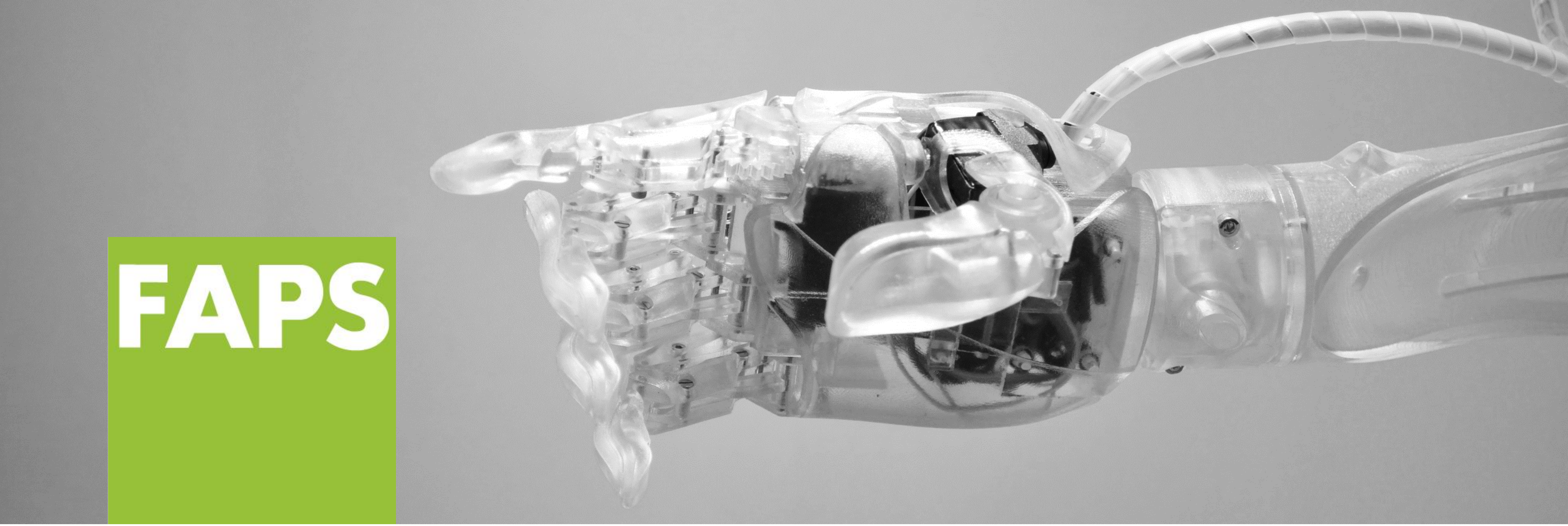


Research Sector Medical Technology

Prof. Dr.-Ing. Jörg Franke

Institute for Factory Automation and Production Systems

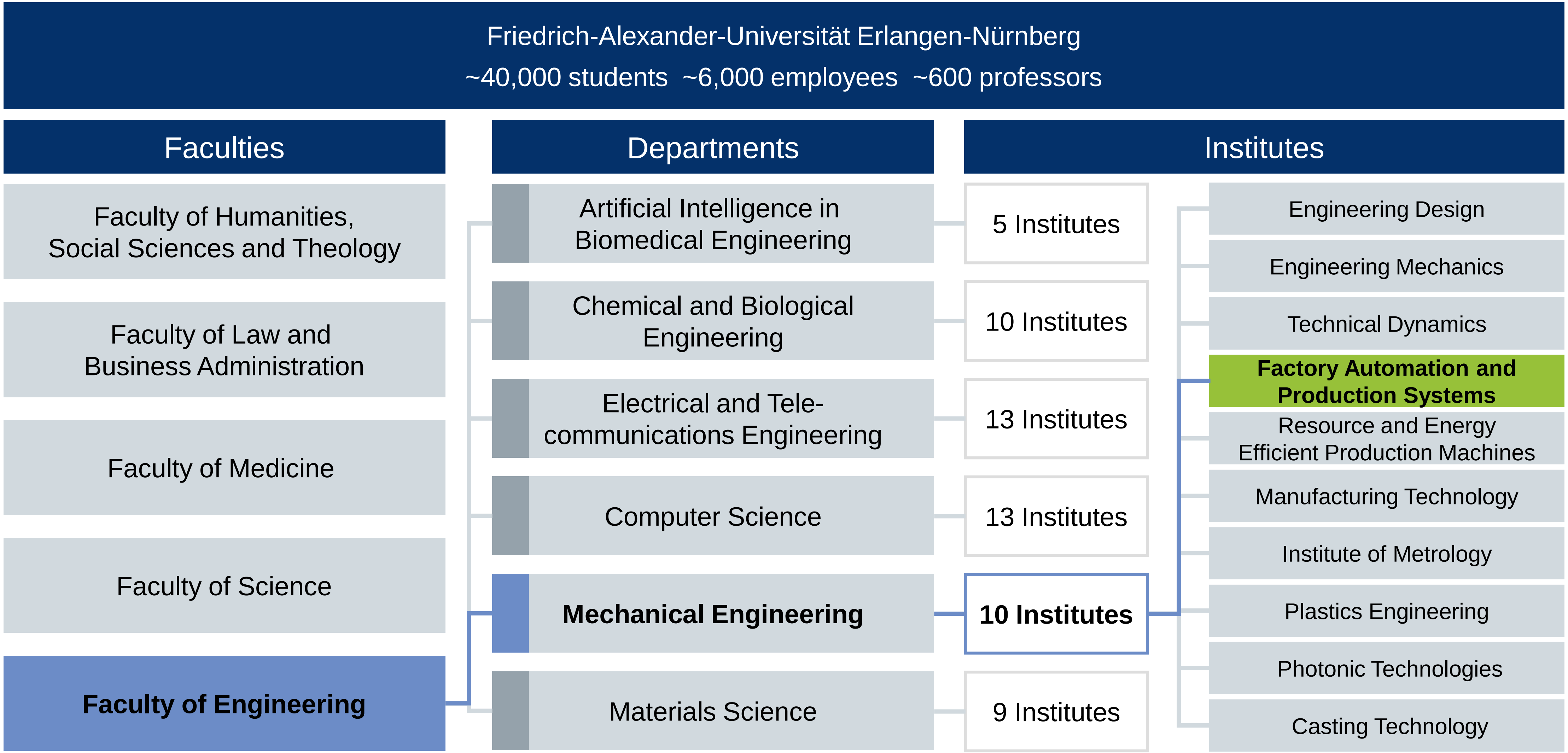
Friedrich-Alexander University Erlangen-Nuremberg

Friedrich-Alexander-Universität
Technische Fakultät

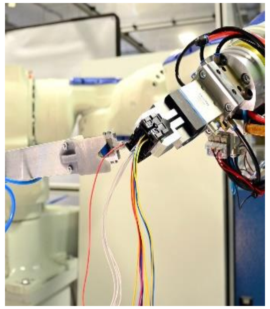
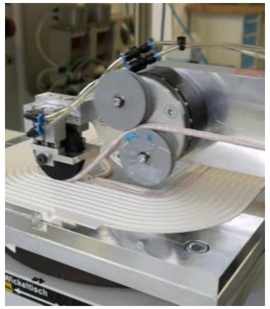
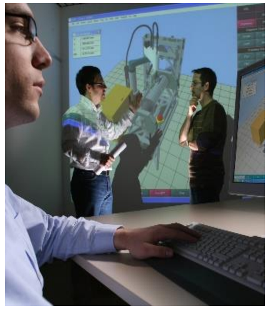
275 years of university history form the foundation for our success today

- 1742: Establishing of the University of Bayreuth by Margrave Friedrich von Brandenburg-Bayreuth
- 1743: Transfer of the university to Erlangen
- 1769: Renamed in "Friedrich-Alexander-University" in memory of Margrave Alexander of Ansbach and Bayreuth
- 1825: Move into the so-called "castle”
- 1966: First classical university with engineering sciences as an independent branch of education
- 1982: Foundation of the Department of Mechanical Engineering

The Faculty of Engineering of the Friedrich-Alexander-Universität of Erlangen-Nürnberg is structured in six departments of different disciplines.



The Institute for Factory Automation and Production Systems (FAPS) is researching the production and assembly of mechatronic products.

Electronics Production	Electric Motor Production	Data and Power Networks	Electric Road Systems	Medical Technology	Robotics	Automation Technology	Engineering Systems
							

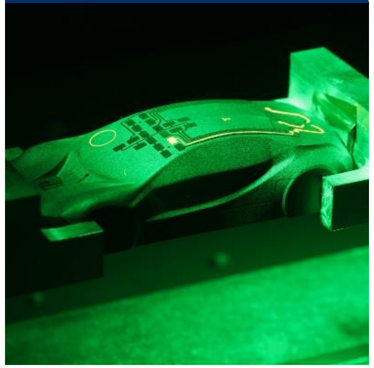
Auf AEG Nuremberg

Technical Faculty Erlangen

Technology fields ensure an exchange of knowledge across research areas and promote specific technologies.

