UNIVERSITÄT LEIPZIG

Faculty of Medicine

iccas

ICCAS ANNUAL REPORT 2022

#Medical_Technologies_Made_Smart

IMPRINT

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Faculty of Medicine
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COVER
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“Cardiologist doctor check up report electronic medical record and examine heart function of patient on Digital tablet. healthcare and network connection Science Medical technology concept”.

PHOTOS
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Diana Pretzsch

Leipzig, March 2023

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#PREFACE

Dear Friends and Colleagues,

We‘re delighted to share with you some of the amazing things that happened at ICCAS in 2022. It was truly a year of new beginnings, with conferences and meetings happening in person again after so many years of pandemic-related challenges. This allowed us to have a more vivid exchange of ideas and enabled us to achieve some great successes.

We‘re proud to have made a significant impact in trendsetting research areas like Artificial Intelligence, 5G/6G, Augmented Reality, Medical Robotics, Image-guided Diagnosis and Therapy. And of course, we know that communicating our scientific innovation is key to its success. That‘s why we made sure to stay closely connected to the professional community, stakeholder groups, and the wider public by participating in leading symposia all over the world, including BMT in Innsbruck, Austria, CARS in Tokyo, Japan and FUS in Rockwell, USA. We were also honored to host the 13th International MRI Symposium (iMRI) and the “Shaping the Future of Medicine” congress in Leipzig.

We‘re thrilled to have launched several new projects with public and industrial funding, including KliNet5G, MediNet, 3MP-FUS, and 6G-Health. Together, these projects have the potential to make a significant difference in people‘s lives. We‘re grateful for the funding we received, with over 12.5 million Euro of public and industry funding. Our team published more than 50 publications, and we‘re proud to say that Hannes Köhler received recognition for his work in patient safety in medical technology.

We want to take a moment to thank everyone who contributed to our success in 2022. We couldn‘t have achieved any of this without the support and collaboration of our colleagues, stakeholders, and the wider community. We‘re excited to see what the future holds and look forward to continuing our work with you all.

Finally, we bid farewell to Prof. Meixensberger, founding director of ICCAS from 2005-2014, as he enters retirement, and thank him for his work and wish him all the best.

Sincerely,

Prof. Dr. Andreas Melzer

Prof. Dr. Thomas Neumuth

#FOREWORD BY THE DEAN

Dear Friends and Colleagues,

I am proud to have ICCAS as a member of our faculty. ICCAS shapes our profile as one of the leading faculties with regard to digital precision medicine of the 21st century. ICCAS is a pioneer in computer assisted surgery and has established a significant network of partners at national and international level.

For our faculty, transfer of knowledge into application is key. At ICCAS, this is done in cooperation with clinical departments, teaching and research institutions evidenced by the fact that ICCAS is the only non-clinical partner of the Center for Robot-Assisted and Navigated Surgery as well as the Cancer Center Central Germany making ICCAS an integral part of Leipzig's wider University Medical Centre.

Excellent Research is teamwork. Therefore, my sincere thanks go to the ICCAS Board and the entire team of researchers, clinicians and staff for their tireless effort, personal dedication and pioneering research. I am looking forward to ICCAS' ongoing path to success, advancing research on medical technology with the aim to support the diagnosis and treatment of our patients.

Sincerely,

Prof. Dr. med. Ingo Bechmann

#ICCAS TIMELINE

2022

- ISO 13485 recertification for ICCAS has been extended
- ICCAS developed a blue print of a future ambulance with 5G
- ICCAS took part at the BMT 2022 with many program contributions
- ICCAS members participated the 13th International MRI Symposium and held a network meeting for their partners
- More than €13 million in new project volume raised by ICCAS in 2022
- Launch of Projects 3MPFUS, 6G-Health, KliNet5G, MediNet, Tri5G, VISION-CRE, CortexMap, SDC-VAS

2021

- ICCAS is founding member of the first center for robot-assisted and navigated surgery in Saxony
- Minister of State Petra Köpping and now Member of the Bundestag Holger Mann visit ICCAS
- Center for Medicine Innovation (CMI) selected to move to the next phase in the ideas competition „Wissen schafft Perspektiven für die Region“
- ICCAS involved within the framework for the establishment of the Comprehensive Cancer Center (CCC) for Central Germany
- Launch of projects EyeHearU, SCD Controlstation MED, MMMP FUS

2020

- 15th anniversary of ICCAS – Greetings and video message by Saxon Minister for Science Sebastian Gemkow
- Institute at the Faculty of Medicine at Leipzig University
- BMT in Leipzig – Opening by Federal Minister of Health Jens Spahn
- New Research Group Biomedical Data Analysis with project PostStroke (Prof. Galina Ivanova)
- Avatera Cooperation: Instrument Positioning
- Launch of projects VITALS, KAIT, MSI-Endoscopy, HSI-Laparoscopy, AIQ-NET, SORLIC, AutoCuff, Brainsaver

2019

- ICCAS organizes the ‘FutureMedTechnologies‘ doctoral workshop and transfer meeting
- Habilitation of Dr. Claire Chalopin
- OR.Net e.V. presents the SDC-Standard at DMEA 2019
- 6th Digital Operating Room Summer School successfully performed
- ICCAS conducts a public discussion on AI in Medicine in the framework of the BMBF’s Year of Science
- Launch of projects MR-Stents, MR Thrombosis, MOMENTUM, MPM and ProDial

2018

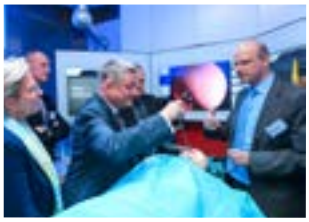
- ICCAS welcomes Saxony’s Prime Minister Michael Kretschmer
- 5th DORS inspired international participants
- ICCAS takes part at the Surgical Robot Challenge of the Hamlyn Symposium in London
- ICCAS hosts Steering Committee Meeting of the EUMFH project
- ICCAS invites to the 17th Annual Conference of the CURAC-Society
- Launch of projects ENSEMBLE, COMPASS and LYSiS
- EU Commissioner for Humanitarian Aid & Crisis Management Christos Stylianides visits ICCAS

2017

- ICCAS meets Federal Chancellor Angela Merkel at Digital Summit 2017
- 4th DORS consolidates its unique feature
- EUFUS 2017 & Preconference Workshop Experimental FUS and HIFU take place in Leipzig
- Successful non-invasive treatments with HIFU at Leipzig University Hospital
- PROJECT AREA Life Support Systems with projects IMPACT and EMU launches
- Start of projects European Modular Field Hospital (EUMFH), PAPA-ARTIS and MoVE

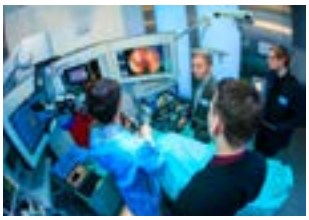
2016

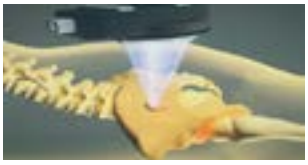
- Final presentation of the flagship project OR.Net
- ICCAS receives ISO 13485 certification
- Federal health minister visits ICCAS
- 3rd DORS
- Project start of Meta-ZIK SONO-RAY



2015

- Launching of cooperation with several scientific and clinical institutions
- 10th anniversary of ICCAS with 2nd DORS and ICCAS International Symposium
- Project OR.Net: Presentation of results in the complete demonstrator
- NEW RESEARCH AREAS: Noninvasive Image Guided Interventions (Prof. Andreas Melzer), Multimodal Intraoperative Imaging (Dr. Claire Chalopin)
- Clinical Advisory Board founded





2014

- Prof. Andreas Melzer joins ICCAS as Director as well as Professor of Computer Assisted Surgery
- IT Innovation Award for ‚oncoflow‘
- First Digital Operating Room Summer School – DORS 2014

2013

- TPU including ‚oncoflow‘ launched at Leipzig University Hospital
- PascAL (Patient Simulation Models for Surgical Training and Teaching) – research project by Leipzig University and HTWK Leipzig
- ICCAS plays a key role in the national BMBF research project ‘OR.Net – Safe and Dynamic Networks in the Operating Room’
- Honorary Professorship of Biomedical Information Systems at the HTWK Leipzig: Thomas Neumuth
- Project ‘HWS – Structural Defect Classification and Modeling of the Cervical Spine’ in cooperation with the Institute of Anatomy (Leipzig University) and the Fraunhofer IWU, Dresden
- Researcher exchange programs with University of Southern California, ARTORG Center for Biomedical Engineering Research (University of Bern) and Fraunhofer MEVIS in Bremen

