

# Recent research results at the Antal Bejczy Center for Intelligent Robotics



Péter Galambos

INTERNATIONAL ERC & BEJCZY DAY 2017



## Main goals

- Participation in high-end robotics R&D projects
- Managing university projects and robotics education
- Building a strong international network
- Publication of world class research results

## Background

- Founded in 2012, Lab opened in 2014
- 15 members
- Unique robot infrastructure
- Industrial and professional background
- Strong student community
- Notable international events



## **Emeritus professors**

János Somló, János Bitó, László Horváth

## **Full professors**

Imre Rudas, József Tar

## **Associate professors**

Tamás Haidegger, Péter Galambos, Gábor Hegedűs, Péter Zentay

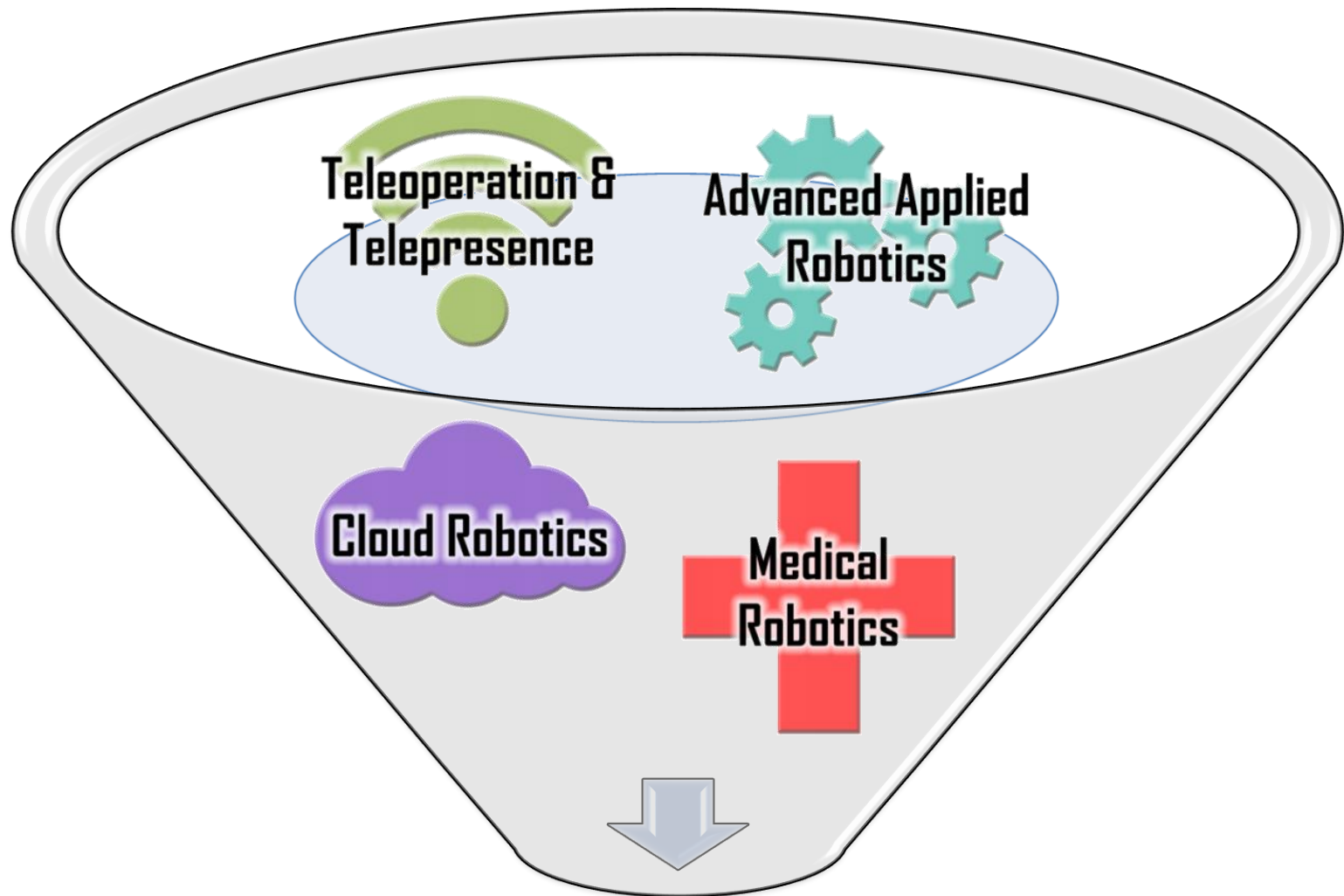
## **PhD students**

Árpád Takács, Dénes Ákos Nagy, Gergely Windisch, Renáta Elek  
József Kuti, Bence Takács, Péter Pausits, Gábor Szögi, Tamás Nagy

**Lab engineers** Tivadar Garamvölgyi, Sándor Tarsoly



# Research domains



**Industrial and Medical Cyber Physical Systems**



# Infrastructure

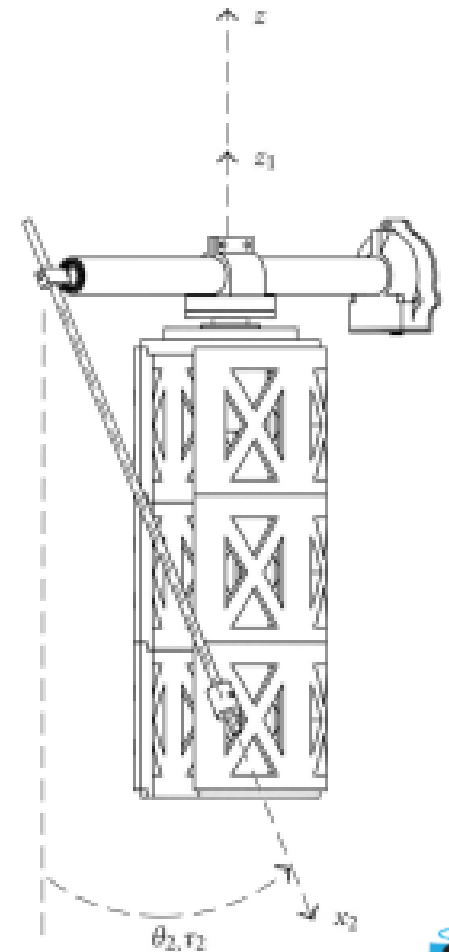




# RFPT-based Methods in Adaptive Dynamic Control

## Main results in the past years

- Stiffness control for robotic arm
- Adaptive control of underactuated systems: 2DoF pendulum, Kapitza Pendulum, Furuta pendulum
- Performance improvements of fuzzy controllers
- Adaptive inverse kinematics for redundant robot arms
- RFPT-based parameter tuning

