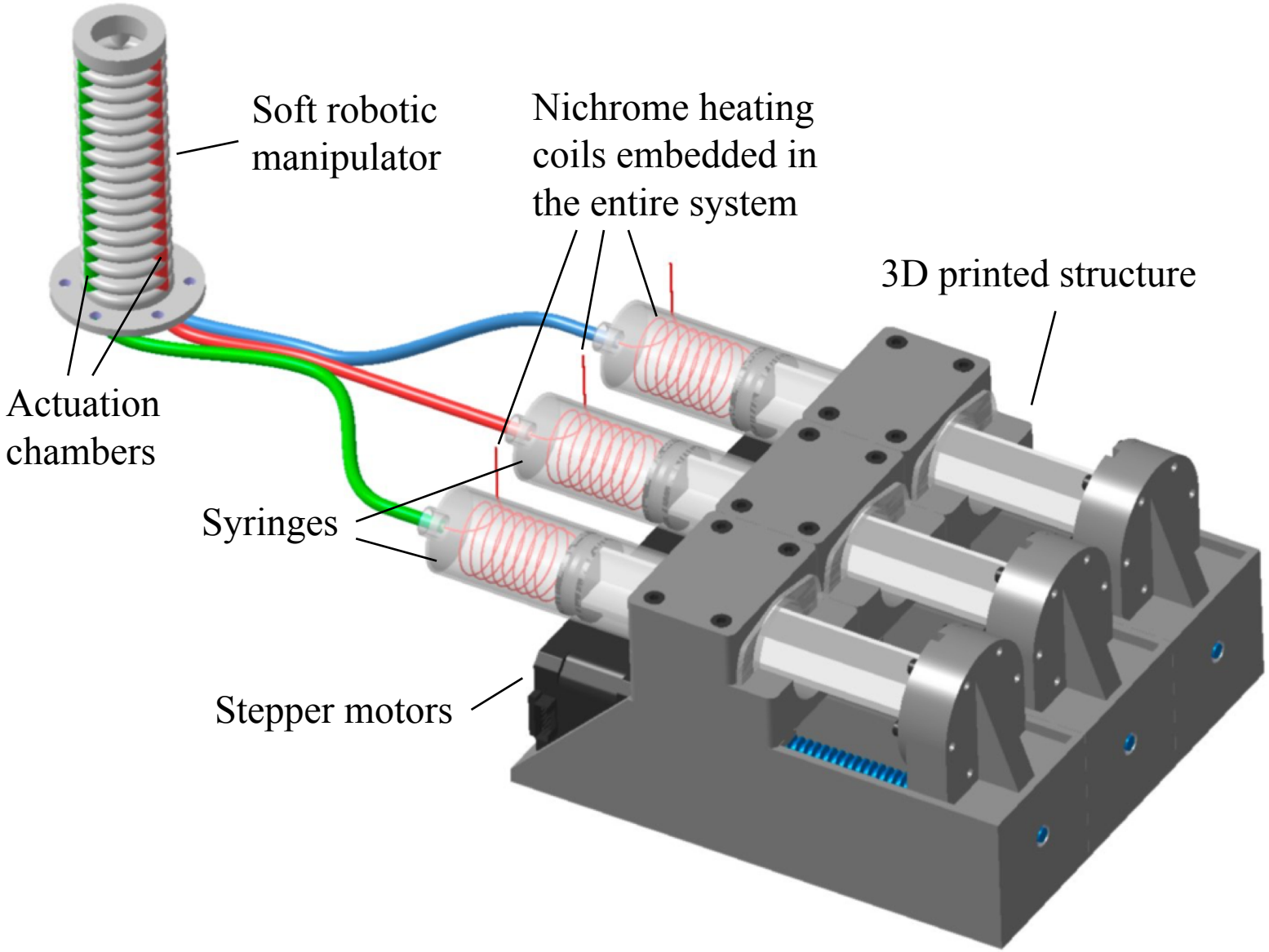


The aim of the project is to develop a valvuloplasty robotic balloon catheter, capable of determining the size and the mechanical properties of the aortic annulus from intra-balloon volume and pressure measurements.



Actuation/stiffening of soft robots with low melting point material

Dr Helge Wurdemann, University College London
h.wurdemann@ucl.ac.uk | helge-wurdemann.com



The aim of the project is to develop an actuation system that allows to use low melting point material to actuate soft robotic manipulators.

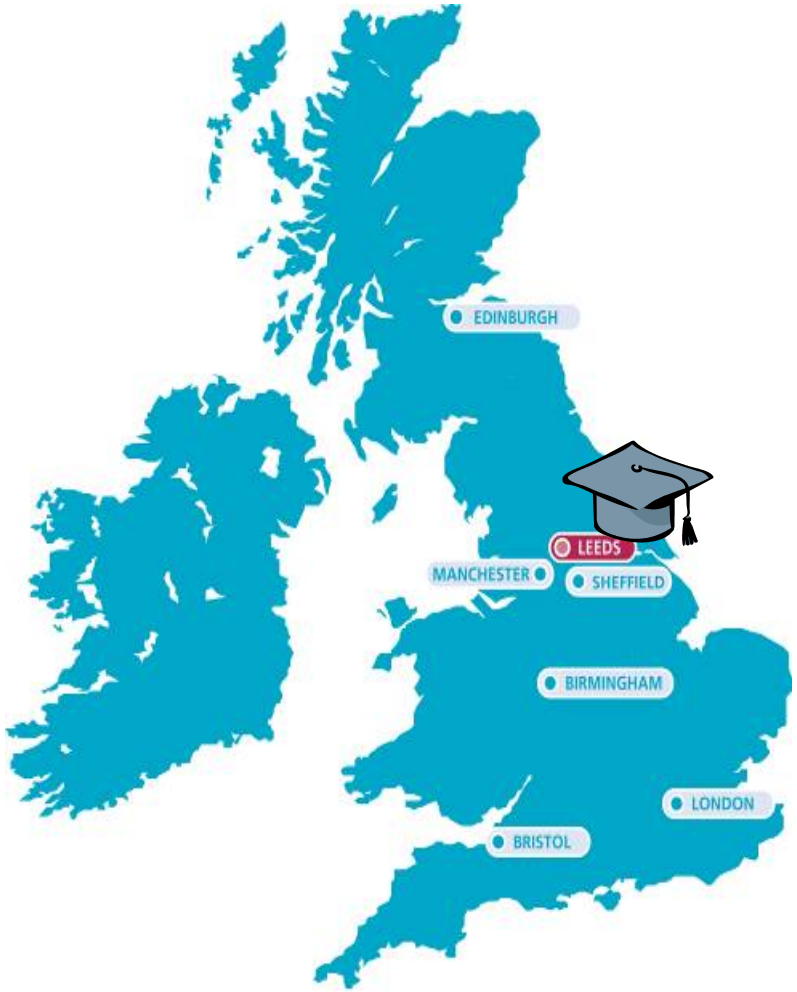
This project will consider wax and alloy material that will liquefy at about 50°C. Integrated nichrome wires will allow to control the temperature inside the robotic actuation system and the actuation chambers.