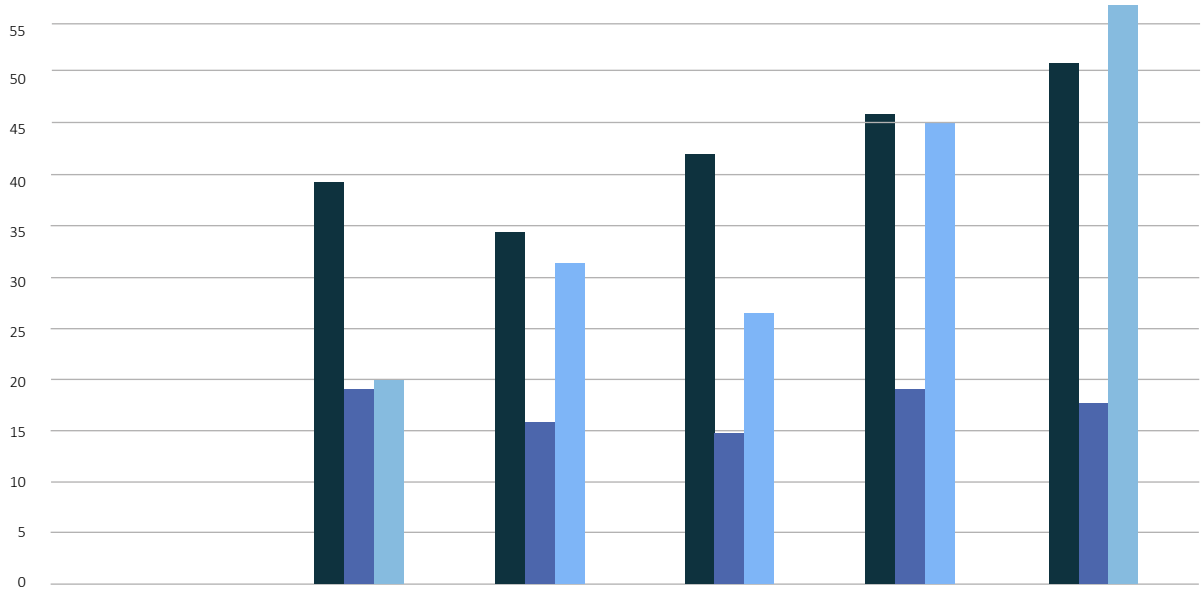
2012

- ICCAS starts academic courses at HTWK
- RESEARCH AREA: Digital Patient Model (Dr. Kerstin Denecke) starts

#1 KPI, NETWORK, HONORS AND AWARDS

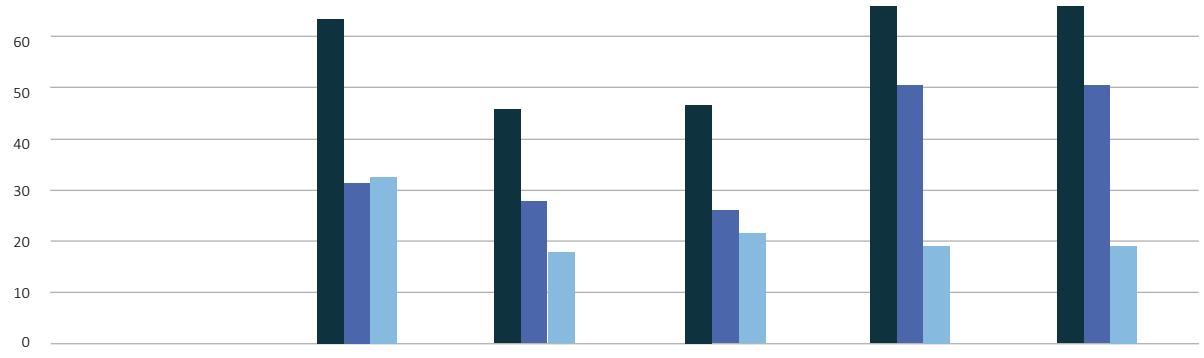
#1.1 KEY PERFORMANCE INDICATORS

HEADCOUNT



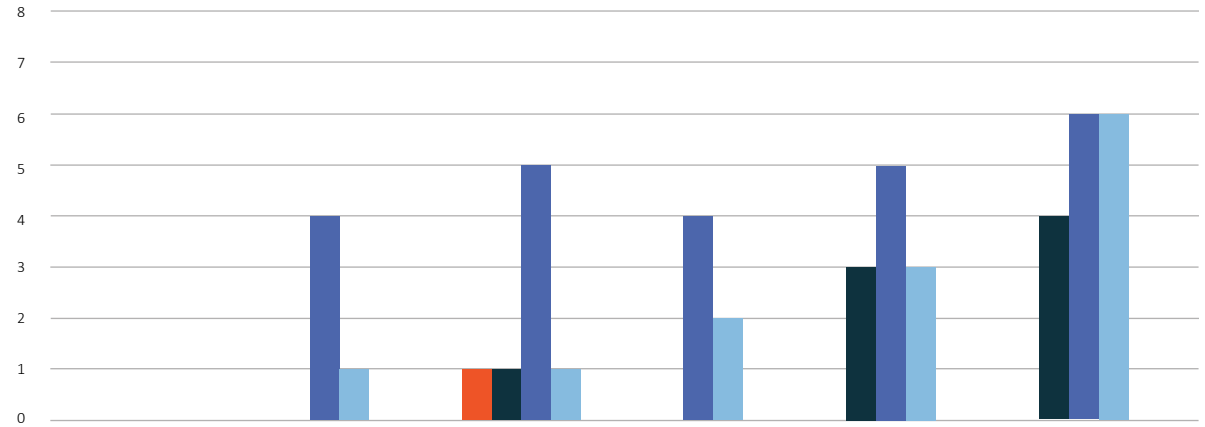
	2018	2019	2020	2021	2022
Research Associates	39	34	42	46	51
Research Assistents	18	16	14	18	17
Guest Researchers	20	32	26	45	57

PUBLICATIONS



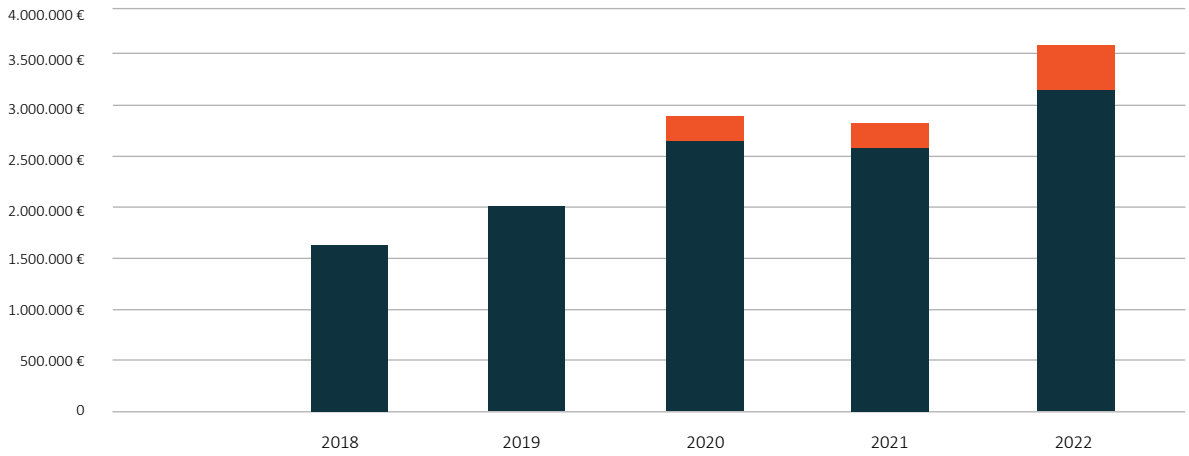
	2018	2019	2020	2021	2022
Total	63	46	47	69	69
Journalpublications	31	28	26	50	50
Conference Proceedings & Book Chapters	32	18	21	19	19

GRADUATIONS



	2018	2019	2020	2021	2022
Habilitation	0	1	0	0	0
Doctoral theses	0	1	0	3	4
Master theses	4	5	4	5	6
Bachelor theses	1	1	2	3	6