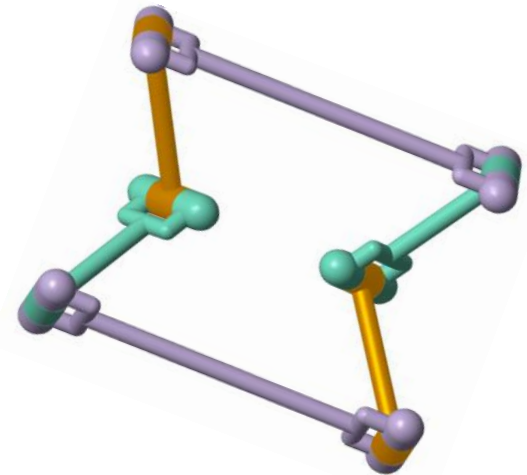


Principal investigator: **József Tar**



# Kinematics – closed linkages

Principal investigator: **Gábor Hegedűs**



- New 6R linkages were constructed
- An upper bound was given for the genus of a coupler curve of a movable 6R linkage
- All spatial movable closed 5R linkages were classified
- Four-Pose Synthesis of Angle-Symmetric 6R Linkages
- Spatial straight line linkages by factorization of motion polynomial



**Goal is to provide an efficient mathematical toolset that**

- Generates polytopic representations of qLPV systems
- Makes direct connection to LMI, BMI etc. optimization methods
- Relax the conservativeness of the polytopic model based approaches
- Allows for the combination of various design objectives
- Hides the underlying complexity

Principal investigator: **József Kuti**



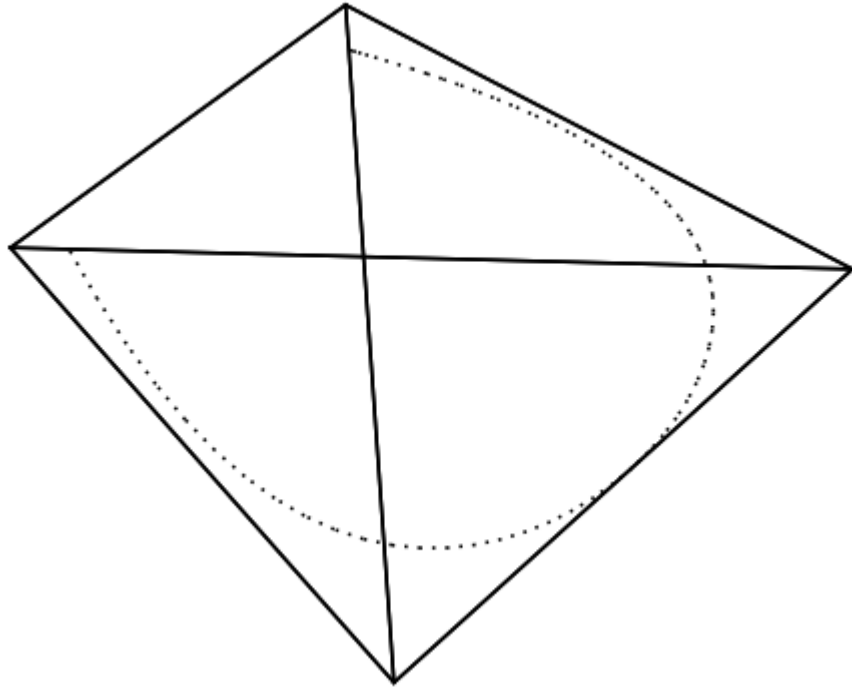


# Polytopic model-based multi objective control

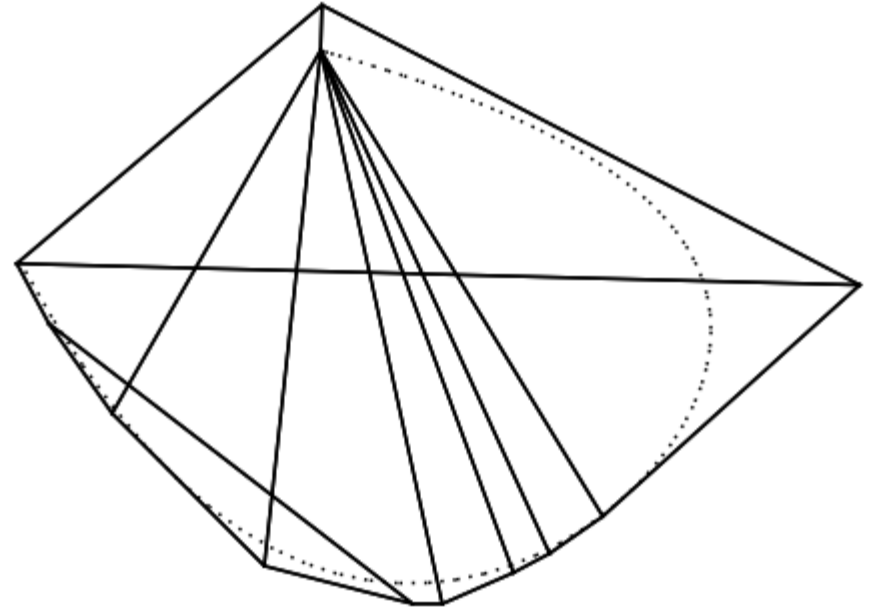
- **Generalization of polytopic TP modelling**
  - Handling polytopic uncertainty and gain scheduling (PDC)
- **Extension of Polytopic model-based synthesis methods**
  - Parameter separation only for scheduling variables
- **Introducing Affine TP Model Transformation**
  - Generalization of former approaches
  - Consolidates the derivation of Polytopic TP Models
- **New efficient numerical methods to obtain enclosing polytopes**
  - Minimal Volume Simplex enclosing polytopes
  - Manipulation of enclosing polytopes along problem specific constraints

Principal investigator: **József Kuti**





Minimal Volume Simplex  
enclosing polytope

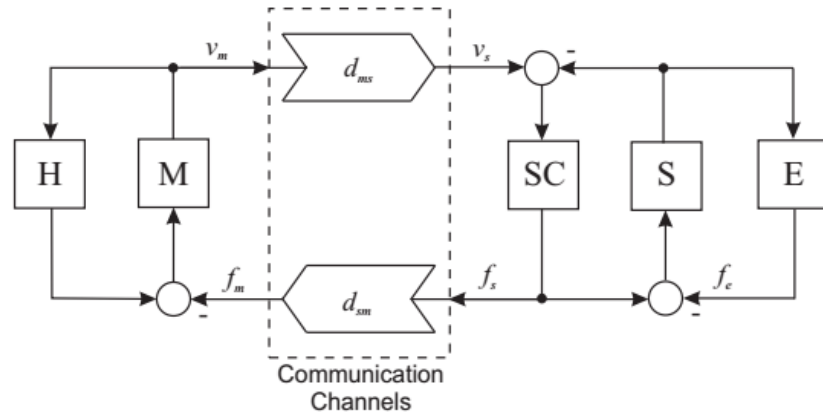


Non-simplex enclosing polytope

Principal investigator: **József Kuti**



# Teleoperation control



- Improved time-domain passivity controller
- Integration of Audio / Video / Haptics data with traffic control