Life in Leeds

FACULTY OF ENGINEERING

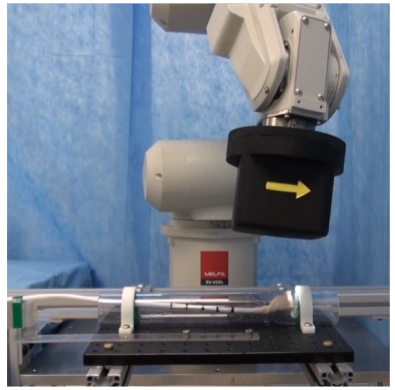
- A vibrant and multicultural student city that is home to 100 nationalities and over 200,000 students
- Yorkshire is voted the **happiest place** in the UK and one of the best travel destinations by World Travel Awards
- One of the UK's main financial and business centres outside of London

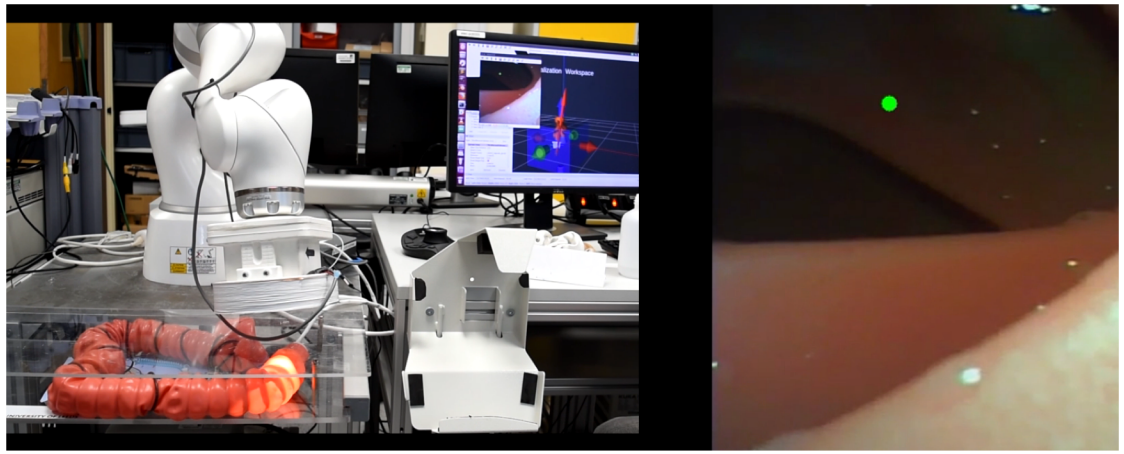
- **University of Leeds**
  - Established in 1904, the University of Leeds is one of the UK's largest universities
  - 31,000 students from over 146 countries
  - Top 100 (87) in QS World University Ranking (2016)
  - Top 10 for research power in the most recent Research Excellence Framework (REF)



Magnetic tethered capsule for painless autonomous colonoscopy

Main goal of the project:
semi autonomous colonoscopy





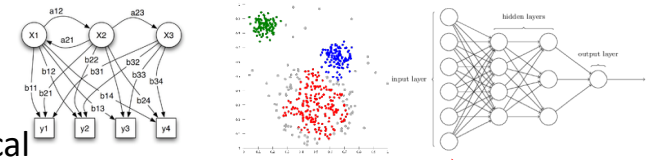
Available projects for master students:

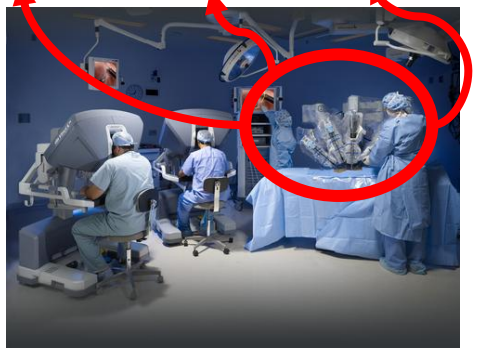
- MPC path planning and control of the capsule motion
- Development of a high-level strategy for autonomous locomotion
- Autonomous biopsy
- Nonlinear dynamic control – capsule levitation
- Robot/clinician collaboration: integration of external vision system and user interface