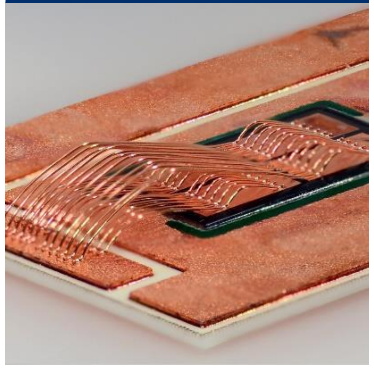
FAPS

Mechatronic Integrated Devices (3D-MID)



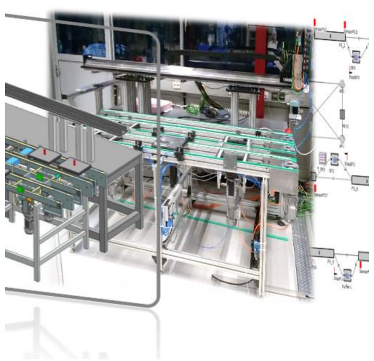
Additive Manufacturing

Construction and connection technology



Handling technology and Intralogistics

Planning and Simulation

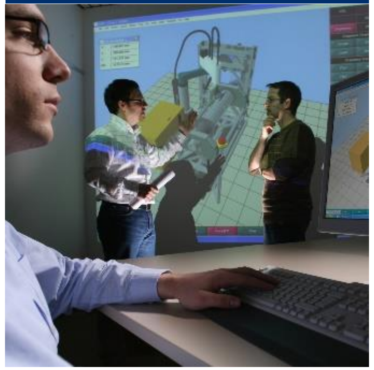


Artificial Intelligence & Machine Learning

Communication und Cooperation

Energy Efficiency and Environmental protection

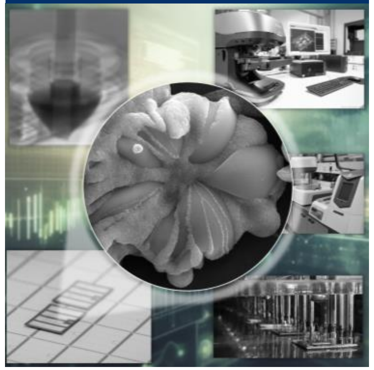
Software Engineering and Deployment



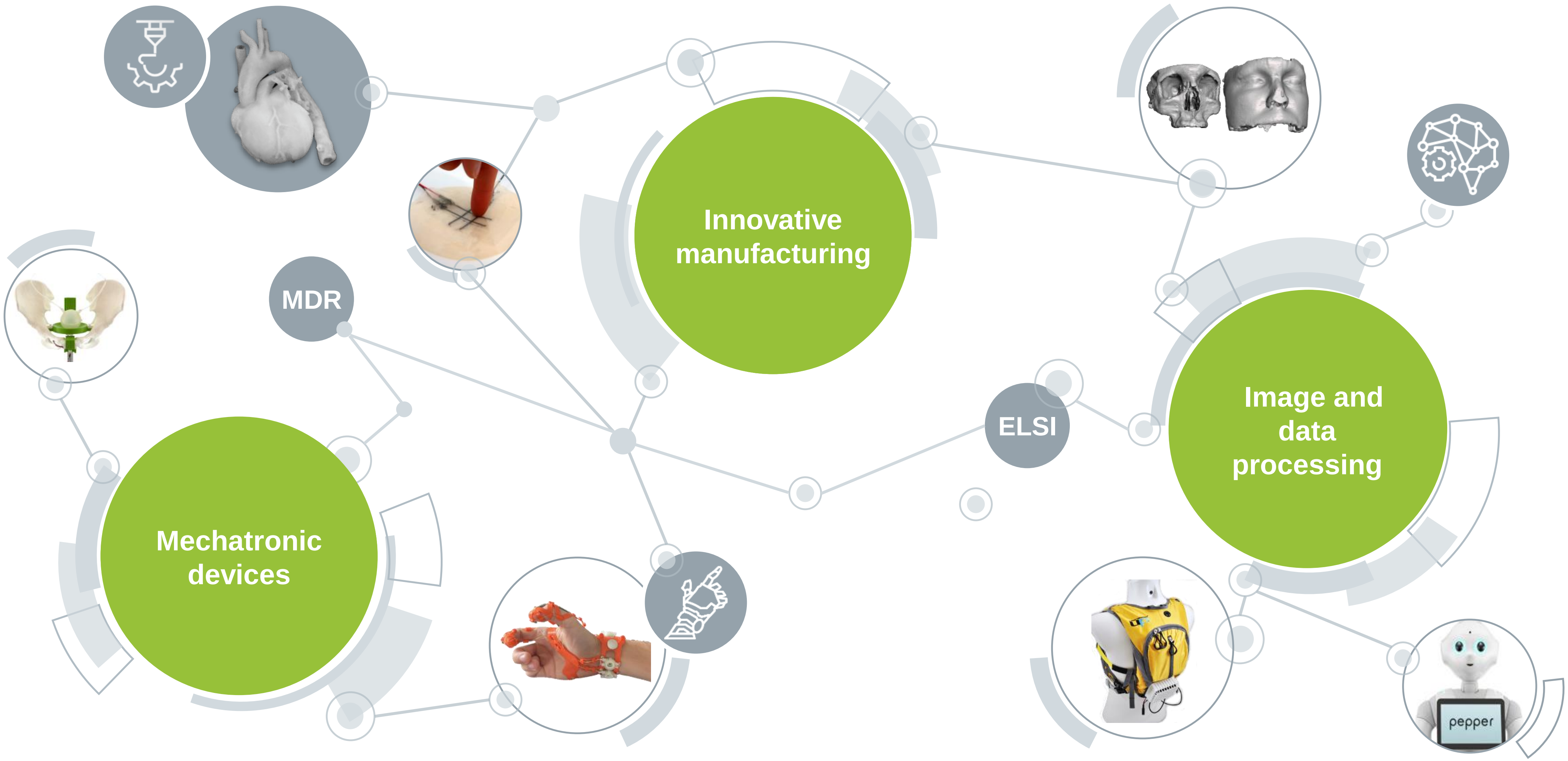
Quality and Management

Energy storage

Analytics



The Medical Technology Research Sector explores interdisciplinary technologies in manufacturing, prevention and therapy for the benefit of humankind.



ISMT 2023 was a good start, but our goal is to establish and grow the conference even further.

ISMT 25.-26. Sep. 2024

FAPS

Call for Keynotes and Sponsors!

- Keynotes and presentations from industry and research
- Networking possibilities and events
- Sponsoring with interesting advertisement options

Get more information!

FAU MED IEEE IEEE EMBS MEDICAL VALLEY Europäische Metropolregion Nürnberg MDPI

Impressions from ISMT 2023

Prosthetic fitting is currently a manual procedure based on the skills and knowledge of the prosthetist.

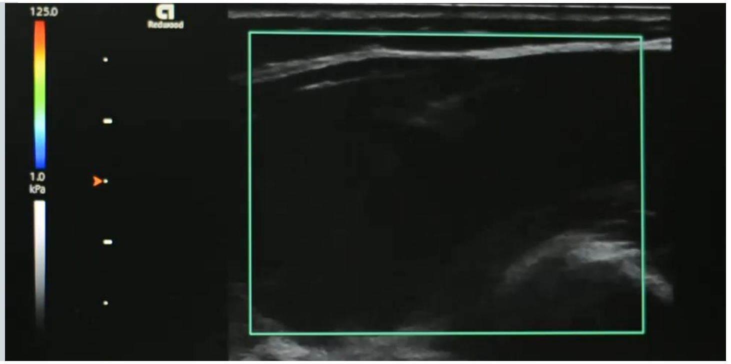
Current standard for prosthetic fitting

- Physical modeling of a plaster cast based on the manually captured tissue structure
- Difficulty: High dependence on the competence of the orthopedic technician


Quelle: Ottobock

Detection of tissue structure by Shear Wave Elastography (SWE)