Mobile Manipulator -  
Slave Side



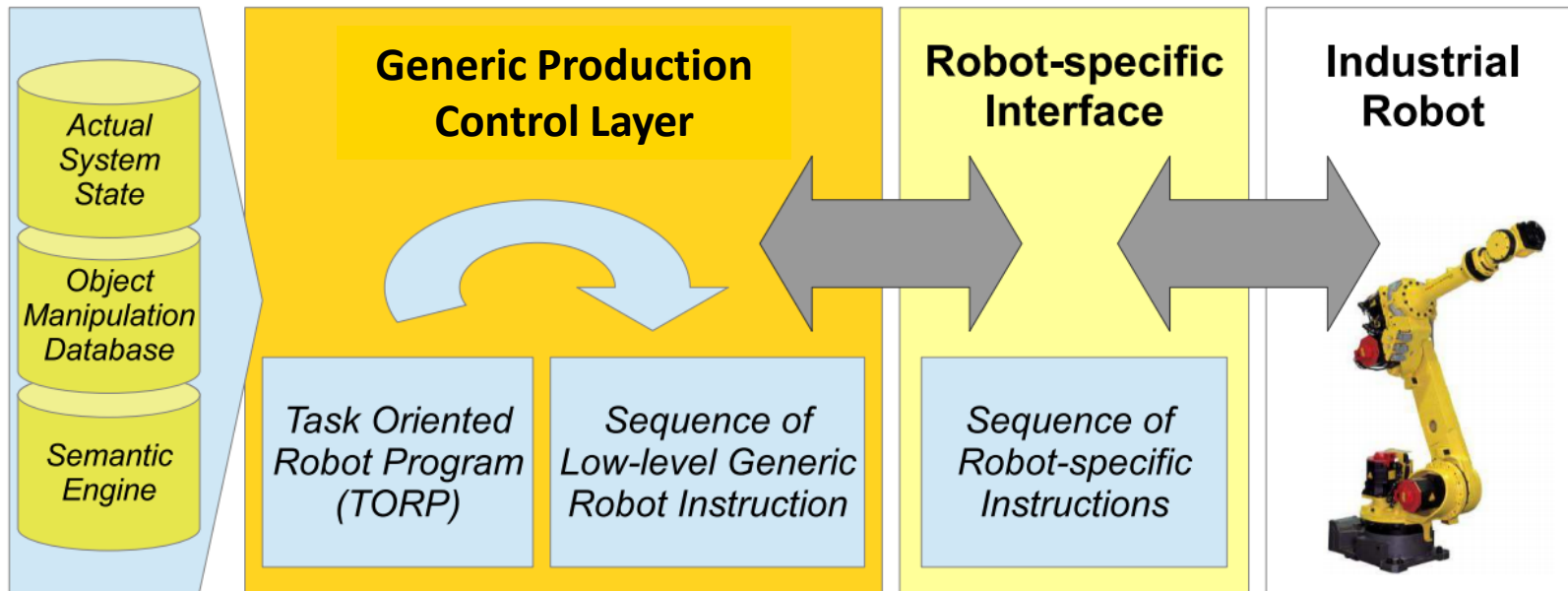
Video Camera View  
Master Side

Principal investigator: **Márton Lőrinc**



# Orchestration of production systems

- Unified robot (production device) representations
- Virtual Reality as generic information pool
- Integration of production process up to the ESB level
- Distributed control
- Modular software frameworks (ROS, RTM, etc.)



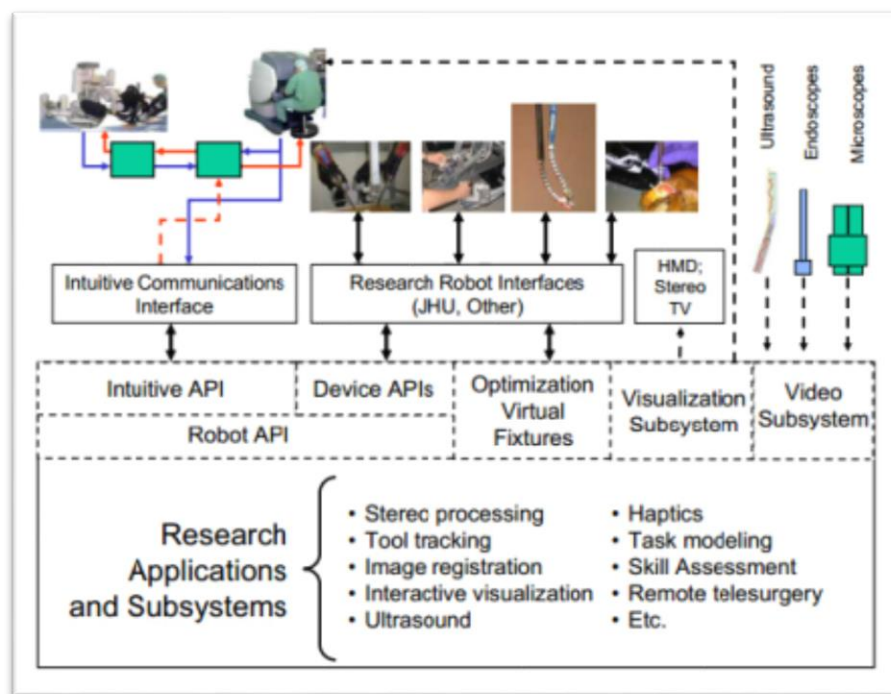
Principal investigator: **Péter Galambos**