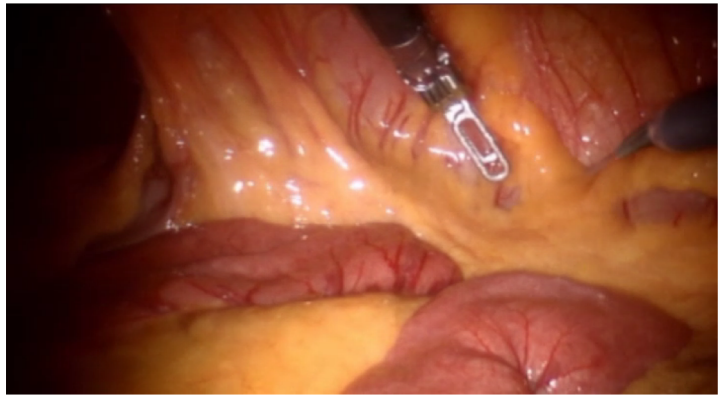
Dataset Retrieval and Validation on da Vinci Research Kit

Objectives:

- Retrieve data from surgeons trial on human cadavers for automation of surgical tasks
- Building the first dataset for analysis and assessment of surgical gestures on human trials





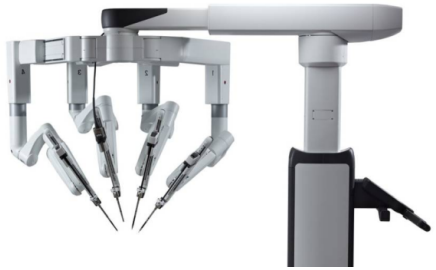


Requirements:

- Programming skills (C++, Python)
- Basic knowledge in Machine Learning (Neural Networks, Hidden Markov Models)

Personal achievements:

- Work in collaboration with clinicians
- Learn how to build a public dataset

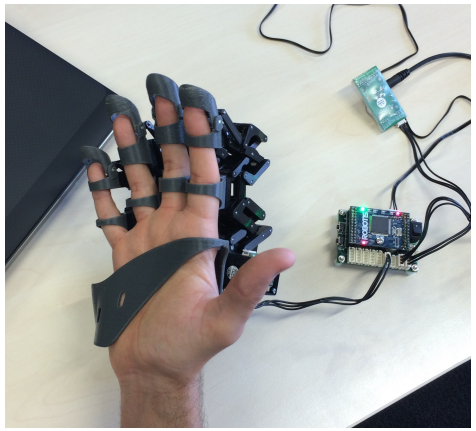


University of Leeds

Develop a *tele-operation* system with *haptic feedback* integrating a bespoke upper body *exoskeleton* and a COTS cobot from the ground up.

Using ROS and the existing control software for the two systems the candidate will develop the low level controllers to achieve low-latency control of the arm dynamics. The system will provide life-like haptic feedback to enable minimally-trained operators to perform complex tasks precisely and accurately.

The successful candidates will join the Robotics, Mechanisms & Structures Team in the Brussels office.



Qualifications

- Good programming skills level (C++ or Python)
- Hands-on experience in robotics
- Experience with ROS & MoveIt will be considered as an asset
- Excellent written and spoken English.

Tasks and Responsibilities

- Real-time control
- High fidelity haptic feedback.

What Do We Offer?

- A 6 months' internship
- An experience in the space industry
- A monthly Lump Sum Allowance.

Space Applications Services NV/SA is an independent Belgian company founded in 1987, with a subsidiary in Houston, USA.

www.SpaceApplications.com

Development of a novel angular sensor for medical tracking systems

- The goal of this project is to design, realize and characterize an innovative angular sensor.

Description

- The flagship project MIRACLE (https://miracle.dbe.unibas.ch/), short for Minimally Invasive Robot-Assisted Computer-guided LaserosteotomE, aims to develop a robotic endoscope to perform contact-free bone surgery with laser light.

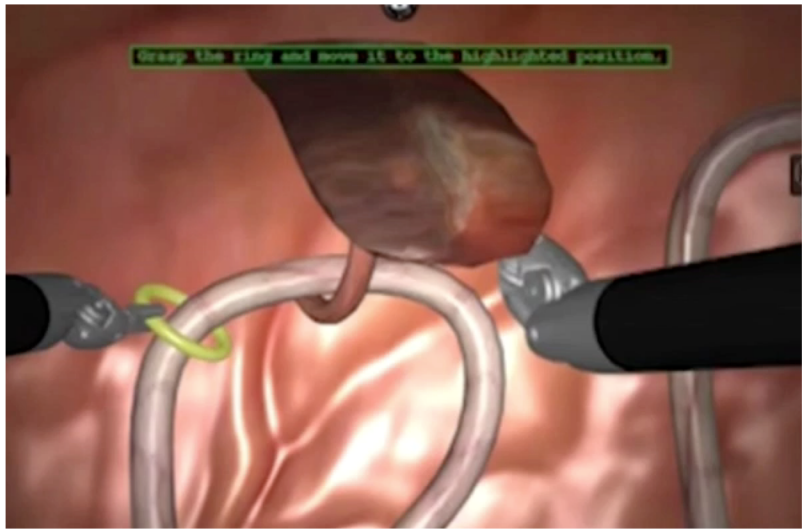
- Laserosteotomy offers several advantages over conventional mechanical bone surgery such as precise and small cuts based on pre-operative planning, functional cut geometry (so-called smart cuts), accelerated healing, and less trauma.

University of Basel

Italy and @Milan

Development of a deformable anatomical model for simulation of laparoscopic surgery

The aim of this project is the development of a framework where the user can interact with a deformable model of the anatomy through virtual da Vinci instruments, for simulation purposes.
Either the SOFA framework[1] or NVIDIA FleX[2] will be used to obtain the deformations.