FUNDING

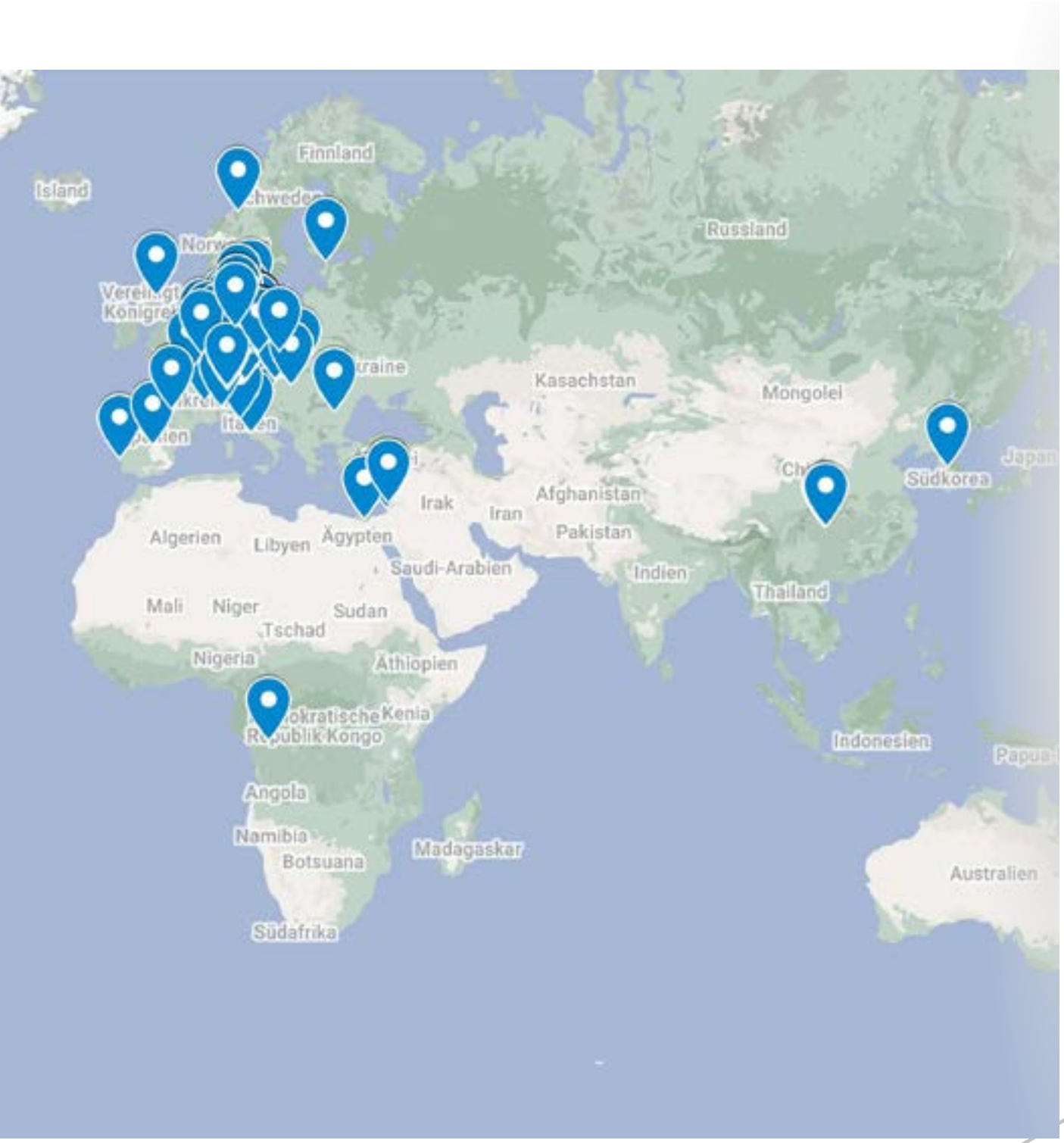


ICCAS' main funding is provided by the BMBF - Federal Ministry of Education and Research. Furthermore, ICCAS receives funding from the BMWi - Federal Ministry for Economic Affairs and Energy for projects related to the ZIM Central Innovation Program for small and medium-sized enterprises. Leipzig University's Faculty of Medicine provides ICCAS with performance-based funding.

Amount of ICCAS industry-funded project output.

#1 KPI, NETWORK, HONORS AND AWARDS

#1.2 NETWORK AND COOPERATIONS


Finnland
Island
Russland
Kasachstan
Mongolei
Südkorea
Irak
Iran
Afghanistan
Pakistan
Algerien
Libyen
Ägypten
Saudi-Arabien
Indien
Thailand
Mali
Niger
Sudan
Tschad
Nigeria
Äthiopien
Kenia
Indonesien
Angola
Namibia
Botsuana
Madagaskar
Australien
Südafrika

#1 KPI, NETWORK, HONORS AND AWARDS

#1.3 SELECTED HONORS AND AWARDS

SEVERAL MEMBERS OF THE ICCAS TEAM HAVE RECENTLY BEEN RECOGNIZED FOR THEIR EXCEPTIONAL WORK IN THE FIELD OF MEDICAL RESEARCH:

Hannes Köhler was awarded the second prize for patient safety in medical technology by the German Society for Biomedical Engineering (VDE DGBMT) and the Patient Safety Action Alliance for his contribution on a laparoscopic system for high-resolution color video and simultaneous hyperspectral imaging in the visible and near-infrared range.

Madeleine Thomassen received the „Boston Scientific Innovation Prize of the CAES 2022“ at the 51st Congress of the German Society for Endoscopy and Imaging Procedures e.V. in Potsdam for her oral presentation on the clinical evaluation of a hyperspectral imaging system for minimally invasive surgery. This new endoscopic system was developed in collaboration with the clinic and polyclinic for visceral, transplant, thoracic and vascular surgery, the company Diaspective Vision GmbH, and led by PD Dr. Claire Chalopin of the Intraoperative Multimodal Imaging team.

Reinhard Fuchs and his co-authors were awarded the 1st Prize of the CARS 2022 Best Paper Award for their publication on a system for analyzing differences in movement and muscle activation during surgical training.

Dr. Marianne Maktabi was selected for the esteemed DFG-Program supporting aspiring scientists, which is dedicated to the topic of AI in Radiology. Her work on tissue identification and semi-automatic decision-making processes using HSI for minimally invasive surgery, with a focus on applications for colorectal carcinoma, has earned her targeted support towards drafting her own DFG funding proposal.

Professor Andreas Melzer has been invited to continue his guest professorship at the National Cancer Center Graduate School of Cancer Science and Policy in Seoul until autumn 2025.

Finally, Professor Thomas Neumuth has been appointed as a panel member of the EIC Pathfinder Challenges program, where he will lend his expertise to evaluate proposals and select the most promising projects to receive funding.

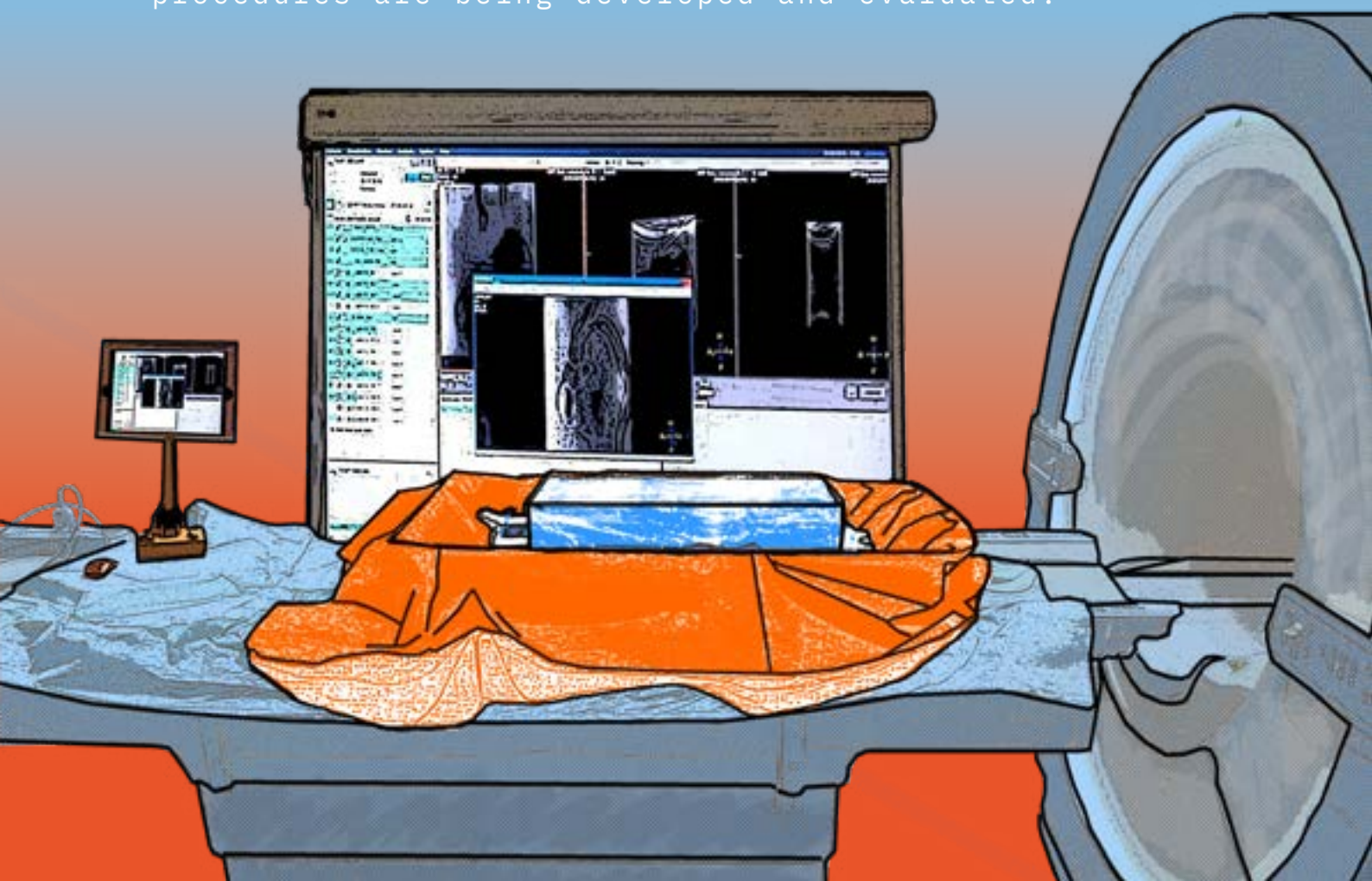
#2 RESEARCH ACTIVITIES

Interrelated research: #Computer_Assisted_Image_Guided Interventions
#Model_Based_Automation_and_Intelligent_OR
#Intraoperative_Multimodal_Imaging
#Biomedical_Data_Analysis

ICCAS

#2.1 COMPUTER_ASSISTED_IMAGE_GUIDED INTERVENTIONS

The research is focused on advancing new technologies for MRI-guided procedures that enable minimally and non-invasive approaches for diagnosis and treatment. In addition to providing improved soft tissue contrast, MRI offers benefits such as the absence of iodine-containing contrast agents and ionizing radiation. The project's goal is to develop innovative MR-compatible instruments, explore suitable medical workflows with limited patient access, and investigate communication within the MR environment. The application of focused ultrasound, transfer of minimally invasive catheter intervention, and robotic-assisted procedures are being developed and evaluated.