## Da Vinci Surgical System Research Kit

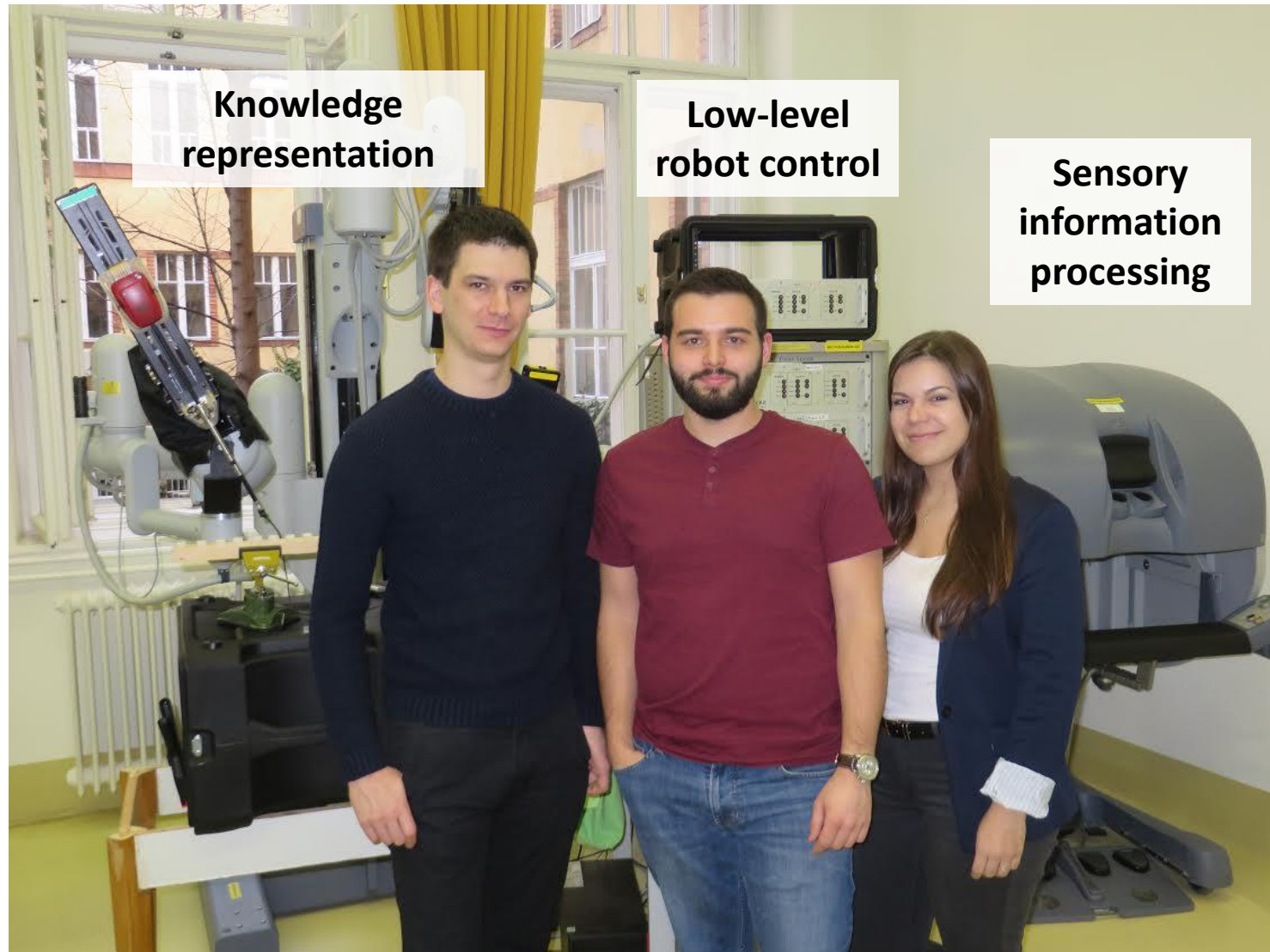
### Surgical Assistant Workstation (SAW)

- Developed by the Johns Hopkins University
- Research was founded by the National Science Foundation (NSF)
- Integration of different components of a robotic surgical system
- Using and reusing the elements in the system structure





# Surgical robotics – The team





# Improvements for MIS

- Integration of modern robotic applications into the current surgical workflows
- Ontology based task and subtask automation
- Soft tissue model validation
- Hardware extensions for enhanced and additional sensory inputs
- Surgical skill assessment



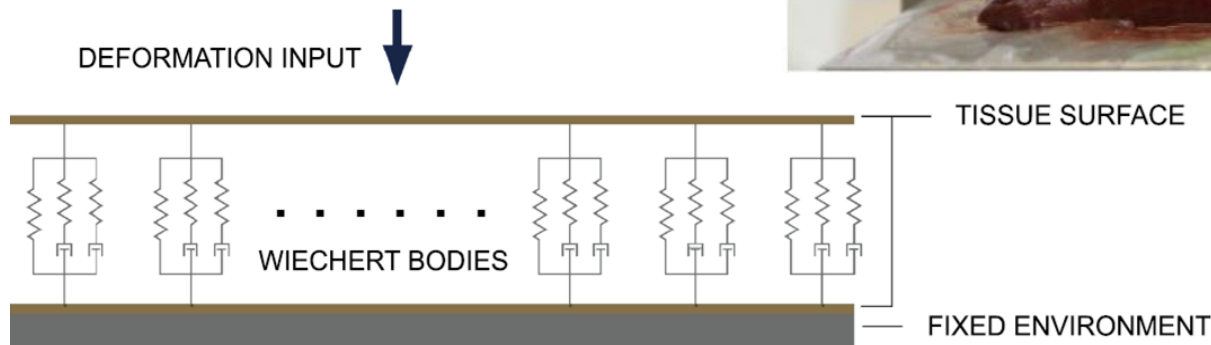
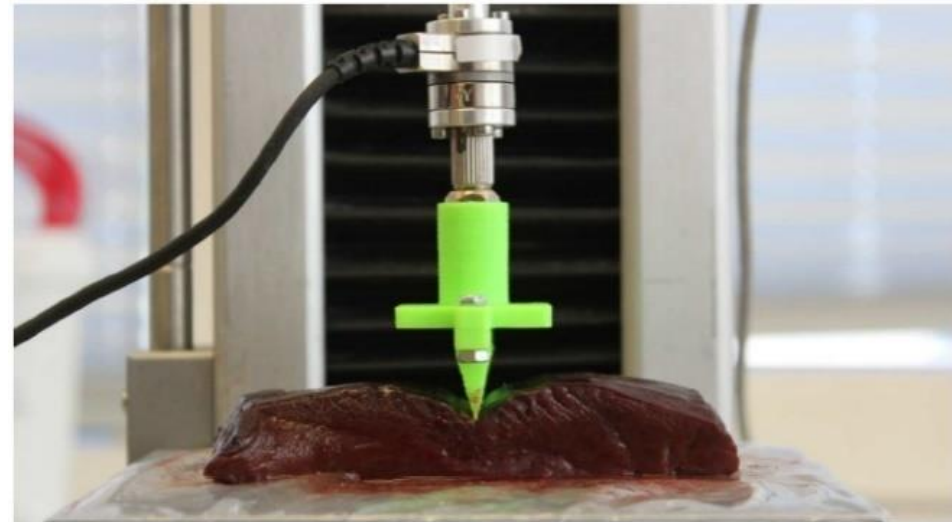
Courtesy of József Balatoni, MTI