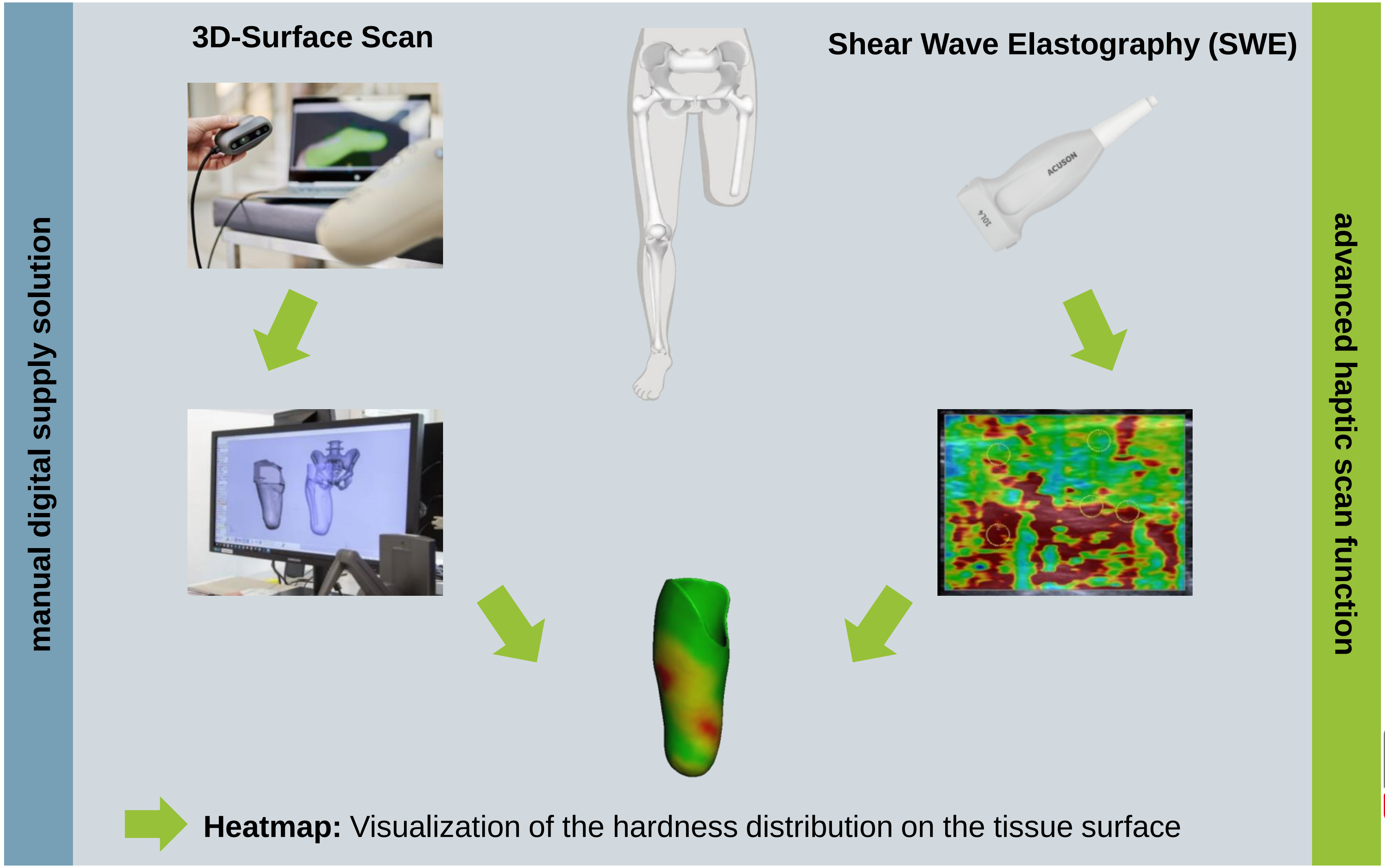
- Measurement of the propagation speed of the shear waves in the tissue
- Quantification of elastic tissue properties (in kPa)
- Local detection by contact-based measurement



Digitalization of the workflow through the fusion of quantified tissue data with surface data

Objective assessment and consistent prosthetic supply	**Individualized and more efficient patient care**	**Reduced number of revisions and repeated adjustments**

The acquired tissue data is fused with the data from a surface scan to create a holistic information basis for prosthesis fitting.



Federal Ministry of Education and Research

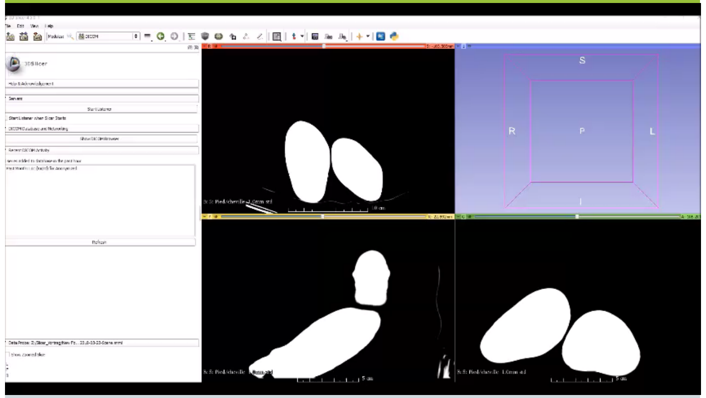
ottobock.

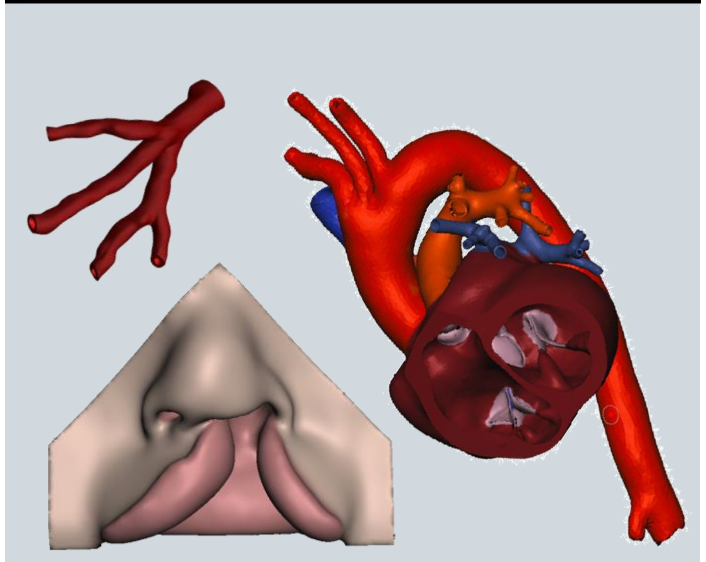
Ostbayerische Technische Hochschule Amberg-Weiden

Ergo-Tec

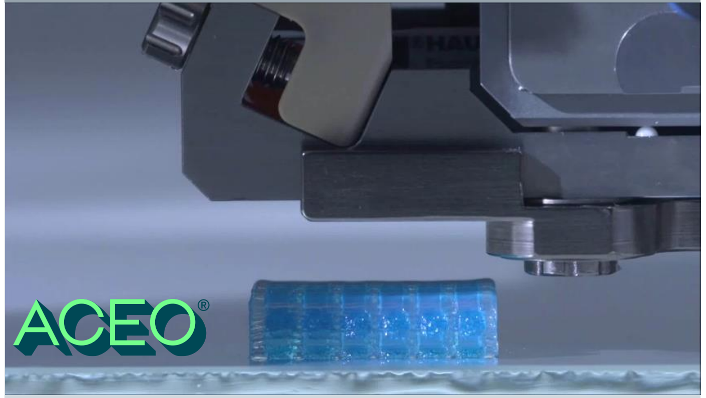
Haptic models of anatomical structures can be used for surgical simulation and should reflect the biological original as closely as possible.

Digital model creation based on CT/MRI data

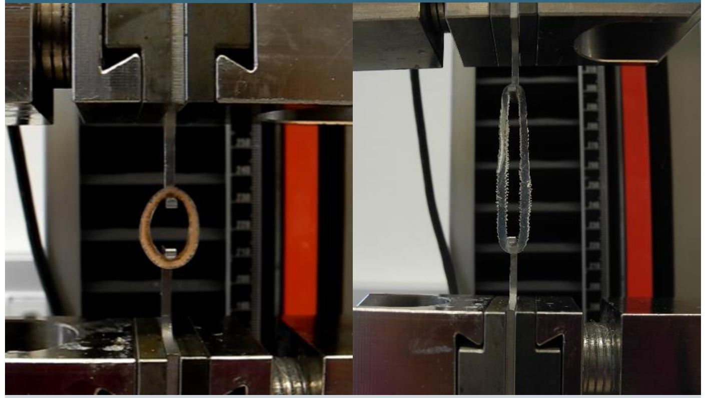




Additive manufacturing from silicone with various properties



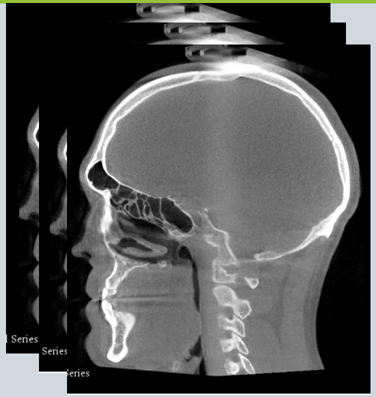
Biomechanical and clinical evaluation of the models



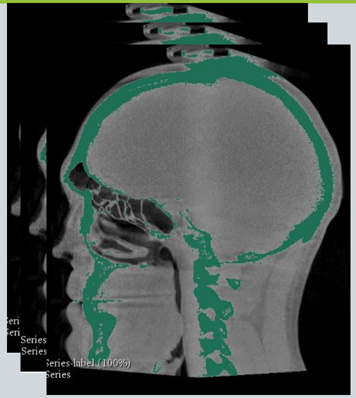
Based on medical image data, digital models can be created via segmentation and then manipulated as desired.