LEAD

Prof. Dr. Andreas Melzer

´ICCAS researches on new technologies for computer-assisted image-guided procedures. This theme is a logic development of the traditional ICCAS research on computer-assisted surgery towards less invasive image-guided surgery and interventions.´

SCIENTIFIC STAFF

Denis Bajestani, Johann Berger, Andreas Eger, Till Handel, Lisa Landgraf, Christina Mulik, C. Martin Reich, Michael Unger

SELECTED PUBLICATIONS

- Landgraf L, Kozlowski A, Zhang X, Fournelle M, Becker FJ, Tretbar S, Melzer A. Focused Ultrasound Treatment of a Spheroid In Vitro Tumour Model. Cells. 2022;11(9):1518. DOI: https://doi.org/10.3390/cells11091518

- Köhler H, Pfahl A, Moulla Y, Thomaßen MT, Maktabi M, Gockel I, Neumuth T, Melzer A, Chalopin C Comparison of image registration methods for combining laparoscopic video and spectral image data. Sci Rep. 2022;12(1):16459. DOI: https://doi.org/10.1038/s41598-022-20816-1

- Tretbar SH, Fournelle M, Speicher D, Becker FJ, Anastasiadis P, Landgraf L, Roy U, Melzer A. A Novel Matrix-Array-Based MR-Conditional Ultrasound System for Local Hyperthermia of Small Animals. IEEE Trans Biomed Eng. 2022;69(2):758–70. DOI: 10.1109/TBME.2021.3104865

#RESEARCH_DIVISION
#2.1 COMPUTER_ASSISTED_IMAGE_GUIDED INTERVENTIONS

SCIENTIFIC RESEARCH AREAS AND RELATED PROJECTS:

#2.1.1 IMAGE_GUIDED_FOCUSED_ULTRASOUND – IGFUS:

- CURE-OP | Combinational Ultrasound and Radiotherapy Enhanced Oncology Platform | Funding: BMBF
- Imaging Robotics | Concepts for Robotic-guided Focused Ultrasound Hyperthermia and Radiation Therapy in the Clinic | Funding: Freistaat Sachsen – SMWK
- Prepositioning avatera | Optimizing the Positioning Principles of a Novel Robotic System | Funding: avateramedical GmbH
- MRgFUS | Non-invasive Magnetic-Resonance-Guided Focused Ultrasound (MRgFUS) for the Treatment of Uterine Fibroids – Collaborative Project with UKL
- 3MPFUS | Multi-modality, Multi-purpose and Multi-platform Focused Ultrasoundsystem-Neuromodulation in Rare Neuropsychatric Disorders with Focused Ultrasound | Funding: BMBF

#2.1.2 MAGNETIC RESONANCE-GUIDED INTERVENTIONS – MRGI – LEAD: C. MARTIN REICH:

- MR-Thrombosis-Theranostic | MRI-guided Minimally Invasive Diagnostic and Therapy of Thrombosis | Funding: BMBF
- MR-Biopsy | MR Compatible Biopsy Forceps for Minimally Invasive Tissue Sampling | Funding: BMBF
- MR-Stents | MR-Guided Stent-Implantation |Funding: BMBF

Fig. 1: Prototypical system consisting of a Kuka LBR Med robotic arm with the treatment head attached.

Fig. 2: The setup of two KUKA lbr iiwa 7 R800 robot arms (KUKA AG, Augsburg) in the demonstrator OR at ICCAS Leipzig.

#2.1.1 RESEARCH AREA: IMAGE GUIDED FOCUSED ULTRASOUND – IGFUS

CURE-OP – COMBINATIONAL ULTRASOUND AND RADIOTHERAPY ENHANCED ONCOLOGY PLATFORM

The CURE-OP project seeks to develop a high-intensity focused ultrasound (HIFU) platform commercially available for combinational cancer therapy. ICCAS is working on developing a robotic system that can provide a wide range of ultrasound regimes, including hyperthermia, thermal ablation, and cavitation. This system will allow for different types of cancer polytherapy. To achieve this, the project combines a Kuka LBR Med robotic arm with Theraclion's HIFU treatment head.

ICCAS is also developing motion algorithms to ensure a stable acoustic coupling of the treatment head. To validate the developed algorithms, a clinical study is being carried out in collaboration with the ENT department of the Leipzig University Medical Center. The study involves obtaining data sets of CT, MRI, and US scans. The project aims to provide an innovative and effective way to treat cancer with minimal invasiveness and better patient outcomes.

IMAGING ROBOTICS

The ICCAS robotics group is working to integrate robotic systems into the clinical workflow of image-guided interventions. The group's primary aim is to develop a robotic control software that can be adapted for multiple use-cases, increasing the robots' usability in the clinic. The KUKA lbr iiwa 7 R800 and Med robotic arms have collaborative concepts that allow direct user interaction during automated movement, making them easier to handle during surgical workflows. (Fig. 2) To facilitate connectivity between medical devices, ICCAS researchers utilized the IEEE 11073 SDC standard for medical device connectivity, creating a demonstrator with two robot arms that communicates with other SDC medical devices in the same network. The group published a feasibility study for ultrasound-guided biopsies in the „Frontiers in Robotics and AI" journal.

PREPOSITIONING AVATERA

ICCAS is collaborating with avateramedical GmbH to investigate the optimization of a novel robotic system for laparoscopic interventions. In collaboration with the urology department of the University of Leipzig Medical Center, ICCAS has defined the requirements for the pre-positioning of the system at the OR-table and transferred them into robotic workspace simulations. The aim is to provide an intuitive approach for the side-docking

Fig. 3: The avatera robot model in the simulation environment CoppeliaSim.

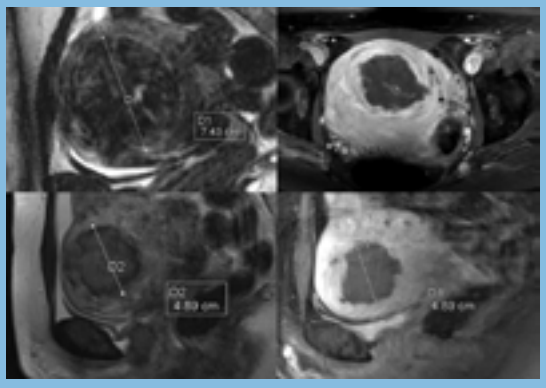


Fig. 4: Diagnostic T2-weighted- and contrast-enhanced- MR-images before, immediately and 6 months after MR-HIFU of a 39-year-old patient with a big intramural fibroid and hyper-/dysmenorrhea. Volume reduction and complete absence of symptoms 6 months after HIFU treatment was achieved, although the fibroid was not to 100% ablated (71% NPV).

process of the robot at the OR-table as well as an optimized positioning of the robot arms at the patient, for the best possible workspace during the intervention. The simulations were performed with a 3D model of the avatera system, provided by ITK Engineering GmbH, to isolate the best parameters for efficient positioning. This included the height of the robot, the docking angle at the OR-Table, the distance to the patient and the work angle of the trocar holders on the patient. ICCAS has developed a guidance manual for the side docking of the system and is currently investigating its feasibility for radical prostatectomies and combined hysterectomy and lymphadenectomy.

MRGFUS – MAGNETIC RESONANCE IMAGING GUIDED FOCUSED ULTRASOUND IN THE TREATMENT OF UTERUS MYOMATOSUS

In 2017, Leipzig University Hospital established a treatment center for symptomatic uterine myomas, with a focus on individualized treatment options. The center offers modern therapy options, including MRgFUS (Profound Medical Sonalleve MR-HIFU System), with over 300 patients screened and 71 successfully treated since installation (Fig. 4). Patients are treated in a clinical setting, under analgesia and sedation, and discharged on the next day after treatment without significant complaints. Approximately 2/3 of patients achieved symptom control, and three successful pregnancies have resulted from the treatment. In addition, the center successfully performed a multisession MRgFUS-treatment of four desmoid tumors of the thoracoabdominal wall with control of growth. The center's focus on individualized treatment options has resulted in successful outcomes for patients with symptomatic uterine myomas.