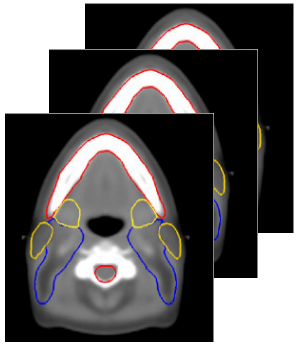
We'll be happy to welcome students at ALTAIR lab in Verona
http://metropolis.scienze.univr.it/altair/

For further information: *eleonora.tagliabue@univr.it*

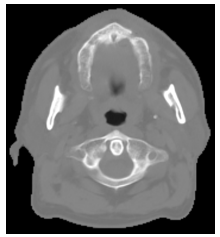
[1] https://www.sofa-framework.org/
[2] https://developer.nvidia.com/flex

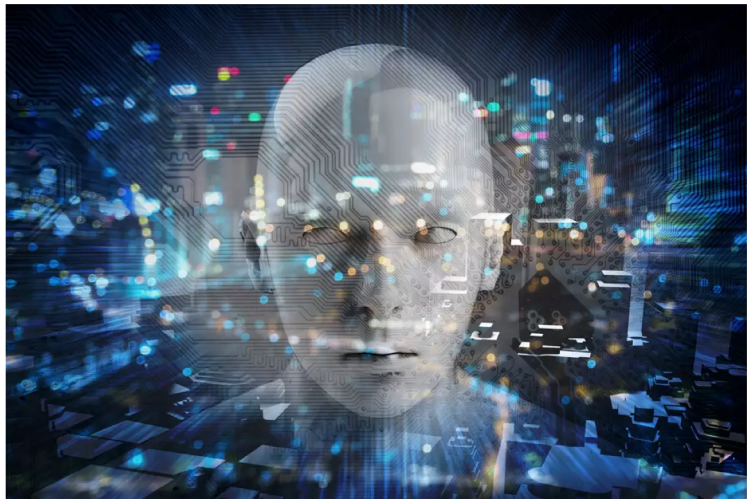
Predict segmentation accuracy only by looking to anatomical images: a dream for clinicians!

N atlases
(already contoured patients)



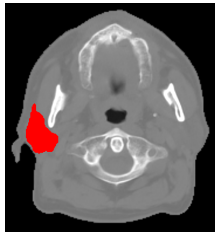
Patient





Accuracy atlas #1 = 0.80
Accuracy atlas #2 = 0.73
Accuracy atlas #3 = 0.85
…
Accuracy atlas n = 0.77

Best possible segmentation

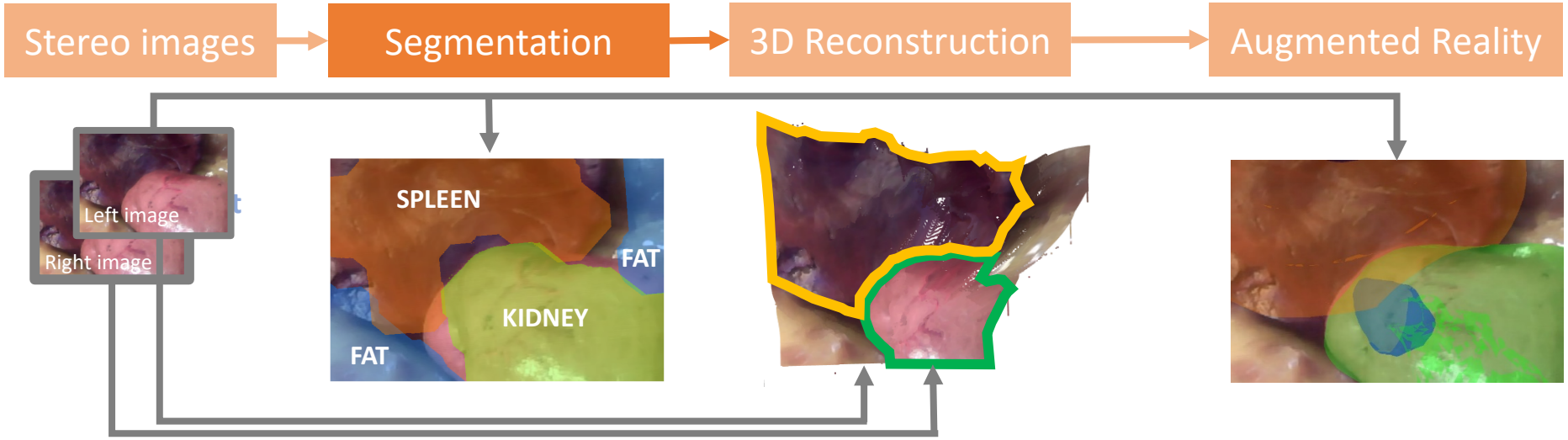


UMG
Dubium sapientiae initium

Surgical Scene Semantic Segmentation

Augmented Reality (AR) tools in combination with robotic systems, can greatly help in enhancing the surgeons' capabilities during Minimally Invasive Surgery (MIS), providing direct patient and process-specific support to surgeons with different degrees of experience.
The awareness of the surgical scene plays a fundamental role in an AR system, allowing to discriminate the position of different tissues and instruments at run-time.

This project will be focused on developing a **real time and accurate semantic segmentation of the surgical scene**, exploiting deep learning techniques [1][2].



[1] Chen, Liang-Chieh, et al. "Deeplab: Semantic image segmentation with deep convolutional nets, atrous convolution, and fully connected crfs." *IEEE transactions on pattern analysis and machine intelligence* 40.4 (2018): 834-848.
[2] Bernal, Jorge, et al. "Comparative validation of polyp detection methods in video colonoscopy: results from the MICCAI 2015 Endoscopic Vision Challenge." *IEEE transactions on medical imaging* 36.6 (2017): 1231-1249.