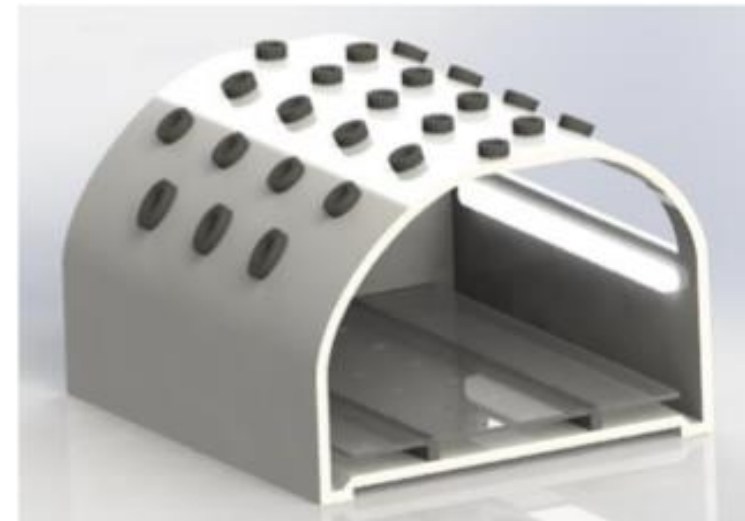
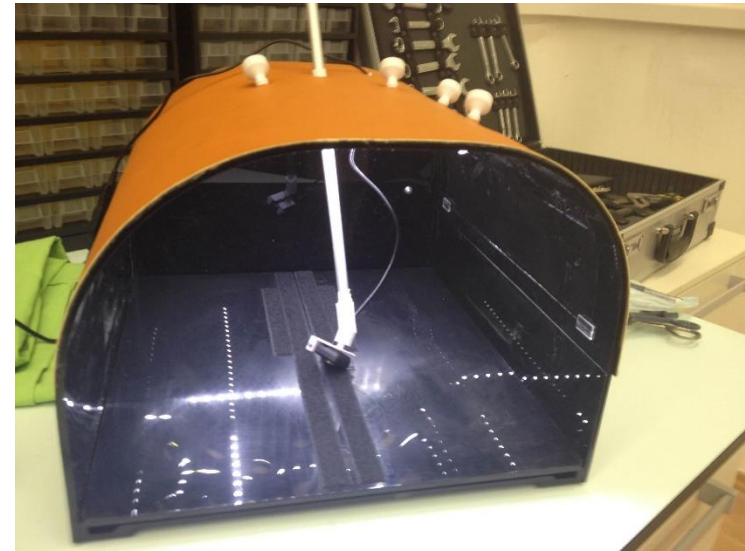


# Investigation of nonlinear tissue models in robotic applications

- Analyzing soft tissue behavior under manipulation tasks
- Creating a mechanical model for soft tissues and tool–tissue interaction
- Model verification and parameter estimation by curve fitting
- Implementation of model-based force control for time-delayed robotic systems