3MP-FUS: MULTI-MODALITY, MULTI-PURPOSE, AND MULTI-PLATFORM FOCUSED ULTRASOUND SYSTEM – "NEUROMODULATION IN RARE NEUROPSYCHIATRIC DISORDERS WITH FOCUSED ULTRASOUND. "

The 3MP-FUS project aims to develop a multi-modal, platform-independent focused ultrasound (FUS) system for neuromodulation in dystonia and rare forms of Parkinson's disease. Unlike currently available clinically approved MRI-guided FUS systems, the 3MP-FUS system will be flexible and cost-effective for use in different MRI and PET/MRI scanners. In 2022, ICCAS analyzed the clinical requirements for the system and reviewed the specifications. The installation requirements for the new dedicated demonstrator MRI were checked and clarified with the Department of Diagnostic and Interventional Radiology. Experiments were started to visualize the FUS transducer inside the MRI bore for better control of its position during the in-

Fig. 5: MR-marker tests and positioning of the FUS transducer in PET/MRI at Department of Nuclear Medicine, Leipzig.

Fig. 6: Silicone-based patient model for simulation of MRI-guided vena cava filter (VCF) delivery with implanted VCF with introduced in-vitro thrombus (white arrows).

tervention (Fig. 5). Additionally, solutions for holding and positioning the transducer at the patient's head were developed. The ultimate goal is to precisely target circumscribed brain regions and alter their function through the integration of the 3MP-FUS system into different MRI and PET/MRI.

#2.1.2 RESEARCH AREA: RESEARCH AREA: MAGNETIC RESONANCE-GUIDED INTERVENTIONS – MRGI

MR-THROMBOSIS-THERANOSTICS – MRI-GUIDED MINIMALLY INVASIVE DIAGNOSTIC AND THERAPY OF THROMBOSIS

MR-THROMBOSIS-THERANOSTICS is an integrated approach that utilizes MR imaging to improve thrombosis diagnosis and treatment. The approach conforms to MR Safety and compatibility regulations and involves iterative development of novel medical instruments and workflows.

With integrated resonant circuits the MR signal is locally enhanced, allowing visualization of thromboembolisms that are trapped in implanted vena cava filters or blocked peripheral arteries. A silicone-based patient model of a human arteriovenous vessel system was used for in-vitro testing of devices and workflows, and testing conditions were made lifelike by incorporating in-vitro blood clots and connecting a pulsatile flow pump system (Fig. 6).

Additionally, a technical setup for interventional MRI was developed to enable real-time control and communication between the physician and technical staff. Successful first procedures were conducted with the patient model, and an animal trial has been authorized for validation using a porcine model.

MR-BIOPSY – MR COMPATIBLE BIOPSY FORCEPS FOR MINIMALLY INVASIVE TISSUE SAMPLING

Endomyocardial biopsy (EMB) is a procedure commonly used for diagnosing tumor, acute myocarditis, or transplant rejection. Unfortunately, this procedure often involves X-ray fluoroscopy, which exposes patients to ionizing radiation and nephrotoxic contrast agents, particularly affecting young patients requiring recurring examinations.

The MR-BIOPSY joint project aimed to address these challenges by developing a flexible EMB forceps that conforms to MR Safety regulations standards (MR Conditional according to ASTM F2503). In an iterative development process, we achieved MRI-visibility with novel MRI markers based on passive paramagnetic nanoparticles.

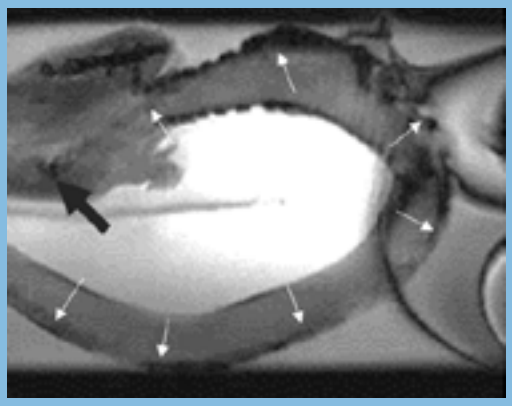


Fig. 7: Realtime-MRI during Endomyocardial biopsy (EMB) in a hybrid silicone patient model. Shaft (white arrows in aorta) and head (black arrow inside left ventricle) of the bioptome are visible due to passive MRI artefacts.

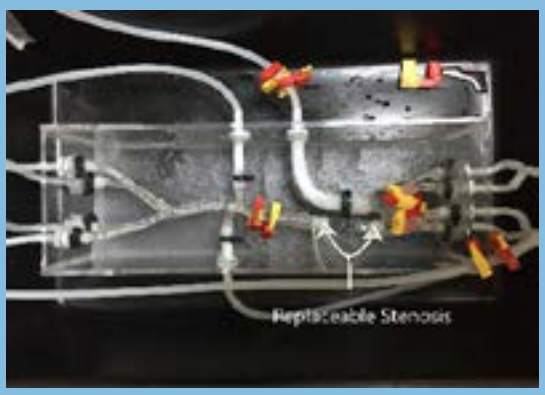


Fig. 8: MR Safe vascular phantom with flow simulation for testing samples in realtime-MRI.

In cooperation with the Department of Cardiology at the University of Leipzig Medical Center, a corresponding clinical workflow was developed, and an MR Safe hybrid patient model of a silicone-based human arterial vessel system connected to a Thiel soft embalmed porcine heart was manufactured. This model was used to demonstrate general usability and visibility in both the cardiac catheterization laboratory and the MR environment, and a successful MRI-guided EMB was performed (Fig. 7).

MR-STENTS – MRI-GUIDED STENT IMPLANTATION

The MR-STENTS project aims to enable MRI-guided stent implantation, avoiding the risks of ionizing radiation for children with congenital heart disease. The project involves developing devices in collaboration with OEM medical device manufacturers conforming to MR safety and compatibility regulations, including novel MR markers based on paramagnetic nanoparticles or resonant circuits to visualize the stent implantation process.

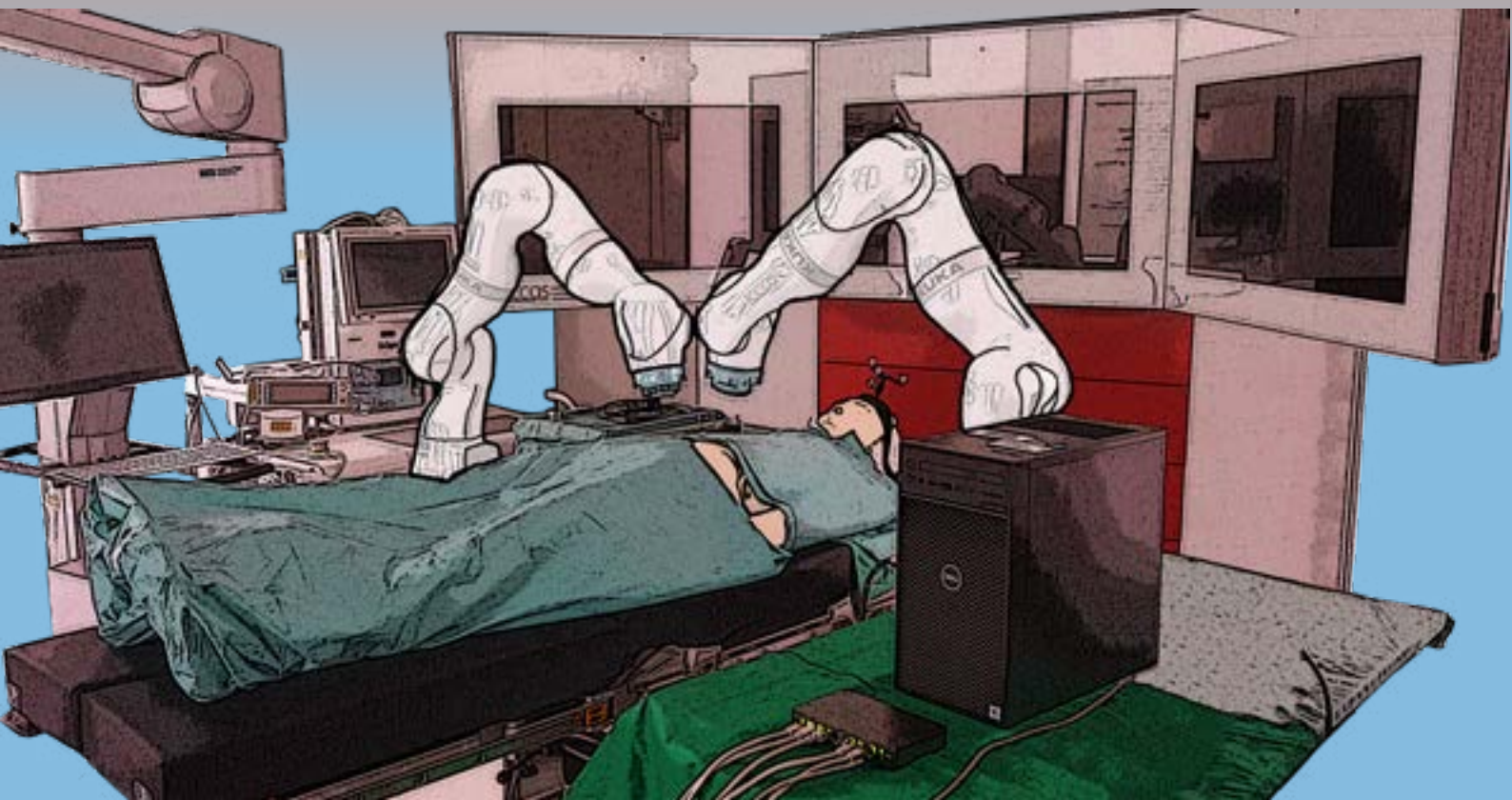
An MR Safe stenosis-phantom was manufactured to simulate stent implantations and validate developed medical devices and workflows in the MR environment. Animal trials will be conducted using a porcine model to further validate the developed intervention.