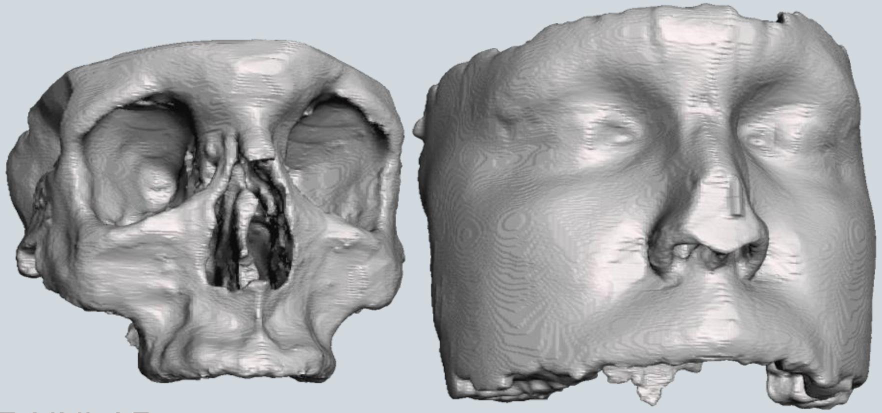
FAPS

Segmentation



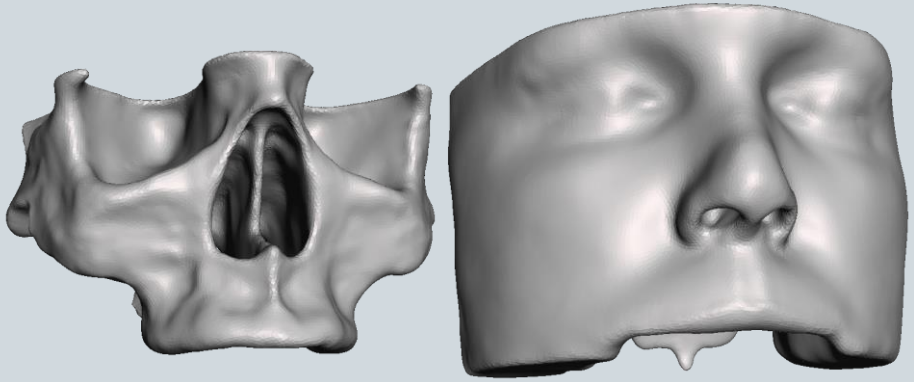
CT-Data

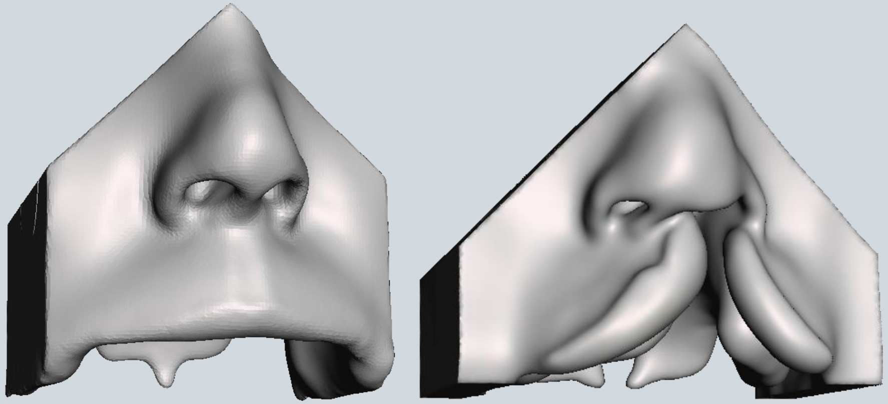




BRAINLAB

Manipulation

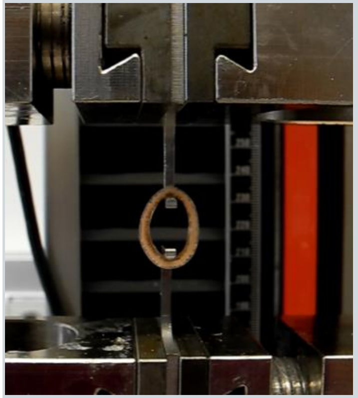




Cleft lip and palate

The biomechanical and clinical evaluation compare the characteristics of the models with the biological originals.

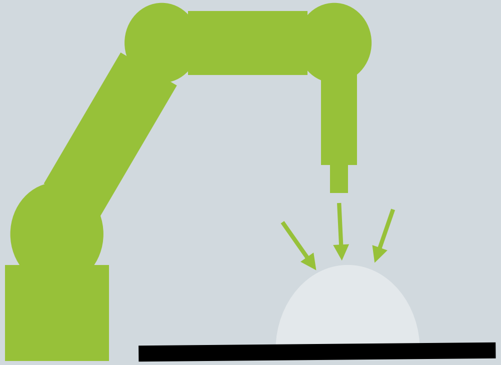
Biomechanical evaluation

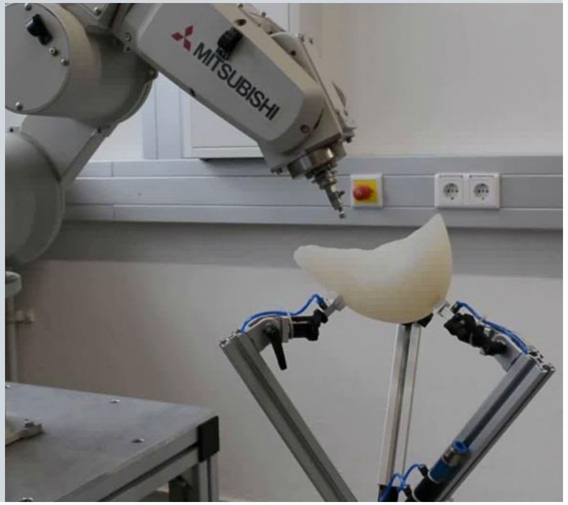


Tensile tests

Source: Optotechnik Zeiss

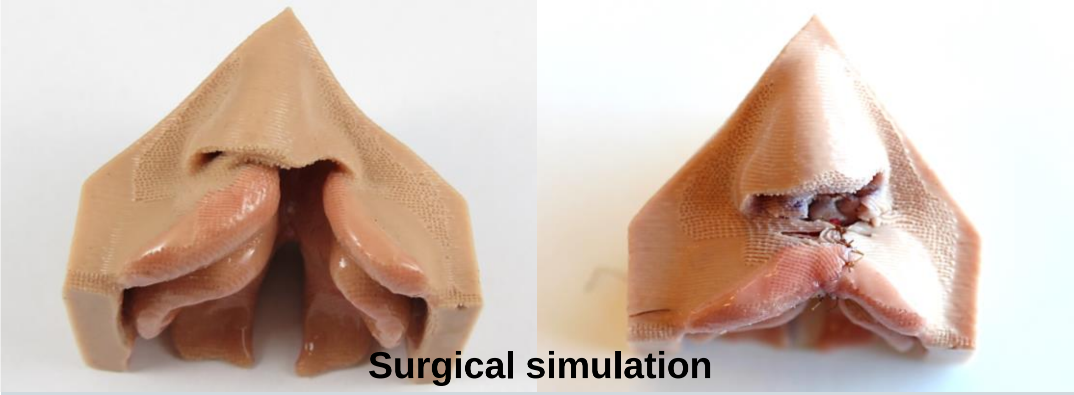
Deformation analysis



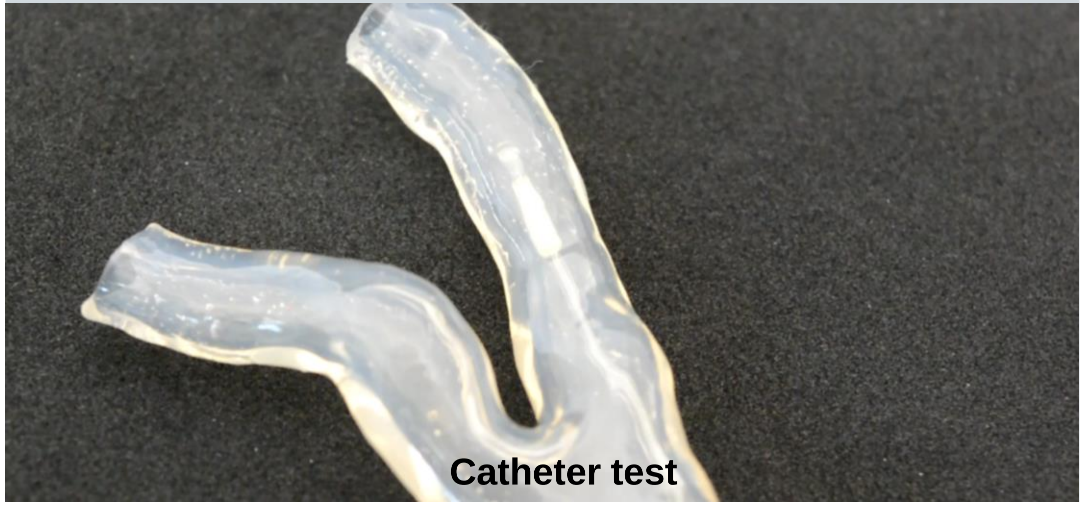


Palpation test bench

Clinical Evaluation



Surgical simulation



Catheter test

Within the ProLAM project, the silicone printing process is optimized by means of both geometry-optimized slicing and dynamic process control.

1 CAD model

2 Slicing

Geometry-optimized

3 Additive Manufacturing

Data acquisition

Parameter tuning

4 Optimized part

Digital process twin

Model of the material deposition mechanism ➕ **Model of the temperature distribution**

Adaptive curing mechanism

- Investigation of different energy input mechanisms
- Optimization of printing parameters

Optimized material deposition

- Investigation of the influence of different printing parameters on the material behavior
- Increase in part accuracy and surface quality

Minimized pre- and post-processing

- Reduction in the number of test prints
- Increase accessibility for inexperienced users

➡ **Pre- and in-process optimization**

Quelle: innovatiQ.com

Processing 2K silicones

- Process adjustment and stabilization
- Expansion of the range of materials
- Use of multiple components and extruders
- Approaches for the production of overhangs
- Dynamic process control towards the desktop

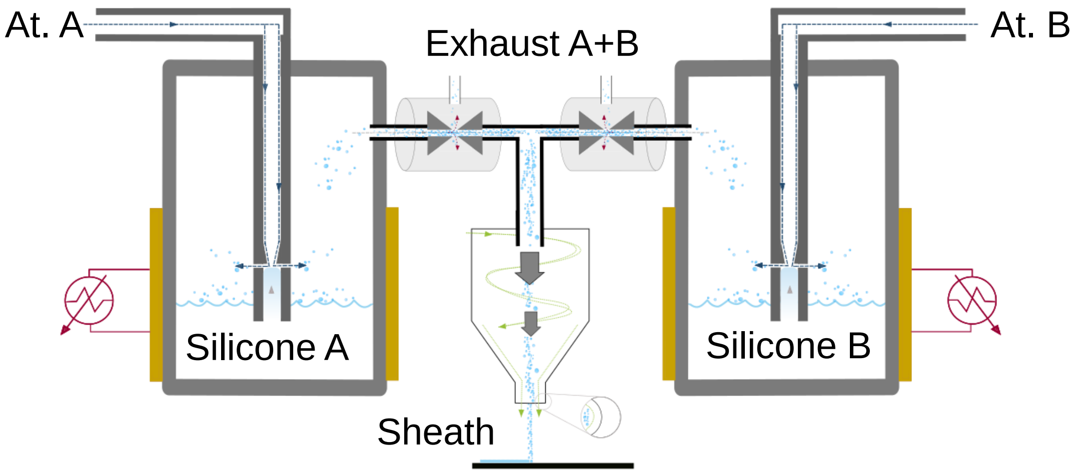
Direct additive manufacturing of silicone components offers advantages for the geometric complexity of the components and duration of the manufacturing process.