Veronica Penza
veronica.penza@iit.it

ISTITUTO ITALIANO DI TECNOLOGIA

Declarative Reasoning over Ontologies and Big Data

- Department of Mathematics and Computer Science, University of Calabria, Italy and DLVSystem Ltd, Italy
- Collaborations with TU Vienna, Oxford University, Uni Klagenfurt, and more
- Contacts: francesco.calimeri@unical.it; simona.perri@unical.it

- ACLLMPRVZ, "*The AI System DLV: Ontologies, Reasoning, and more*", 10th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2018), Seville Spain 18-20 September 2018

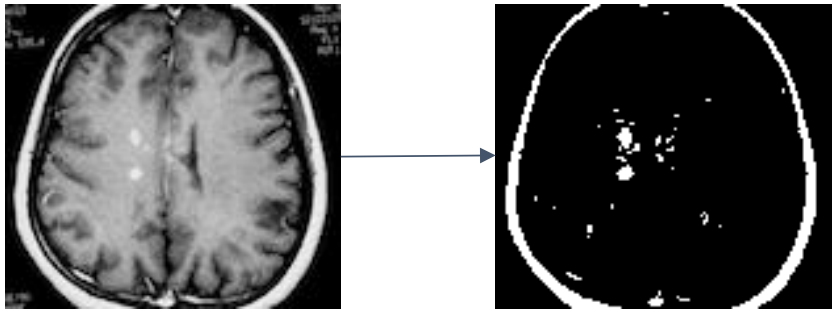
DLVSYSTEM S.R.L. SPIN-OFF OF UNIVERSITY OF CALABRIA

UNIVERSITÀ DELLA CALABRIA

UNIVERSITÀ DELLA CALABRIA

Department of Mathematics and Computer Science

Multiple Sclerosis Lesion Segmentation using Autoencoder Neural Networks



Related works:

F. Calimeri, A. Marzullo, C. Stamile, G. Terracina, “Graph Based Neural Networks for Automatic Classification of Multiple Sclerosis Clinical Courses," forthcoming in European Symposium on Artificial Neural Networks, Computational Intelligence and Machine Learning (ESANN), 2018

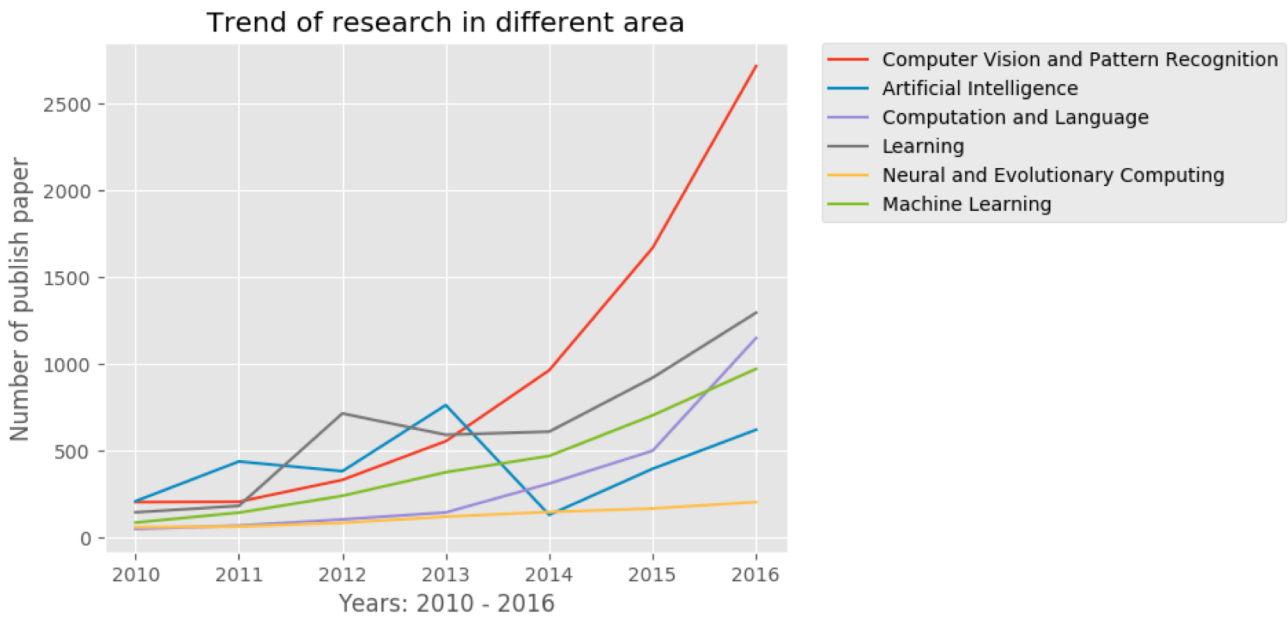
F. Calimeri, A. Marzullo, C. Stamile, G. Terracina, “Biomedical Data Augmentation using Generative Adversarial Neural Networks," 26th International Conference on Artificial Neural Networks (ICANN), 2017

F. Calimeri, A. Marzullo, C. Stamile, G.Terracina, ”Optic Disc Detection using Fine Tuned Convolutional Neural Networks," In IEEE 12th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS), pp. 69-75, 2016

{calimeri, marzullo}@mat.unical.it

Other possible topics

- **Human robot interaction** (Università Federico II, Napoli, IIT Genova)
- **Focussed US** (SSSA)
- **Machine learning in computer vision** (Università Politecnica delle Marche, Ancona)



@Nearlab MRS

Brain arteries and veins segmentation from CE-CBCT datasets for Pre-Operative Planning