Principal investigator: **Árpád Takács**

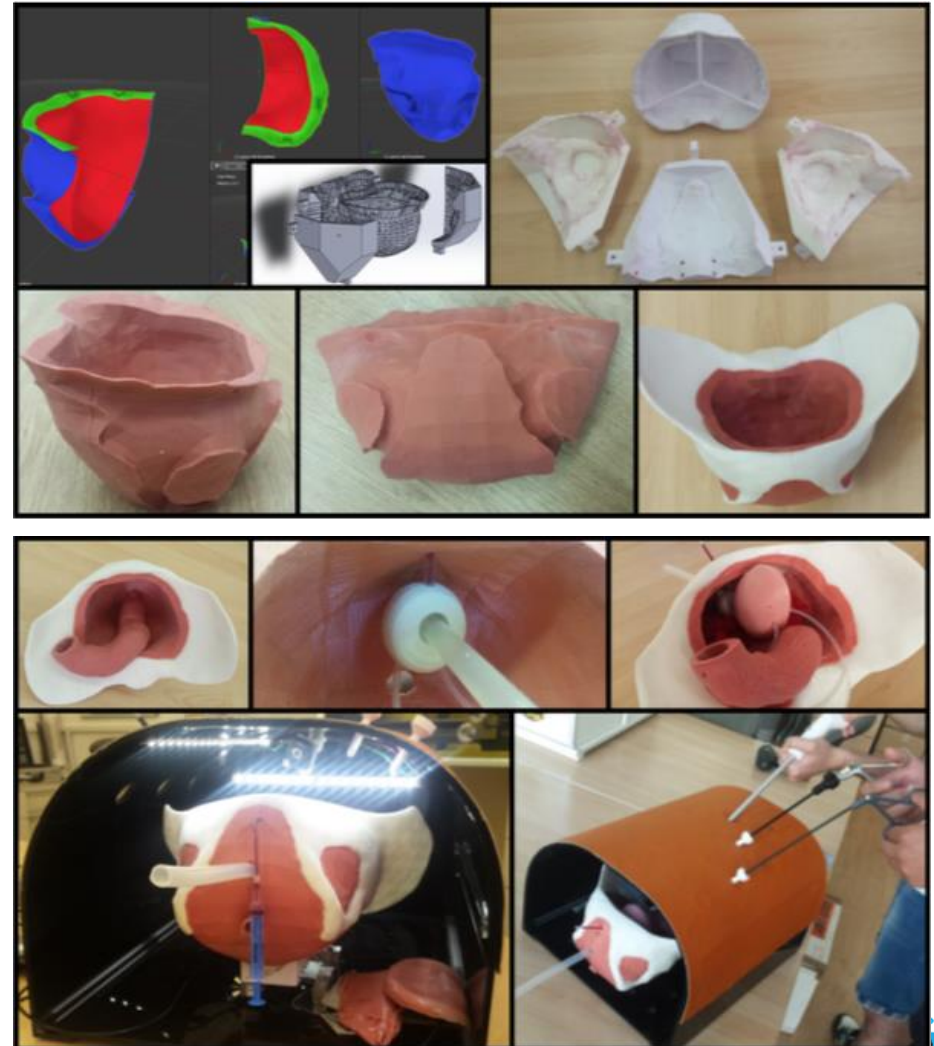




Principal investigator: **Szilvia Barta**



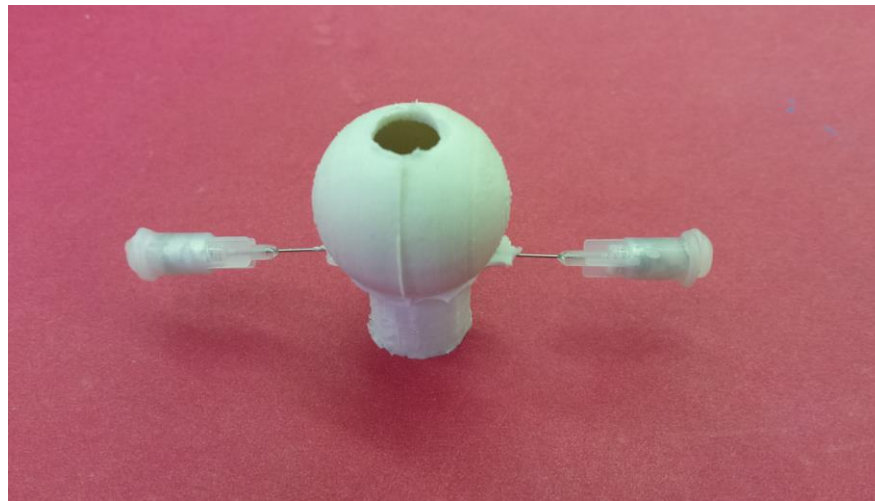




Principal investigator: **Illés Nigicser**

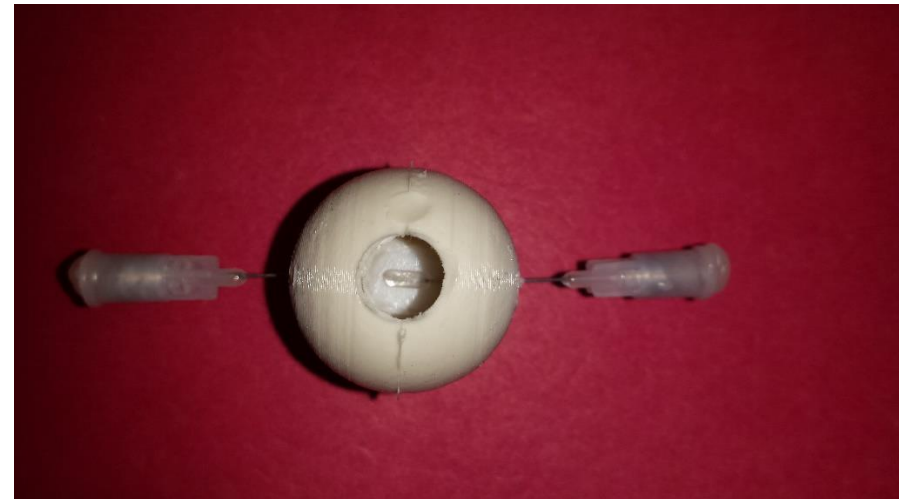
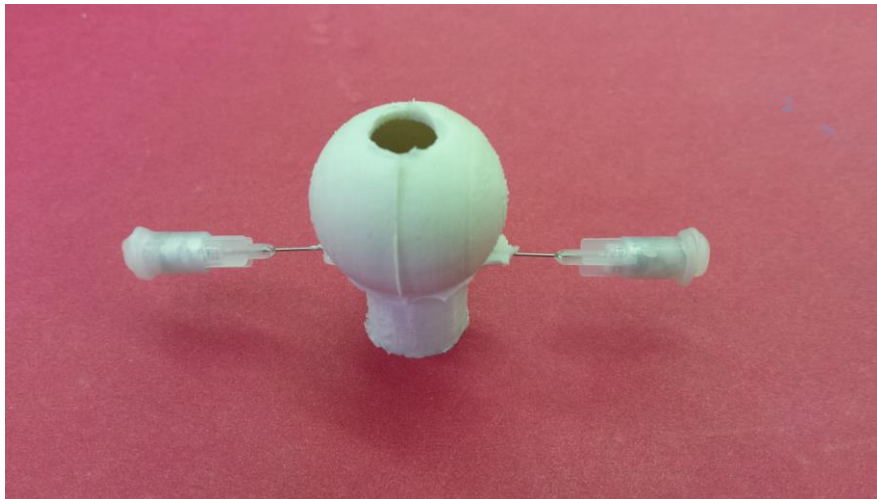
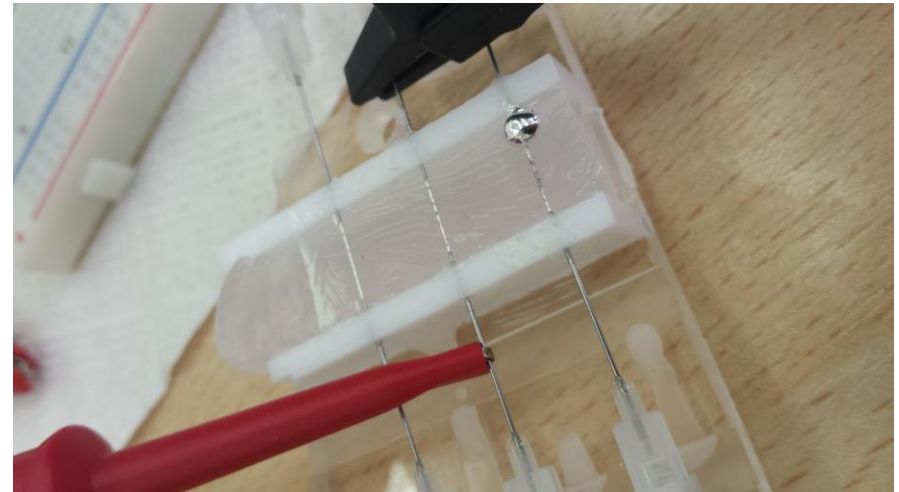
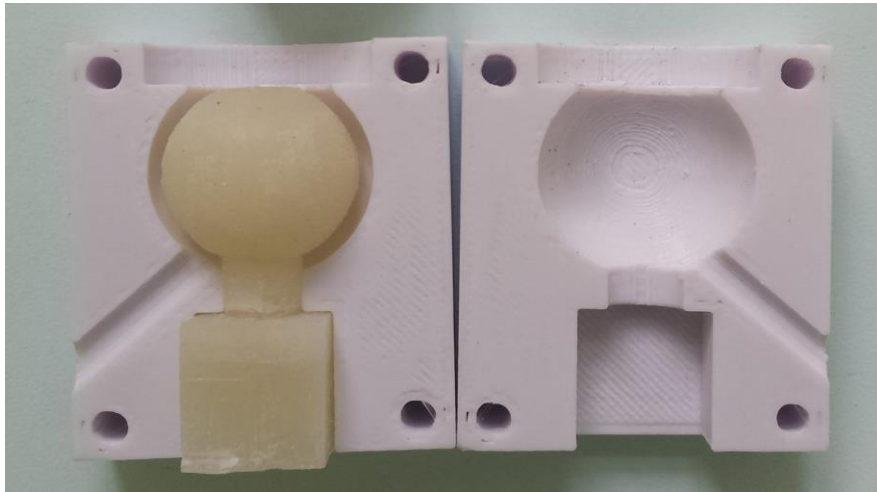