- Production of 2K material systems
- Temperature control and process control by cooling unit
- Use of different materials with different properties
- Modular system as "low cost" approach for different kinematics (e.g. FFF)

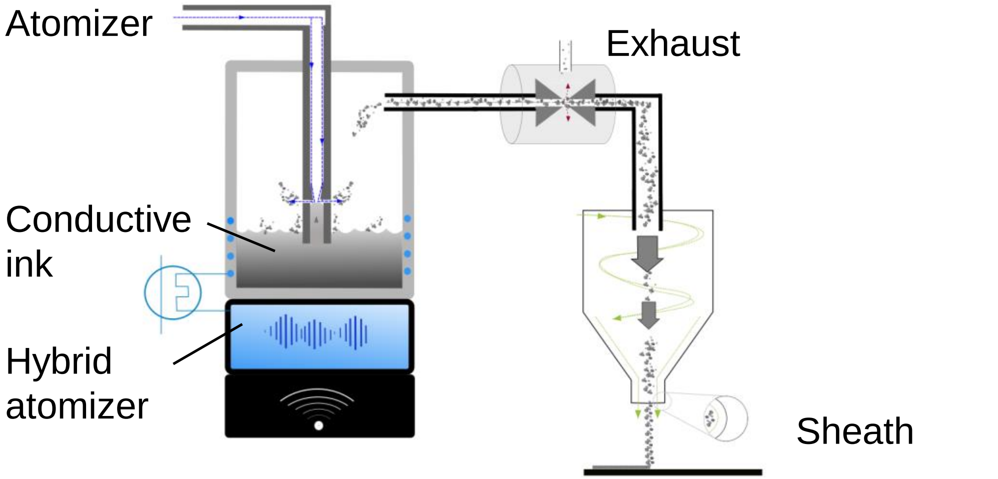
- Process adjustment/stabilization
- Expansion of the range of materials
- Use of multiple components and extruders
- Approaches for the production of overhangs
- Dynamic process control towards the desktop printer

With the ability to print silicone structures and rGO inks in one process, the production of dielectric elastomer actuators for the realization of artificial muscles is possible.

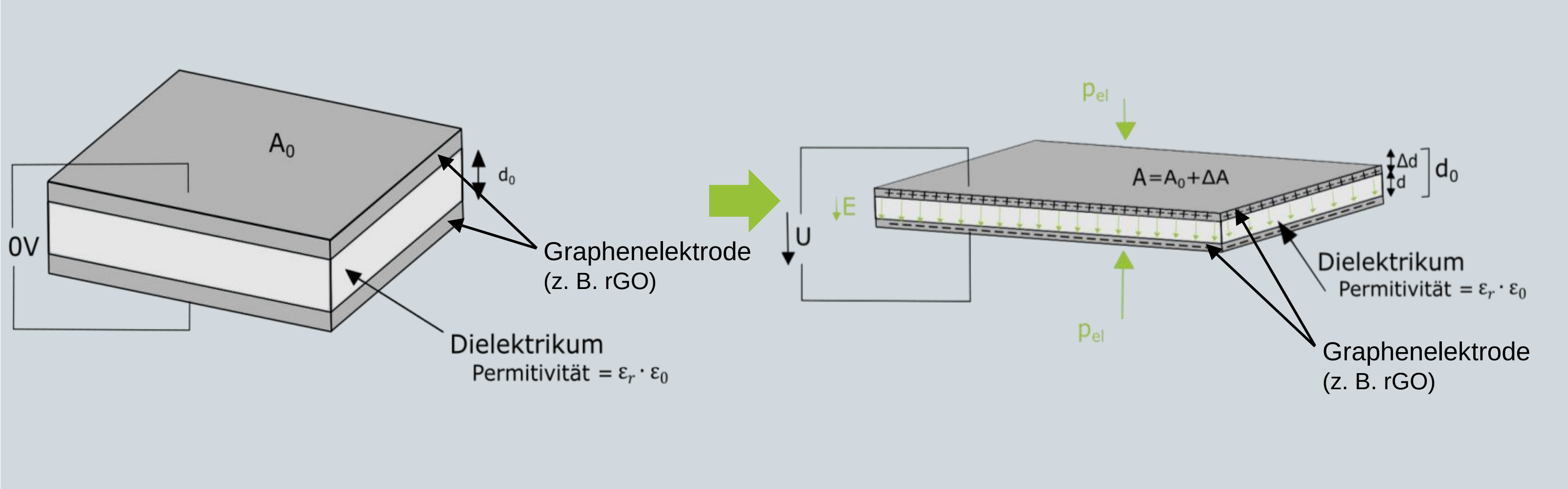
Aerosol jet printing of RTV-2 silicone

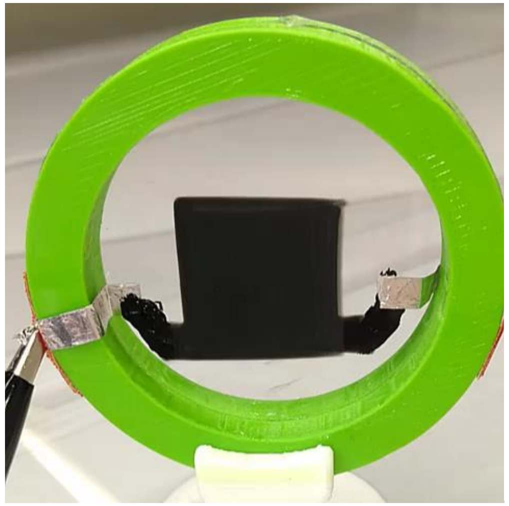


Fabrication of conductive graphene electrodes



Operating principle of DEA





The use of dielectric elastomers opens up new, bionically inspired possibilities in the field of sensors and actuators.

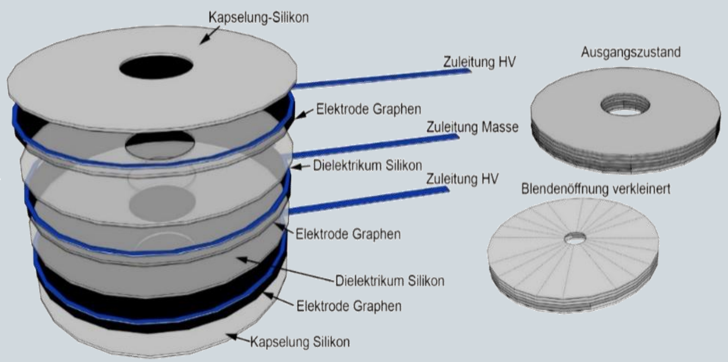
Properties

- Lightweight construction
- Silent operation
- Flexible structure
- Use as sensors & actuators
- Design freedom
- High efficiency

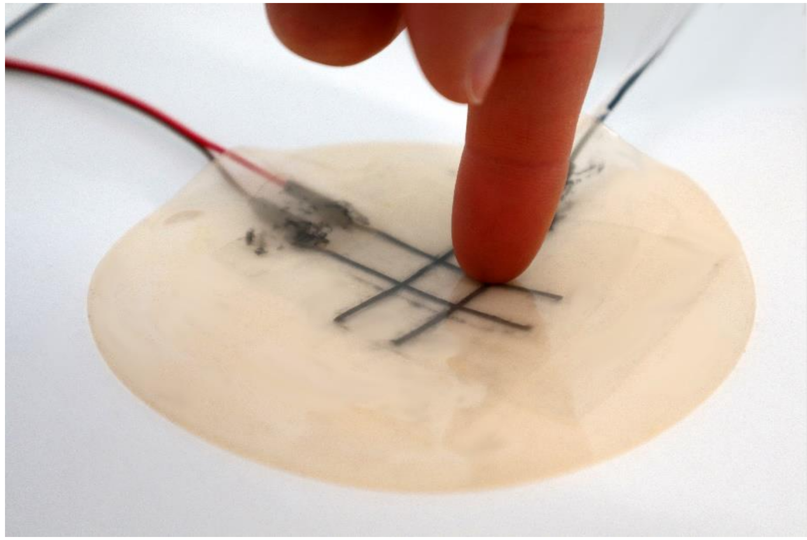
Bionics applications
Realization of technical systems based on nature