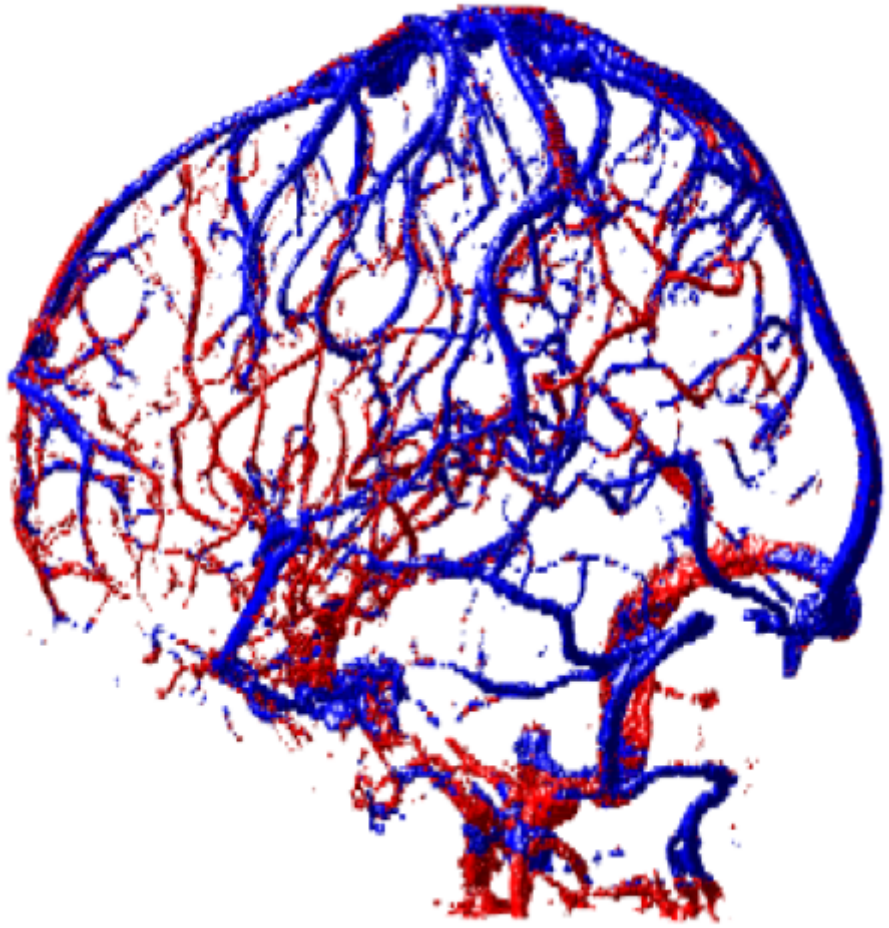
Objective:
Brain arteries and veins segmentation

Clinical application:
Several neurosurgical intervention require accurate pre-operative planning to avoid brain damages and bleeding.

Main tasks:
- **Deep Learning** approaches for pre-processing data
- **CBCT reconstruction** methods for arteries and veins separation;

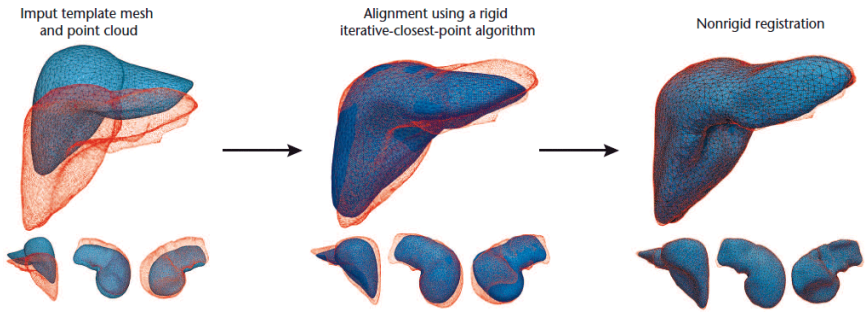
Collaboration:
Niguarda, Centre for epilepsy and parkinson surgery;
Medtronic, Littleton, Boston

Contact: sara.elhadji@polimi.it

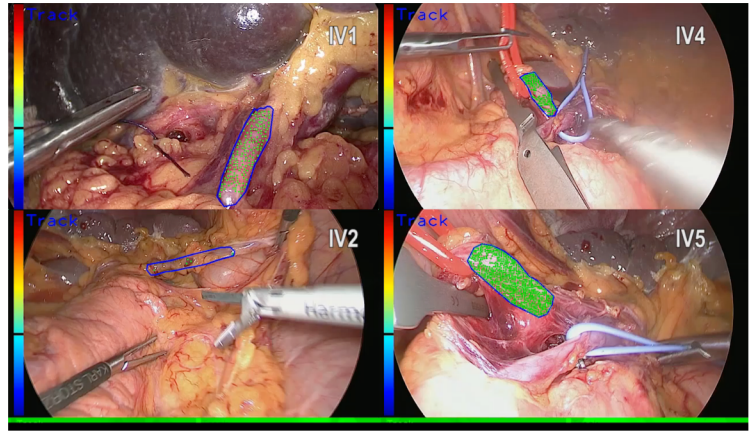


- Robot camera calibration

- Deformable registration



- Soft tissue detection and tracking



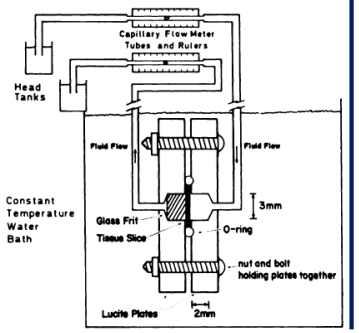
http://www.smartsurg-project.eu/

Hydraulic Permeability

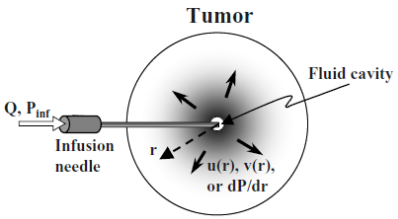
Problem: measure white matter **hydraulic permeability** experimentally on **fresh brain tissue**
Why: computational model validation
How: Darcy's law

State of the art:

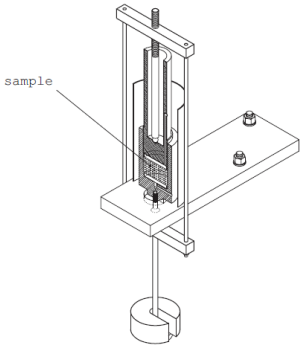
Swabb et al, 1974



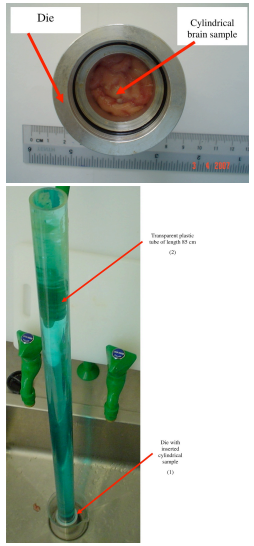
Mc Guire et al, 2006



Franceschini et al, 2006



Tavner et al, 2016



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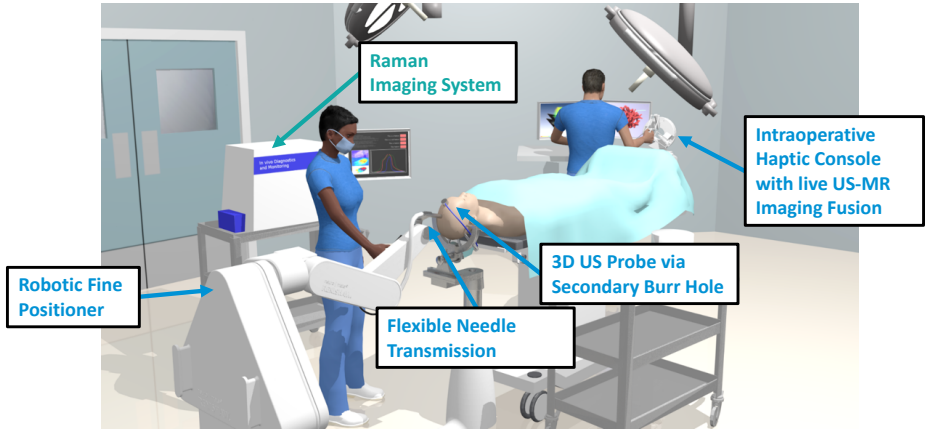
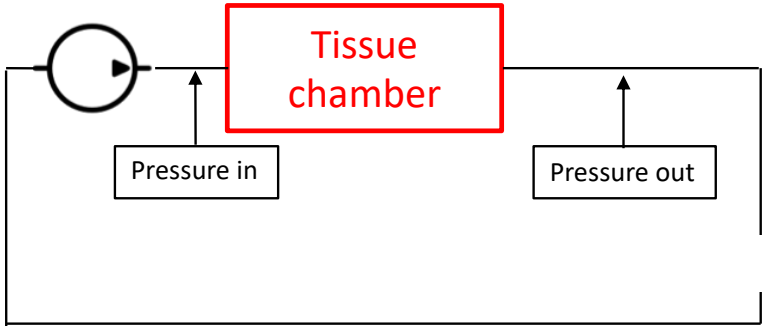
- x Not reliable
- x Indirect measurement methods
- x Strong a priori hypotheses