- Eye phantom for a specific **retinal vein cannulation surgery**
- **100  $\mu\text{m}$  diameter tube** in a silicone matrix representing a retinal vein
- This vein is filled with **gallium** representing blood in the vein
- **Gallium conducts electricity** and **stays liquid** at room temperature
- The needle is inserted into the silicon matrix towards the gallium vessel
- **Electric contact** through a monitoring circuit **signals successful cannulation**



# Eye Phantom (EurEyeCase)

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**Taking part in the EURATHLON competition**

[www.eurathlon.eu/site/index.php/compete/loan](http://www.eurathlon.eu/site/index.php/compete/loan)

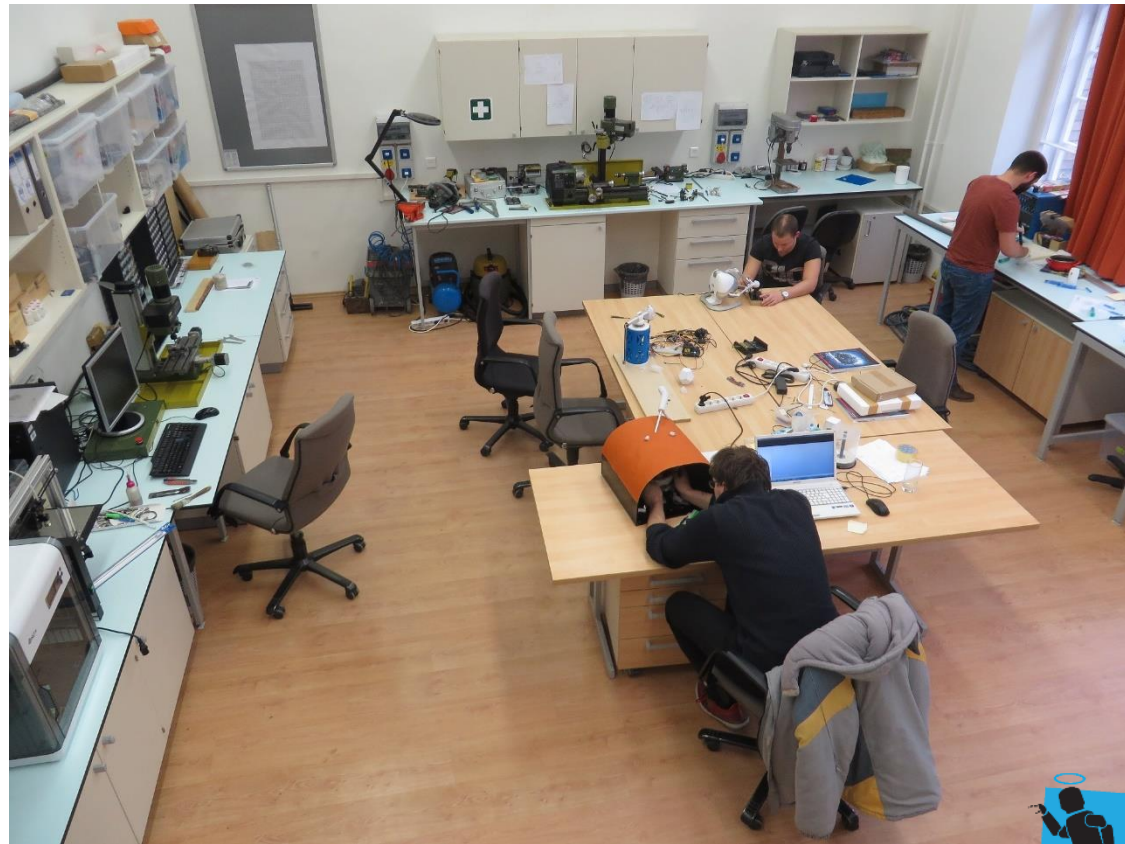
**Simulation, SLAM, autonomous motion and manipulation**



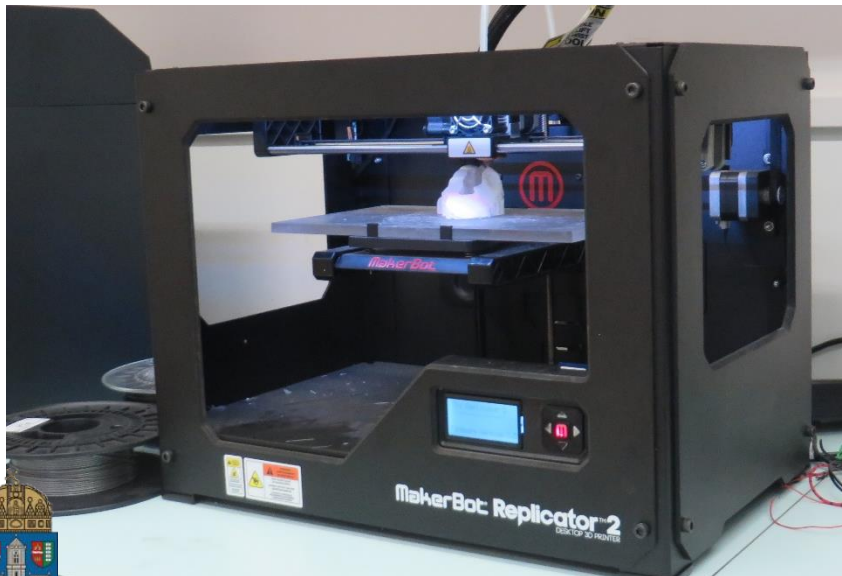
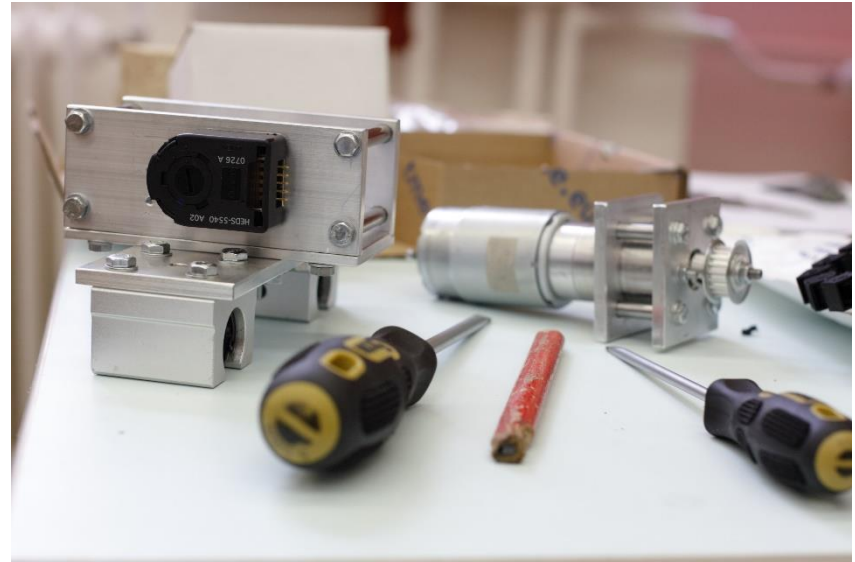
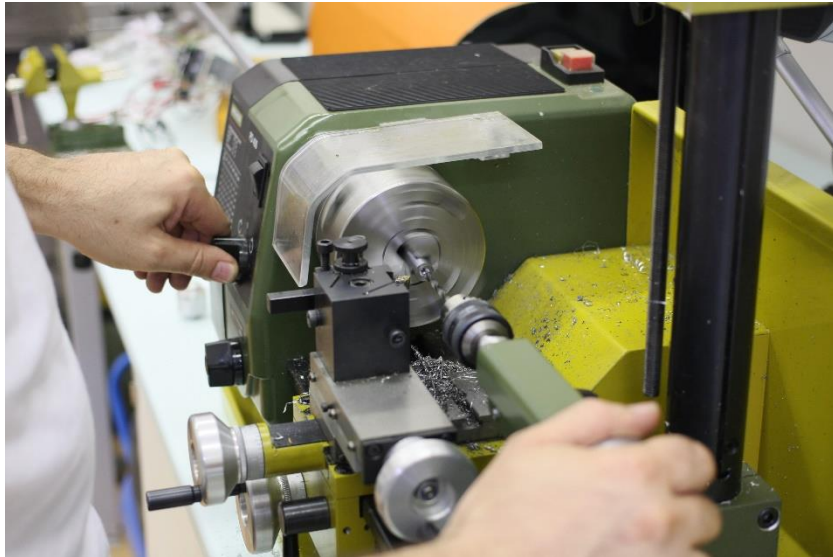
- Team OUBOT has formed by students and researchers from the ABC-iROB and the BioTech Knowledge Center of URIC
- EuRathlon 2015 - outdoor competition for autonomous robots
- Single, Dual, Grand challenges
- Underwater localization and navigation
- Object recognition (buoys, leaking pipe)
- Manipulation (close leaking pipe)
- Communication with operators
- 4th place in single challenge (sea) in 2015
- Special award for „Best new entry team”
- **More to come in 2017!**