The project findings may provide a framework for treating additional use-cases, such as stenting other vascular diseases, the esophagus, liver, and trachea-bronchial system (Fig. 8).

ICCAS

#RESARCH_DIVISION #2.2 MODEL_BASED_MEDICINE AND #INTELLIGENT_OR

Our research focus is the integration of biomedical device technology with medical information systems and data analysis technologies, medical communication technologies, digital twins, and biomedical sensors. Cardinal point of these innovations are “smart” health care technologies, such as operating theatres that adapt to the needs of surgeons or medical technologies using 5G infrastructures for advanced communication. Purpose is the qualitative and quantitative improvement of clinical workflows by refining clinical efficiency and increasing patient safety.



LEAD

Prof. Dr. Thomas Neumuth

´Modern medicine is no longer conceivable without the use of technology: medicine, information management and biomedical technology converge to an ever greater extent. This development requires a combination of traditional medical devices.´

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- Gaebel J, Mehlhorn S, Oeser A, Dietz A, Neumuth T, Stoehr M. Clinical decision support models for oropharyngeal cancer treatment: design and evaluation of a multi-stage knowledge abstraction and formalization process. Int J Comput Assist Radiol Surg. 2022; 17(9): 1643-1650. DOI: 10.1007/s11548-022-02675-3

#RESARCH_DIVISION #MODEL_BASED_MEDICINE AND #INTELLIGENT_OR

SCIENTIFIC RESEARCH AREAS AND RELATED PROJECTS:

#2.2.1 MODEL_BASED_AUTOMATION:

- MOMENTUM | Mobile Medical Technology for Integrated Emergency Care and Trauma Medicine | Funding: BMBF
- COMPASS | Comprehensive Surgical Landscape Guidance System for Immersive Assistance in Minimally-invasive and Microscopic Interventions | Funding: BMBF
- EOS | Emergency Medical Team Operating System
- Tri5G | Mobile Medical Technology in a Trimodal Model Region - 5G-Use Cases for Emergency Care in a Public Mobile Network | Funding: BMDV
- MediNET | Platform for Networking Medical Technology Products | Funding: STARK
- EYEHEARU | Multimodal Acquisition, Simulation and Audiovisual Enhancement for the Individual Training of Basic Functional Laparoscopic Skills | Funding: DFG
- SCADS.AI | Center for Scalable Data Analytics and Artificial Intelligence – Collaborative project | Funding: BMBF
- SDC-CSM – SDC – ControlStation Med | Integration of the New SDC Communication Protocol Family into the Daily Workflow of Technical Staff Members in Clinical Environments – collaborative project with GADV mbH | Funding: BMWI
- SDC- VAS – SDC – Distributed Alert System | Development of a Distributed Alert System-based on the IEEE 11073 SDC- Standards | Funding: BMWK – ZIM-Program
- 6G-Health | Holistic Development of High - Performance 6G Networking for Distributed Medical Technology | Funding: BMBF

#2.2.2 DIGITAL_PATIENT_MODEL:

- MPM | Models for Personlized Medicine | Funding: BMBF
- AIQNET | The Medical Data Ecosystem | Funding: BMWi
- KAIT | Knowledge-Driven and Artificial Intelligence-based Platform for Therapy Decision Support in Hematology | Funding: Janssen Pharmaceutica
- ProDial | Patient-reported Outcome, Biodata and Process Data to Evaluate Dialysis Tolerability | Funding: ERAPerMed
- VISION-CRE | Platform for Evidence-based Modeling of Cognitive Reasoning Processes to Support Therapy Decision-making | Funding: Go-Bio Digital BMBF
- PAPA-ARTIS | Patient-based Individual Modeling of Paraspinal Collateral Network Perfusion after Segmental Artery Occlusion | Funding: European Union – H2020 – GA-no. 733203
- GenoMed4All | Genomics and Personalised Medicine for all through Artificial Intelligence in Haematological Diseases | Funding: European Union – H2020 – GA-no. No 101017549.
- SaxoCell | Automation Platform for Cell Product Manufacturing | Funding: BMBF
- NFDI4DS | NFDI for Data Science and Artificial Intelligence | Funding: DFG

Fig. 9a: Internal structure of the networked ambulance as CAD model.

Fig. 9b: AR application for visualization of multidimensional data.

- GAIA-X | Integration Interface Digital Patient Model | Funding: Acatech Plattform Lernende Systeme

#2.2.3 LIFE_SUPPORT_SYSTEMS:

- VITALS | Visualization of Thorax-related Analysis of Life-Signals | Funding: BMWi – ZIM-Program
- Brainsaver | Development of Robust Methods for Sensor Position Evaluation and Interference-free Blood Flow Detection | Funding: BMWi – ZIM-Program

#2.2.1 RESEARCH AREA: MODEL BASED AUTOMATION AND INTEGRATION – MAI

MOMENTUM – MOBILE MEDICAL TECHNOLOGY FOR INTEGRATED EMERGENCY CARE AND TRAUMA MEDICINE

The MOMENTUM project is evaluating the use of 5G mobile communications technology for emergency medical care. A 5G small cell connects medical devices, a HoloLens, and a mobile Edge-Cloud in the ambulance, while a public mobile communications network connects to hospitals or telemedical facilities (Fig. 9a,9b).

Networking technologies are used to develop value-added services for both the trauma team in the clinic and the emergency team in the field. The integration of network and computing components into the ambulance was completed in 2022, enabling the transmission and processing of medical data in the ambulance and further use in clinical systems.

The development process involved an extensive evaluation in various clinics, with feedback incorporated from medical users at an early stage. The final six months of the project will involve completing integration work and conducting technical and clinical evaluation studies (Fig.10).

COMPASS – COMPREHENSIVE SURGICAL LANDSCAPE GUIDANCE SYSTEM FOR IMMERSIVE ASSISTANCE IN MINIMALLY-INVASIVE AND MICROSCOPIC INTERVENTIONS

The COMPASS project developed a new technology for immersive assistance during minimally invasive and microscopic interventions. The aim was to provide assistance functions by identifying, modeling, and predicting context-relevant information from process and image data during a procedure (Fig. 11).

Navigation steps were initially described in natural language (NLP) to create an instruction-like commentary on the movement of the endoscope. A neural machine translation model was trained to predict future navigation steps of the endoscope, and this was successfully demonstrated.

The translation model was then extended to generate surgical reports from intra-operati-

Fig. 10: Demonstartion of the MOMENTUM ambulance in Mainz.

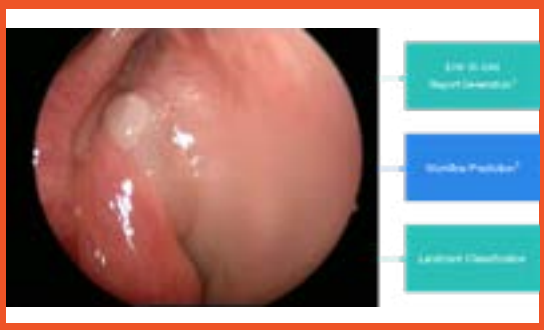

Fig. 11: "The COMPASS principle formulti-task deep learning models in minimally-invasive surgery to emulate navigation awareness"

ve comments, previous surgical reports, and endoscopic video data. In the final step, the model will also perform classification tasks during the procedure, allowing for a comprehensible navigation aid through navigation awareness.

Computed image properties will reinforce sentence descriptions to further enhance the system.

EOS – EMERGENCY MEDICAL OPERATING SYSTEM

The EMT Operating System (EOS) is a field hospital information system designed for Emergency Medical Teams (EMTs) on disaster relief missions. The system supports the entire patient treatment process from triage to discharge and is highly configurable to adapt to the needs of the EMT.

EOS is primarily designed as an electronic patient record but also includes essential functions for EMT mission and field hospital management. It enables quick department configuration, visualization of important hospital key performance indicators, and reporting functionalities to local government or the WHO.

The system is tailored to the requirements of EMTs and can be easily adapted to their needs. EOS is an important tool for EMTs on disaster relief missions, providing essential functions for patient management and treatment documentation.