Soft actuator technology
Enables bending and stretching

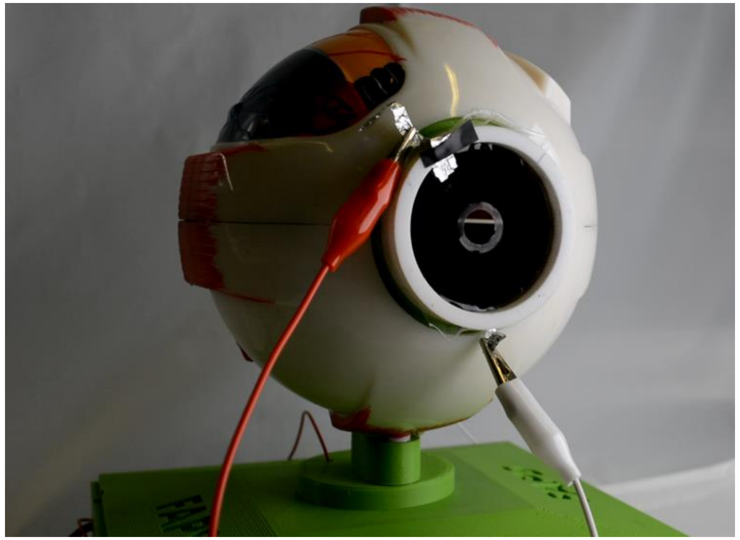
Detection of multiple DoF
Spatially resolved and self-detecting



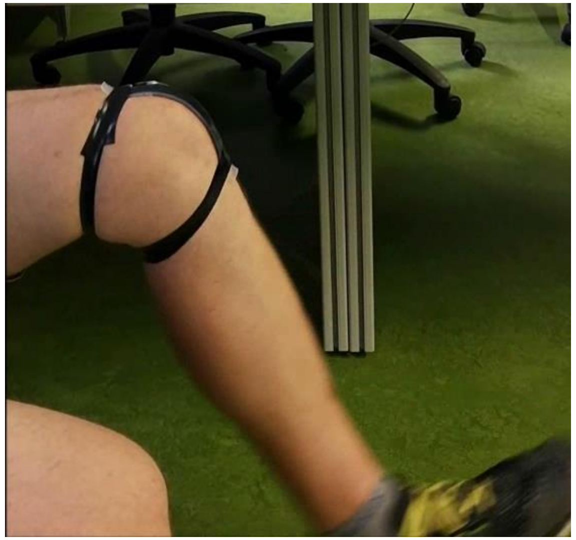
Bionic Application



- Artificial skin as a haptic interface



- Functional Iris Demonstrator from the ADAI project

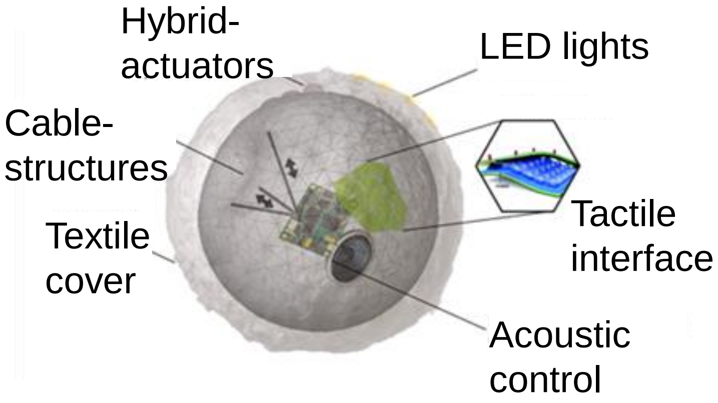


- Application as strain sensor for motion capturing

To enhance the multi-sensory connection between spatially separated people through an interactive physical object.

ToCaro - Closeness over distance

- Focus on psycological and social interaction
- Investigation of how emotions are perceived haptically, acoustically and visually
- Technical reproduction of defined interaction scenarios
- Enhanced bilateral communication



Actuator technologies for versatile haptic stimulation

Dielectric elastomer actuators

- Microscopic movement

High stimulation amplitudes

Hydraulic HASEL-actuators

- Larger movement amplitudes
- Higher impulses
- Lower frequencies

Cabel-driven actuators

- Deformation of the geometry
- High impulses
- Rapid movement

Deutsches Forschungszentrum für Künstliche Intelligenz GmbH

Human Factors Consult

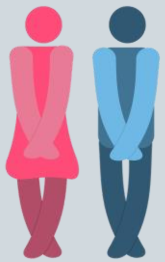
C&S managing care.

Federal Ministry of Education and Research

The PARTIS project is researching patient-friendly interaction with an artificial intraurethral sphincter implant.

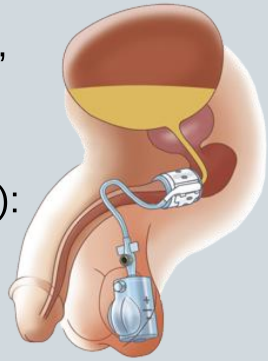
Urinary incontinence - Situation

- Approx. 5 million urinary incontinence patients in Germany alone
- considerable psychological burden and impairment of quality of life
- Increasing problem in medical and socio-economic terms



Complication

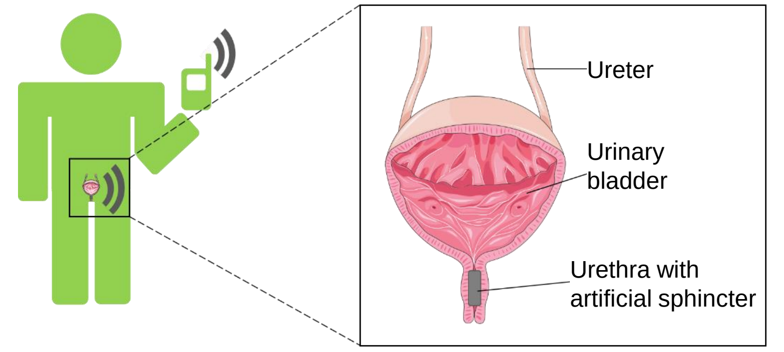
- Current therapy methods are gender-specific, have serious disadvantages or do not help to achieve full continence.
- Mechanical, artificial urinary sphincters (AUS):
  - Invasive, multi-cavity interventions with complications
  - Often only applicable to male patients
  - Uncomfortable and indiscreet control by actuating the control pump positioned in the scrotum



Zephyr Surgical Instruments

Objective of the PARTIS project

- Background: Research on a miniaturised, mechatronic sphincter implant since 2016.
- Development of an intuitive and patient-friendly interaction option, as no such therapy system with which the patient interacts themself exists.



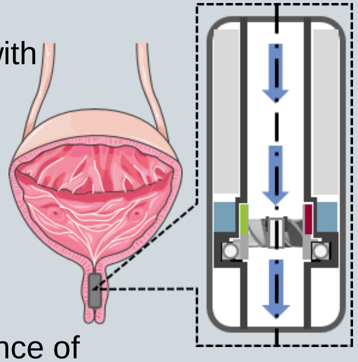
Federal Ministry of Education and Research

At the FAPS Institute, research is being conducted on various aspects of the mechatronic intraurethral implant in order to develop it holistically.

FAPS

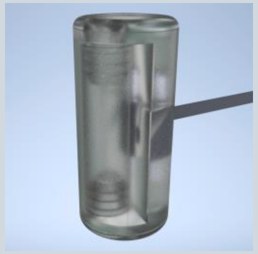
Energy harvesting from the urine flow

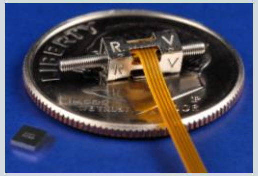
- Micturition: bladder is emptied at 20 - 35 ml/s with intravesical pressure of 25 - 80 cmH_2O
- Energy recovery through turbine-based micro-generator
- Complete integration in the implant to avoid perforation of the urethral tissue
- Prolongation of the implant's lifetime → Avoidance of subsequent surgical interventions to change the energy storage device



Bistable closure mechanism

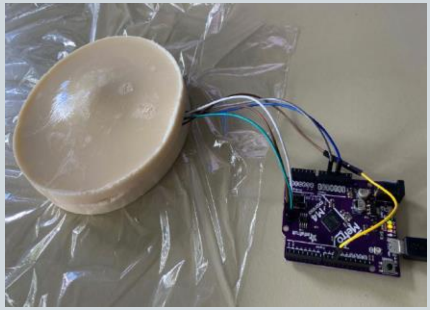
- On-demand release and blocking of the urine flow
- Bistable system to require energy only to change state
- Self-cleaning effect by oscillation of the tubing system to avoid biofilm formation
- Micropiezomotor as actuator





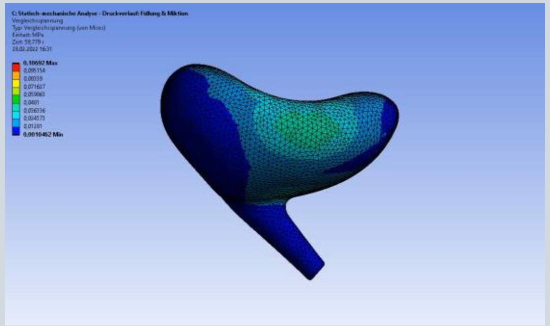
Patient-friendly interaction through ‘knocking’ signals

- Patient must communicate safely and intuitively with implant to fulfil therapy function
- No need for hand-held device, which can be lost or unavailable
- Research approach: manually generated knocking signals on tissue of the abdomen
- Acquisition of a knocking rhythm with implanted acceleration sensor