AIM: design the hydraulic circuit and the Tissue Chamber

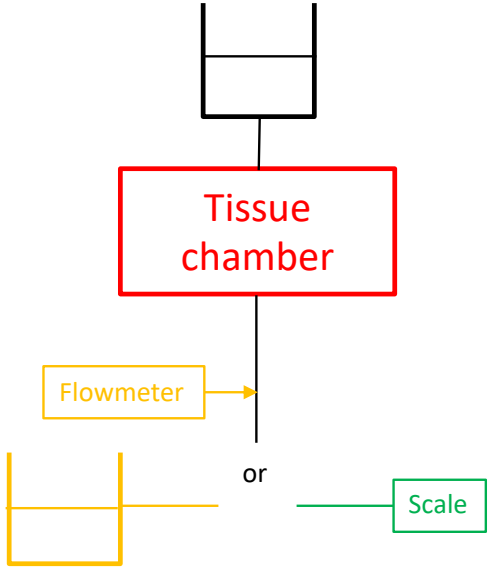


Flow rate controlled



OR

Pressure controlled

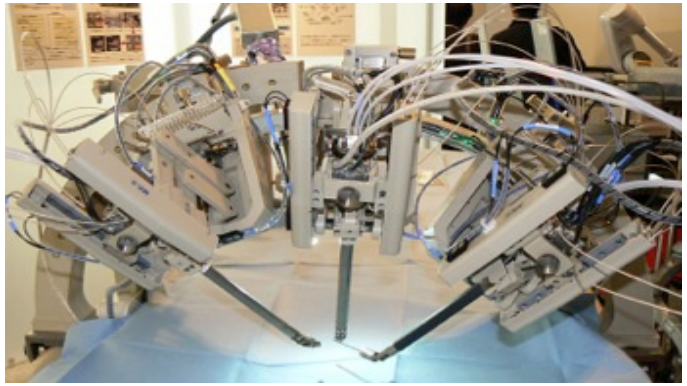


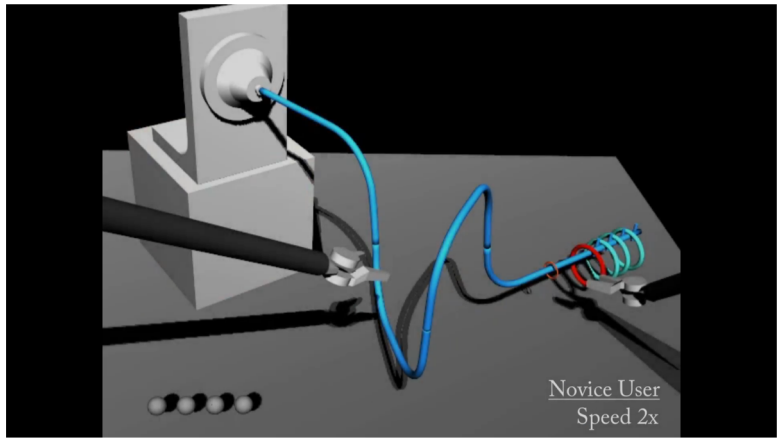
Collaborations

- Biomechanics Group Laboratory (Polimi)
- Imperial College London

Contact information:
marco.vidotto@polimi.it

Adaptive training (with ML) for robotic surgery

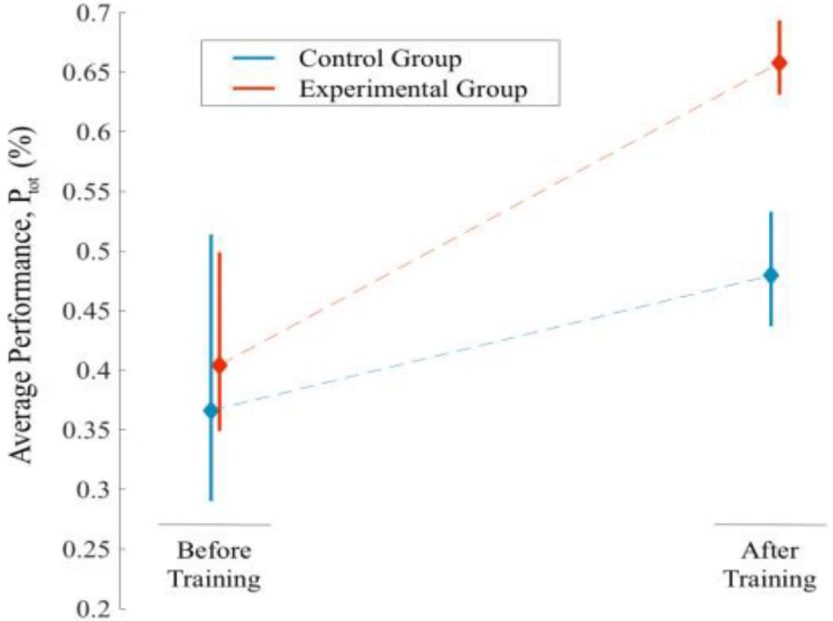




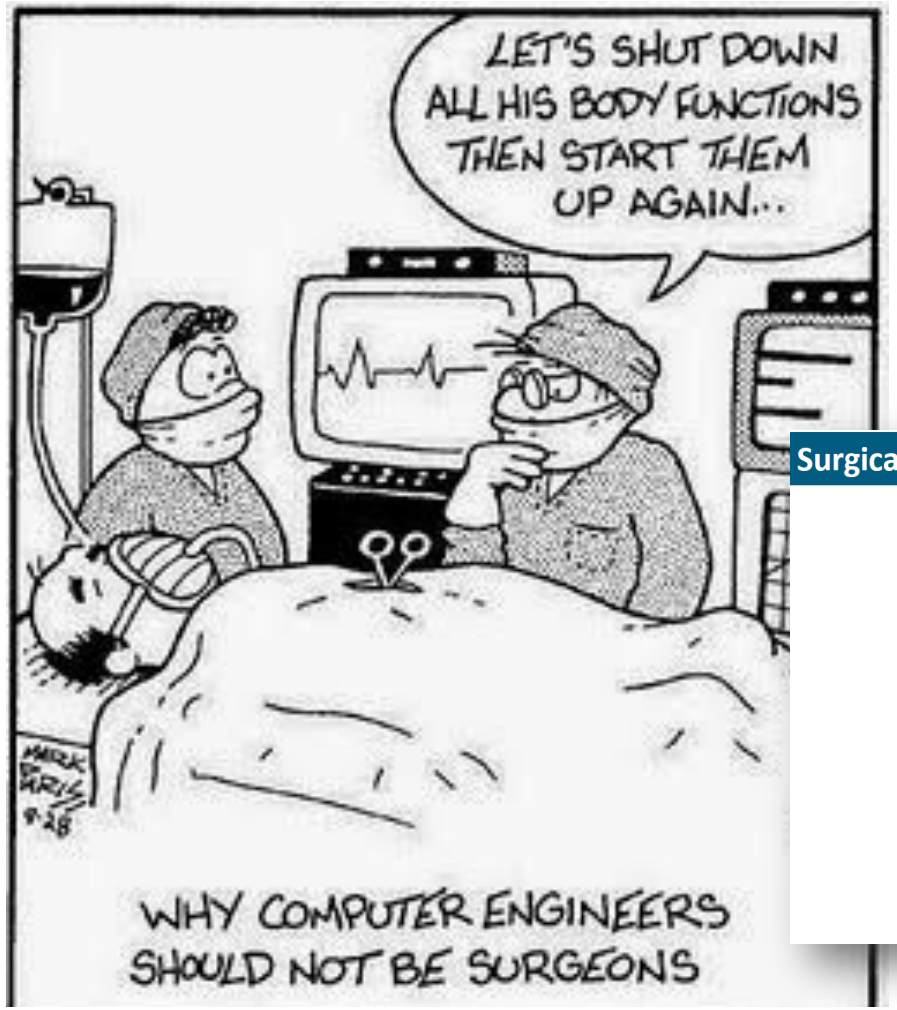
Aim:

To develop an **adaptive training paradigm** for surgical task, tailoring the exercise to elicit needed motor control capabilities to the user.

Machine learning techniques will allow the design of a personalized training schema.



http://nearlab.polimi.it/wp-content/uploads/2018/04/Mariani-Pellegrini.pdf



Thanks!

www.nearlab.polimi.it
@MRSNearlab
elena.demomi@polimi.it