TRI5G – MOBILE MEDICAL TECHNOLOGY IN A TRIMODAL MODEL REGION - 5G-USE CASES FOR EMERGENCY CARE IN A PUBLIC MOBILE NETWORK

The emergency medical care of patients both inside and outside the hospital involves a complex system of interdependent processes, requiring the quick and easy availability of medical resources, information access, and medical expertise.

The Tri5G project evaluates the use of 5G-mobile communications technology to enhance emergency medical care. A 5G small cell is used within the ambulance, and the tri5G public mobile communications network connects the ambulance to the hospital or telemedical facility.

Tri5G carried out latency and throughput tests for video and data transmission within public and private mobile 5G networks, measuring the correlation between network parameters and throughput. An application for a public 5G research network was published and applications collected. The start of a public mobile 5G network and assistance for the project is expected in January 2023.

Fig. 12: Overview of the project goals of the audiovisual feedback during laparoscopic training.

This will enable the transmission and processing of medical data in the ambulance, as well as further use in clinical systems. The architecture for ICCAS use cases was also drawn.

MEDINET – PLATFORM FOR NETWORKING MEDICAL TECHNOLOGY PRODUCTS

In medicine, digitization and interoperability for location and device-independent access to clinical data are becoming increasingly important. However, there are challenges such as the lack of standardized, interoperable interfaces, the complexity of the clinical IT ecosystem, and the requirements for data protection and security.

MediNET aims to establish the necessary interconnections between clinics, research, and companies. ICCAS runs a Transfer center to assist health care providers and companies with organizational and technical challenges when introducing novel products into the medical environment.

ICCAS scientists are developing a technical platform that facilitates clinical studies and innovative treatment strategies with networked medical products. The platform addresses the entire spectrum, from mobile point of care devices to clinical information systems, based on established international standards and new technologies.

In cooperation with regional companies, the next generation of medical products will be integrated into clinical processes and digital infrastructures in the university hospital Through MediNET, ICCAS contributes to the establishment of digitization and interoperability in medicine, ultimately leading to better patient care.

„EYEHEARU" – MULTIMODAL ACQUISITION, SIMULATION AND AUDIOVISUAL ENHANCEMENT FOR THE INDIVIDUAL TRAINING OF BASIC FUNCTIONAL LAPAROSCOPIC SKILLS

Minimally-invasive endoscopic surgery is a common surgical practice, but it poses challenges for both surgeons and equipment due to decoupled hand-eye coordination, limited field-of-view and operating space, and decreased depth perception. Surgeons must train their spatial awareness and instrumentation skill through physical and virtual simulators, but training effectiveness and skill transfer to the operating room are unpredictable.

In this project, we are developing software tools for a novel training assistance system that acquires multimodal data of individual laparoscopic exercises to predict current and overall training progression. The training system provides aural and visual feedback cues to improve performance. A physical simulator

Fig. 13: Visual representation of an OR with attached devices and their technical status. The perfusor is not ready for use (red status and error message).

was extended with multiple sensor components to generate a knowledge base of basic bimanual laparoscopic skills. Training progression and quality are currently improved through explainability methods in Machine Learning (Fig. 12).

This system aims to improve the training effectiveness of laparoscopic skills by providing individualized feedback and assessment, ultimately leading to better surgical outcomes.

SCADS.AI – CENTER FOR SCALABLE DATA ANALYTICS AND ARTIFICIAL INTELLIGENCE

ScaDS.AI is a newly established center for Artificial Intelligence (AI) in Germany with the aim to promote the efficient use of large amounts of data in industry and research using advanced AI methods. Research topics at ScaDS.AI cover foundational AI methodology and application of AI in areas such as engineering, environmental systems, industry, and biomedical research. Local companies and scientific institutions are involved in cooperation to achieve the goals. Additionally, ScaDS.AI considers ethical and societal perspectives to increase public trust in AI and provides research availability through transfer services and Living Labs. ScaDS.AI and ICCAS are collaborating to advance AI in the life sciences, focusing primarily on personalized medicine using model-based approaches. This collaboration includes sharing research expertise and computing resources.

SDC - CONTROLSTATION MED – INTEGRATING THE IEEE 11073 SDC STANDARD INTO A NOVEL CONTROL STATION

The joint project 'SDC – Control Station Med' between GADV mbH and ICCAS aims to integrate the SDC communication protocol family into the daily workflow of technical staff in clinical environments. The project will connect all SDC-able medical devices in departments such as intensive care units, laboratories, and operation rooms to a control station located in the medical-technical department. The goal is to provide different services such as automatic error handling, documentation, visualizing the system status, and management ratios to facilitate work processes. A first demonstrator has already been implemented, including functions like the aggregation and evaluation of technical SDC alarms. The project is expected to be completed by August 2023 (Fig. 13).

SDC - DISTRIBUTED ALTERT SYSTEM (SDC-DAS) – DEVELOPMENT OF A DISTRIBUTED ALERT SYSTEM BASED ON THE IEEE 11073 SDC STANDARD

The SDC-VAS project aims to develop an intelligent distributed alarm system that reduces

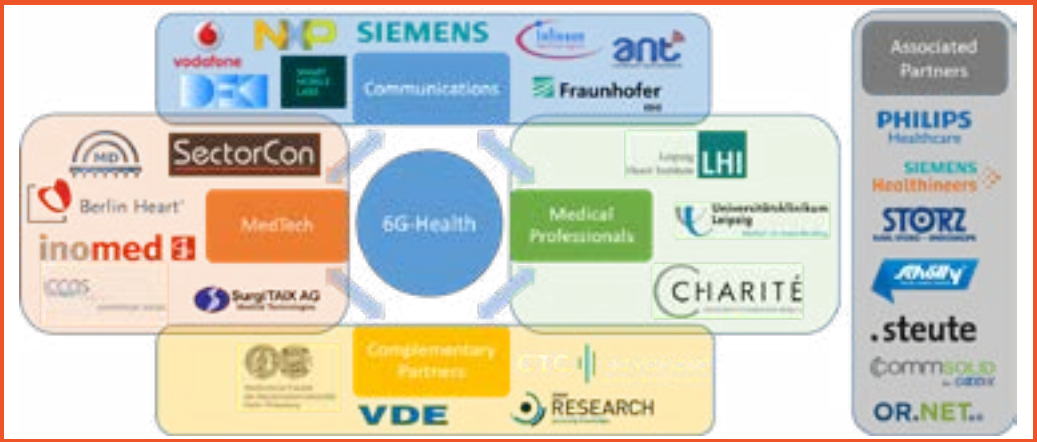

Fig. 14: 6G Research and Innovation Cluster (6G-RIC) – Expertise from the various research fields: mobile communications, artificial intelligence and optical data transmission and compression are combined

alarm fatigue and noise pollution in intensive care units. The project will utilize the IEEE 11073 SDC communication standard to network medical devices in an open, secure, and vendor-independent manner. In addition, data from additional sensors and the clinical information system will be integrated and evaluated to provide targeted alarm distribution. The potential for alarm prediction using machine learning algorithms will also be explored. The project will focus on implementing and extending the SDC standard, developing an aggregated data model, and designing an intelligent alarm distribution system with machine learning algorithms. The project aims to improve patient outcomes and reduce stress for medical personnel by creating a more effective and efficient alarm system.

6G-HEALTH – HOLISTIC DEVELOPMENT OF HIGH-PERFORMANCE 6G NETWORKING FOR DISTRIBUTED MEDICAL TECHNOLOGY

The 6G-Health project is a collaborative effort between the fields of communications engineering and medical technology, with the aim of developing tailored technology in the area of sixth-generation mobile communications (6G). The project encompasses the development of specific 6G technology components, as well as the early identification of market entry barriers and the development of countermeasures, such as approval, operation, and standardization. The technical core of the project involves the integration of sensor technology in 6G, the development of technologies for enhanced network intelligence, and concepts for intelligent distribution of computing resources and efficient pre-processing of data.

The Leipzig University Medical Center (UML) is focusing on the transfer of ideas and concepts from 6G research into medical technology applications, with a main focus on investigating the optimization of 6G technologies in clinical processes. UML aims to act as a mediator between medicine, communications engineering, and medical engineering, considering not only the technical applications but also the requirements for future technologies through standardization and operation. The project is intended to highlight a wide range of future challenges and opportunities in medical applications and will closely collaborate with experts from various domains to prepare for international standardization activities with a focus on medical technology applications. The strategic goals of 6G-Health include developing 6G components for innovative medical applications, analyzing 6G applications with clinical partners, and considering regulatory, technical, and legal frameworks (Fig. 14).

Fig. 15: The project Models for Personalized Medicine develops knowledge graphs, machine learning methods and assistance applications for cancer treatment.

KLINET5G – CLINICAL NETWORK VIA 5G

KliNet5G is a research project exploring the use of Open RAN based 5G technology as the main network technology in a clinic. The aim of the project is to evaluate benefits and challenges for using 5G in hospitals to enable better wireless communications in the future. The project is investigating the benefits for hospital operations and bundling the results into two guides: one for clinic operators and one for medical device manufacturers. Four medical technology applications, including video endoscopy, equipment tracking, constant ECG monitoring, and triggering critical functionalities using a foot switch, are being considered in the project. In 2022, KliNet5G connected with medical users and device manufacturers to develop clinical use cases that demonstrate the benefits of 5G and interconnectivity.