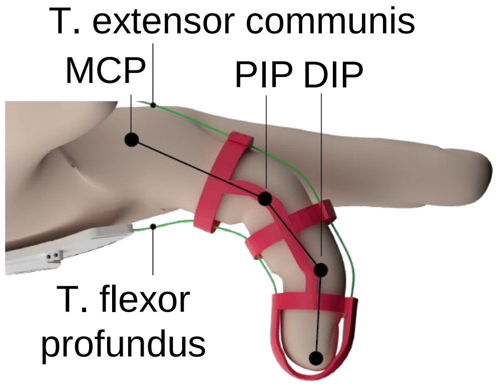
Simulation of physiological processes

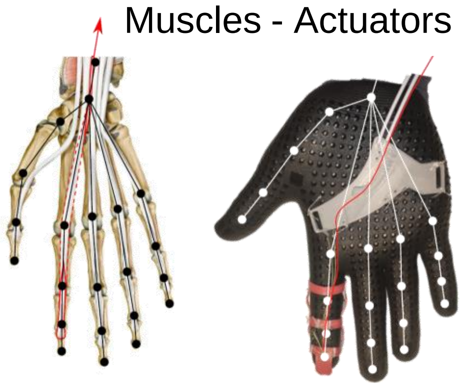
- Refrain from using animal models in the research process for ethical and practical reasons
- Research using digital twins of the implant → Testing of functional performance even before clinical trials
- Example here: Contraction of the bladder during micturition



Direct myoelectric control of a soft cable driven exoskeleton allows movement of the fingers through alight weight support structure.

A tendon driven approach allows biomimetic movement

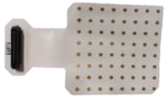


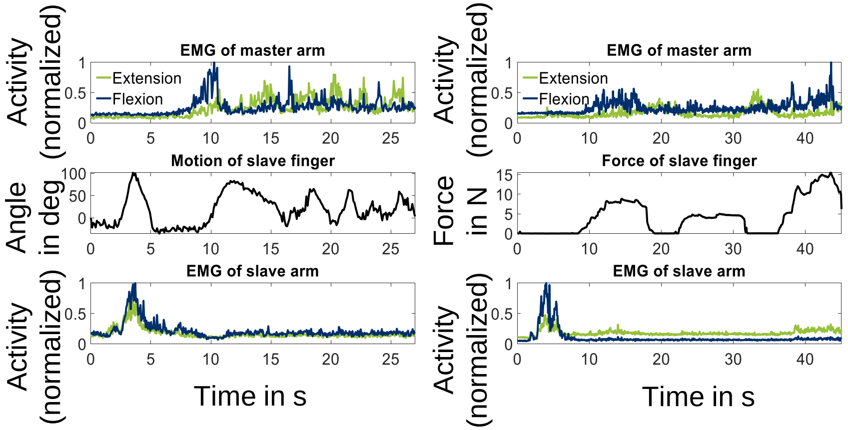


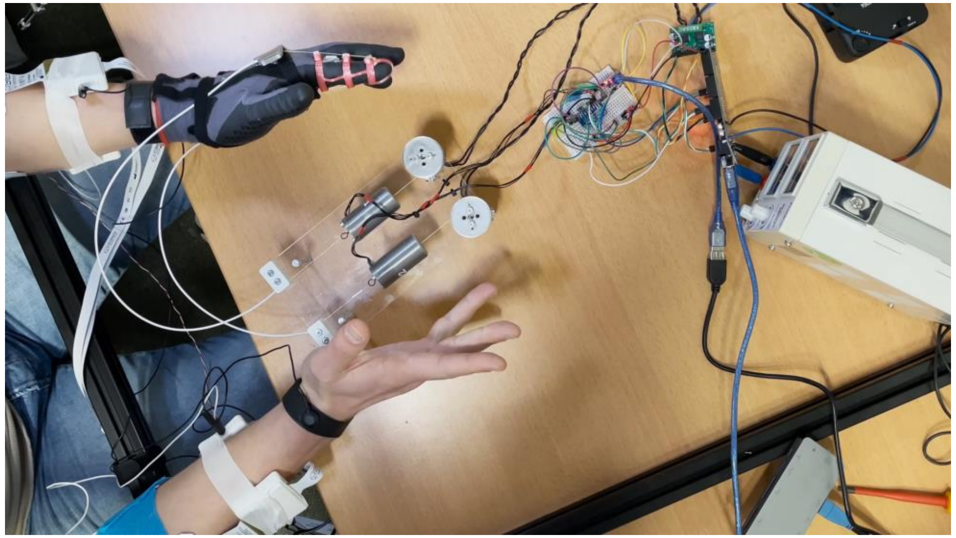
Intuitive control mechanism through high EMG density

Signal amplifier

EMG electrode







- Human machine interface for an intuitive control
- Weight distribution of the control mechanism e.g. backpack
- Tendon driven approach mimics the human movement apparatus
- Individualization allows optimized force coupling

MEDICAL VALLEY AWARD | Department Artificial Intelligence in Biomedical Engineering | FAU Friedrich-Alexander-Universität Technische Fakultät | KNOWLEDGE IN MOTION

A wearable assistance system supports the navigation of visually impaired people through a 3D camera and machine learning.

Assistance system

- Embedded standalone system with 3D stereo cameras and mobile GPU

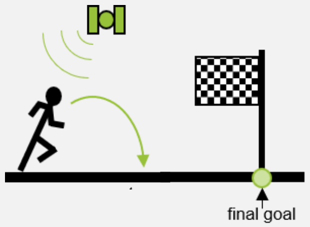
Binary environment segmentation

Path	Obstacles

- Robust and efficient artificial neural networks (encoder-decoders)
- Efficient implementation on embedded GPU

Localization

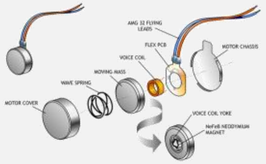
Satellite navigation	Visual odometry



- Robust fusion of mutlimodal localization using Unscented Kalman Filter

Multimodal feedback system

Linear Resonant Actuators	Bone sound headphones

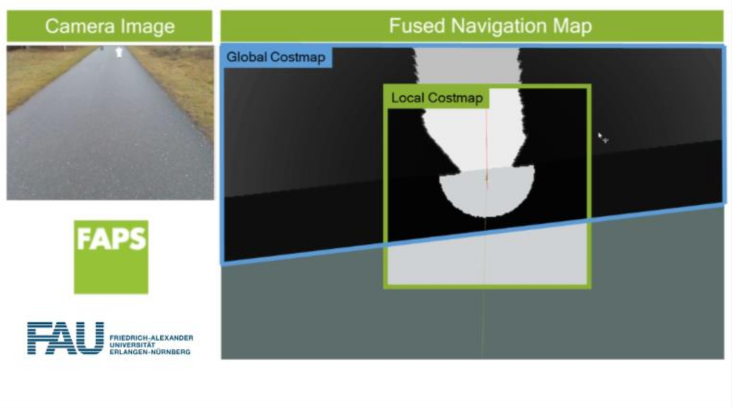


- Local trajectories and warnings are modulated into feedback signals
- Acoustic and/or vibrotactile mediation of the signals

Sources: aftershokz, precision microdrives

Cascaded path planning

- Back-projection of segmented images into hierarchical cost maps
- Orchestration of data processing and path planning via parallel state machines
- Global path planning based on satellite navigation and path trajectories
- Local path planning based on odometry and local environment information



A wearable assistance system enables navigation of blind joggers by environment detection using a 3D stereo camera.

Assistance system

3D Stereo Camera

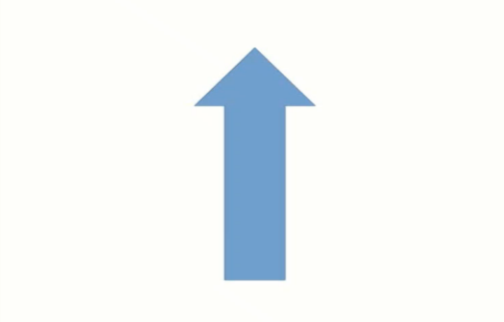
Embedded computing unit

Depth information

Color information

Obstacle map

Route



Robust obstacle and path course detection

- Ground segmentation and projection of obstacles during dynamic movements of the camera
- Path course detection by means of artificial neural networks

Virbotactile feedback

ANWENDUNGSZENTRUM ESI

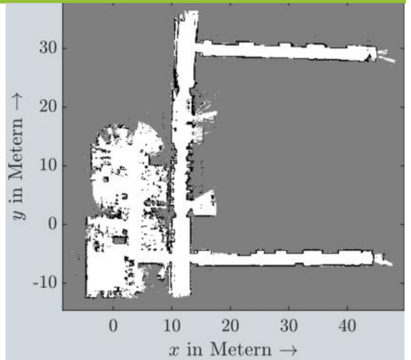
The development of autonomous and intelligent wheelchairs enables novel approaches to support affected persons as well as caregivers and relatives in everyday life.