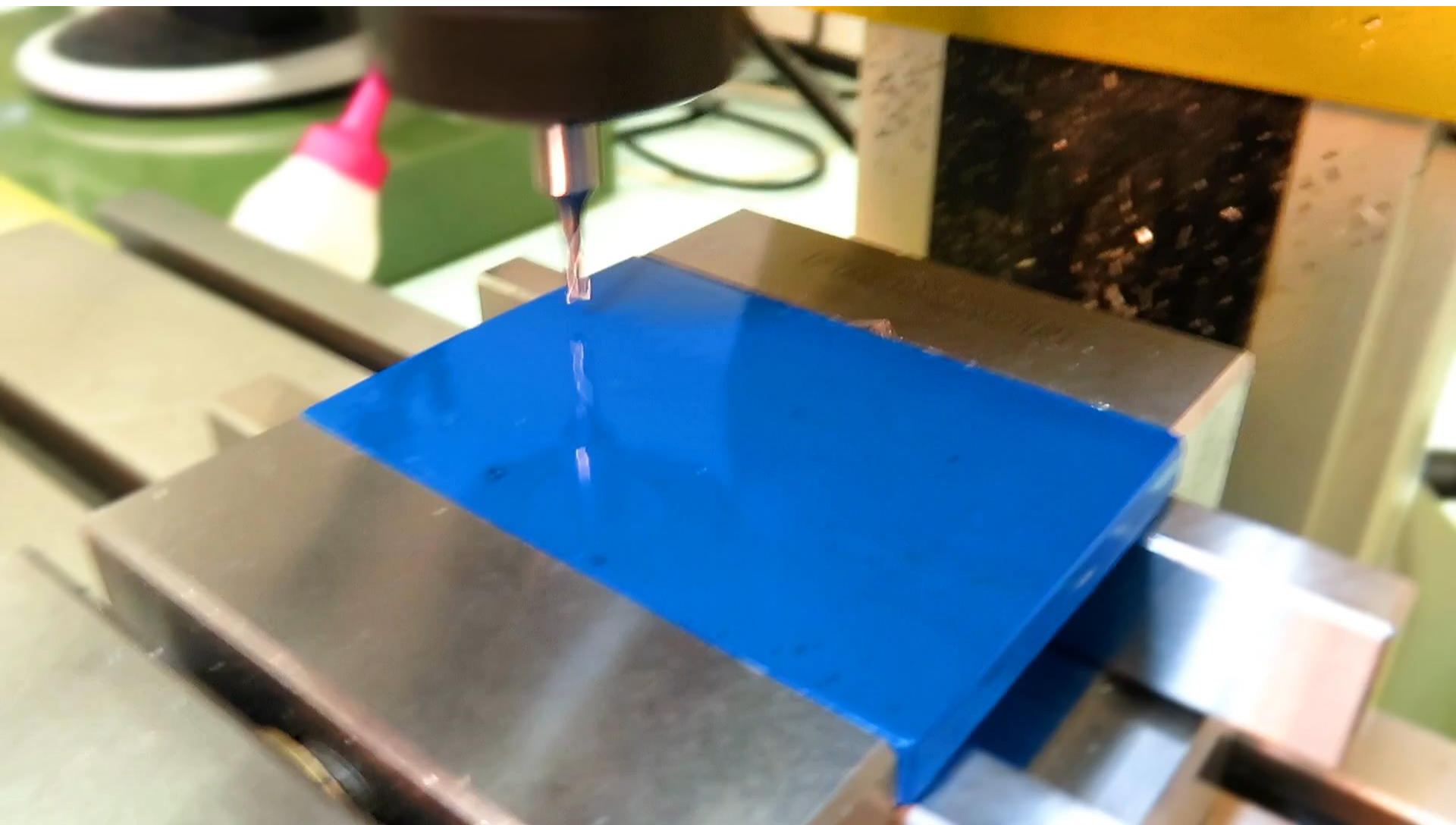


- **Open workshop** for all innovation-minded creators
- Great inventory of **tools and equipments**
- Metal cutting
- 3D printing
- Plastic molding
- Electronics prototyping
- Full engineering support









# University Research and Innovation Center

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<http://ekik.uni-obuda.hu>

Thank you!





# Antal Bejczy Center for Intelligent Robotics

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