- Increasing need for mobility support worldwide
- Reducing the workload of medical staff
- Technologies from related markets (autonomous driving, robotics)
- Improving the mobility of those affected

Sensor-based localisation | **Prediction of pedestrians** | **Socially accepted navigation**

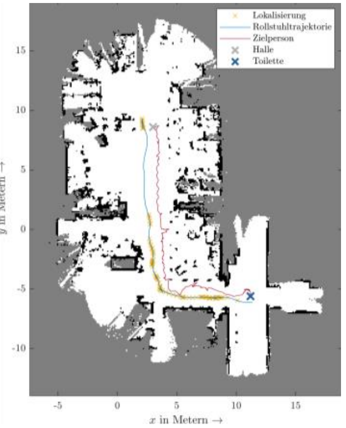
- Open programming environment using the Robot Operating System ROS
- Collision avoidance through mapping of the surroundings
- Partially or fully autonomous navigation
- Socially accepted path planning and movement execution

Autonomous Navigation



Autonomous accompaniment of a person

- Detection of a person using cameras and laser scanner
- Movement prediction of the attendant by interpolation
- Attractiveness distribution for finding optimal companion position
- Extension of the A* algorithm for solving the two-dimensional optimization problem for finding the optimal companion position



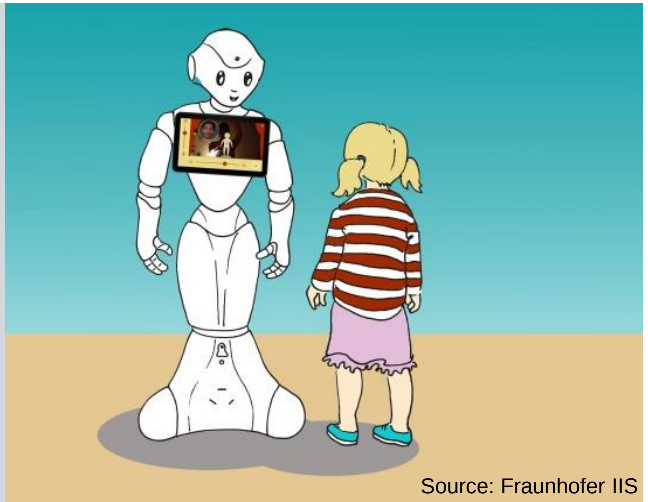
Future Work

- Movement is affected by the low agility of the wheelchair prototype, which can be improved by novel drives
- Improvements in socially accepted navigation, which includes interaction with the environment
- Indoor and outdoor navigation ensuring safety in dangerous situations

Social robots can be used for training socio-emotional skills in children with autism spectrum disorders, thus supporting therapy.

Socially assistive robots for socio-emotional skills training.

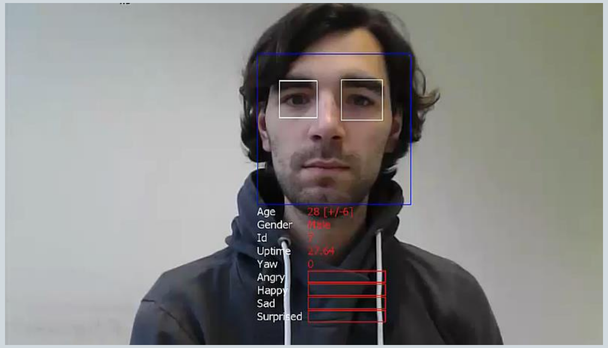
- Interest in humanoid robots among individuals with autism spectrum disorders
  - Limited facial expressions/gestures and predictable responses
  - Generally increased interest in technical topics
- Use of Pepper robot as interaction partner during therapy session
  - Tutor for specific training modules and visualization on tablet
  - Control of robot behavior by therapist
- Use of affective computing to capture emotions and arousal states



Source: Fraunhofer IIS

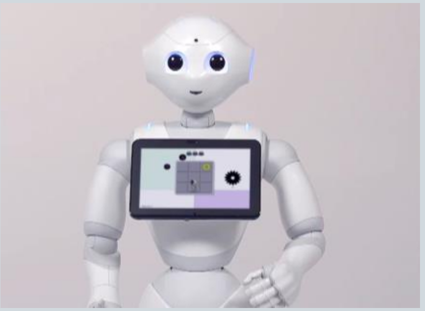
Emotion recognition and mimicry

- Recognition and expression of emotions



Excitation detection and regulation

- Learning game with different difficulty levels and calming exercise if needed



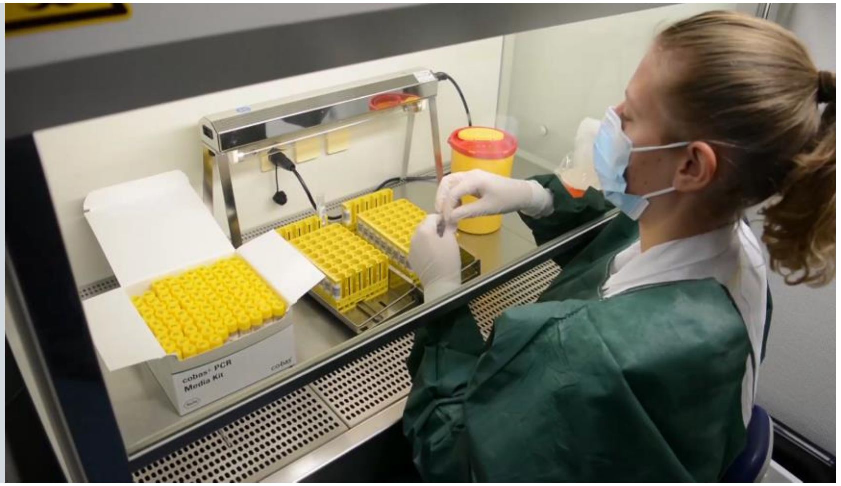
Therapist interface

- Visualization of emotion and pulse recording
- Intuitive and demand-oriented control of therapy content
- Suggestion of robot behavior based on the recorded emotions and arousal states
- Documentation of the course of therapy

The analysis of medical samples is currently still often characterized by manual handling steps for pre- or post-processing and is fraught with various challenges.

Manual handling of medical specimens

- Pre- and post-processing of analytical methods by manual handling steps.
- Potential risk of infection, cross-contamination or contamination
- High hygienic requirements
- Often repetitive activities and insufficient documentation
- Proprietary communication infrastructure



Example: SARS CoV-2 polymerase chain reaction

Sample preparation

- Swabs of the specimen collection are transported in tubes with medium
- Tubes must be manually presorted and optically injected
- Transfer to special transport racks

PCR Analysis

- Fully automated analysis of characteristic viral RNA
- Samples must be manually inserted and removed
- Limitation of maximum throughput

Source: ROCHE cobas

A robot enables sample handling for pre- and post-processing of PCR analysis.

Camera systems

- Localization of the tubes via deep learning
- Camera system for analysis of position and value of barcodes
- Camera and illumination system for detection of swabs and contaminants

7-axis industrial robot

- Implementation of all handling steps by a robot
- Special painting to improve hygiene

Gripper system

- Servo electric gripper
- Additively manufactured multifunction gripper jaws

Communication system

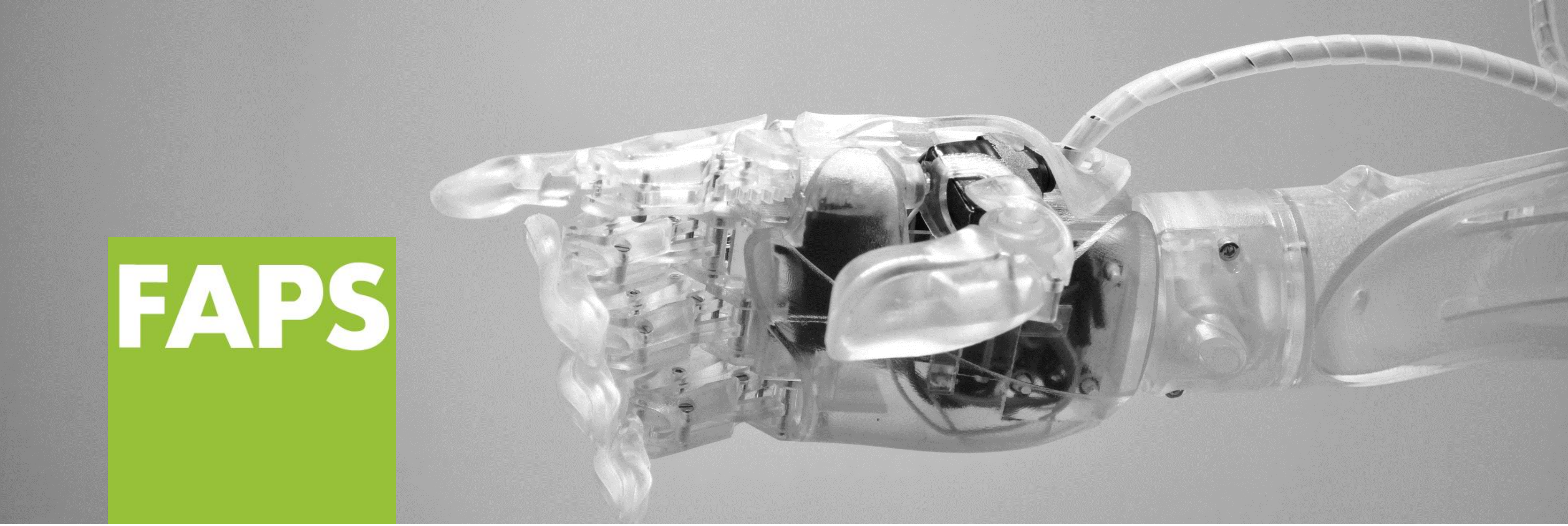
- Communication between robot and PCR system
- Documentation
- GUI for laboratory staff

Project partners

YASKAWA

infoteam software

Universitätsklinikum Erlangen



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THANK YOU