The project is currently in the evaluation phase of these use cases and working with 5G experts to find a suitable technological solution for the demonstrators. Different operator models are being analyzed for business solutions.

#2.2.2 RESEARCH AREA: DIGITAL PATIENT MODEL – DPM

MPM – MODELS FOR PERSONALIZED MEDICINE

The healthcare sector is facing social challenges that demand cost efficiency without compromising therapy effectiveness. Personalized cancer treatments require an abundance of therapy-relevant information, including omics data, imaging, laboratory values, and living conditions. To efficiently provide this data in daily clinical practice and integrate it into decision-making processes, this project aims to establish a scientific and methodological basis for model-based, personalized cancer treatments. Clinical knowledge, such as guidelines and scoring systems, were translated into formal models, and a knowledge graph based on the Resource Description Framework (RDF) was developed to represent patient-related information. The project offers a flexible starting point for integrating personalized tumor therapy into clinical practice. Applications for interdisciplinary treatment and improving patient informed consent have been developed in cooperation with regional SME partners and clinical users. Successful studies and integrations have demonstrated the applicability and the potentialof these assistance systems (Fig. 15).

Fig. 16: Overview of an AI-assisted medical case evaluation using KAIT's internal processing capabilities

Fig. 17: Holistic data gathering of hemodialysis therapy procedures enables the data-driven analysis of various synchronized biomedical data streams to find meaningful correlations for better patient-specific outcome and risk predictions.

NFDI4DATASCIENCE

The NFDI4DS project aims to support the Data Science and Artificial Intelligence community in academia by adapting existing solutions and establishing common interfaces in collaboration with other NFDI consortia. ICCAS leads the subproject on biomedical sciences, which focuses on integrating biomedical data into the overall infrastructure based on the FAIR data principles. Anonymization of case-related data and interoperability of data sources, datasets and software components using standardized interfaces are the main challenges addressed in the project. The subproject will initially focus on four application areas: : clinical workflows, multi modal case related data, medical language technology and biomedical sciences.

KAIT – KNOWLEDGE-DRIVEN AND ARTIFICIAL INTELLIGENCE-BASED PLATFORM FOR THERAPY DECISION SUPPORT IN HEMATOLOGY

The field of hematology faces the challenge of treating a diverse patient population with heterogeneous diseases, often relying on the same therapeutic regimen. With the increasing availability of patient and disease data, physicians must manage and process vast amounts of information during clinical decision-making. The KAIT platform aims to address this issue by providing extensive assistance in managing, processing, and representing clinical data. The platform will utilize knowledge engineering, data mining, and machine learning to generate knowledge bases from multimodal information sources.

KAIT will assist physicians in deriving optimal treatment strategies for individual patients by actively aiding them in reasoning tasks. By doing so, KAIT supports the transition towards personalized therapies in hematology. The platform aims to provide comprehensive assistance to physicians, ultimately enhancing the quality of care for patients (Fig. 16).

PRODIAL – PATIENT-REPORTED OUTCOME, BIODATA AND PROCESS DATA TO EVALUATE DIALYSIS TOLERABILITY

Hemodialysis treatment is vital to end-stage renal disease patients, but it has a high cost and does not prevent high mortality rates. Current quality and process control measures for hemodialysis treatment are limited and do not take into account patient perspectives. The ProDial project aims to develop personalized methods for analyzing dialysis treatments. Time-synchronous data streams will be gathered and evaluated, including patient and therapy characteristics, biomedical real-time feedback, process information, and patient-reported outcomes. Through the development of personalized algorithms, the ProDial project seeks to find significant correlations between the data categories

Fig. 18: Overview of the Papa-Artis work steps.

and enable real-time treatment monitoring and risk prevention. By integrating these algorithms into modern and intelligent dialysis centers, personalized treatment procedures can be developed to benefit patients in the long-term (Fig. 17).

PAPA-ARTIS – PATIENT-BASED INDIVIDUAL MODELING OF PARASPINAL COLLATERAL NETWORK PERFUSION AFTER SEGMENTAL ARTERY OCCLUSION

The repair of large thoracoabdominal aortic aneurysms is a complex endovascular surgical procedure that poses risks of paraplegia or death due to ischaemic reactions in the spinal cord. To reduce these risks, the MISACE procedure is being developed to preemptively close supplying segmental arteries of the aorta. However, clinical guidelines supporting the MISACE procedure are lacking. Patient data from the trial was collected and stored in a knowledge base, with patient-specific parameters extracted, categorized and stored in an overall patient representation. An outcome prediction system for the MISACE procedure was developed using explainable artificial intelligence methods on a trained classifier, with patient parameters included according to the current treatment workflow step. The patient's situation was described in a computer-readable format, using new taxonomic definitions and existing ontologies (Fig. 18).

GENOMED4ALL – GENOMICS AND PERSONALISED MEDICINE FOR ALL THROUGH ARTIFICIAL INTELLIGENCE IN HAEMATOLOGICAL DISEASES

The GenoMed4All project aims to establish a network infrastructure connecting medical institutions across the EU. The project seeks to promote the exchange of clinical data through a federated learning framework that ensures privacy. By incorporating comprehensive clinical data up to multi-OMICS levels, the project intends to enhance quantitative analysis through machine learning and artificial intelligence methods. The project is focused on hematological diseases, which are increasingly complex due to the use of precision diagnostics and personalized therapies. ICCAS is collaborating with the Clinic and Polyclinic for Hematology, Cell Therapy, and Hemostaseology at the University of Leipzig Medical Center to implement federated data integration mechanisms and advanced data standardization based on HL7 FHIR.

SAXOCELL – AUTOMATION PLATFORM FOR CELL PRODUCT MANUFACTURING

ICCAS is working on the SaxoCell Systems project, which aims to develop secure mechanisms for tracking necessary resources in the context of Advanced Therapy Medicinal Products (ATMP) development, including

Fig. 19: Digital Patient Model for Clinical Studies.

findings, cells, and pharmaceutical materials. This is being done using formal process models and interoperable digital resources. A blockchain infrastructure is used to instantiate these digital images and compare them to an ideal process model based on Good Manufacturing Practice (GMP) principles. The goal is to enable seamless traceability for ATMP manufacturing processes, leading to superior and sustainable quality management on the SaxoCell platform.

VISION-CRE – PLATFORM FOR EVIDENCE-BASED MODELING OF COGNITIVE REASONING PROCESS TO SUPPORT THERAPY DECISION-MAKING

Medical decision-making involves a complex consideration of multiple factors and is subject to both, a medical and a regulatory framework where physicians usually rely on indication-specific guidelines to determine the approved treatment options. While these guidelines provide a general framework, they do not account for the vast heterogeneity between patients.

The VISION-CRE project aims to establish a Cognitive Reasoning Engine (CRE) that complements the guideline-based therapy evaluation with a much more granular evidence-based level of outcome assessment. The project focuses on analyzing previously recorded empirical data of the sequence: patient, therapy, and associated outcome to derive valuable conclusions. The overall goal is to assist medical decision-making in a much more personalized and evidence-based way.

AIQNET – THE MEDICAL DATA ECOSYSTEM

The AIQNET project aims to conceptualize and develop a medical data ecosystem that enables compliance with legal and ethical frameworks for acquiring, storing, and analyzing clinical data. The ecosystem will include a database that allows clinics and medical device manufacturers to use clinical data for research and development effectively. ICCAS is collaborating with the Division of Spine Surgery at the University of Leipzig Medical Center to develop a „Digital Patient Model“ (Fig. 19) that integrates different perspectives on the diagnosis, disease, therapies, and patient-specific characteristics. This model will provide relevant data for clinical trials and further clinical research. Additionally, the project will develop and evaluate AI-based assistance systems for clinical decision support, information visualization, and predictive trend analysis. The goal is to improve the clinical quality and performance assessment by incorporating previous knowledge about the patient and treatment. The project is vital due to the increasing requirements for reliable medical device data set by the new Medical Device Regulation of the EU.

Fig. 20: Integration of digital twins to the GAIA-X ecosystem

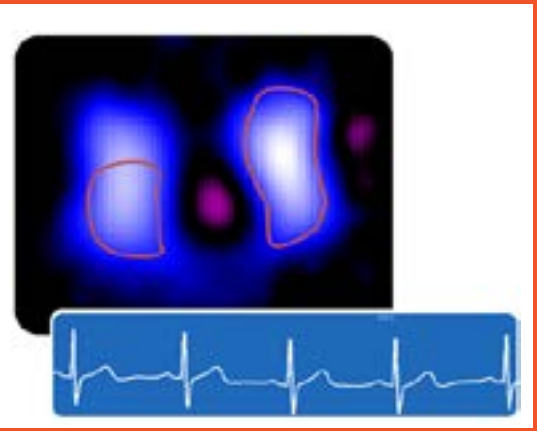

Fig. 21: UP: Reconstructed EIT image with perfused lung areas framed in red; DOWN: ECG curve used for trigger-algorithm

GAIA-X – INTEGRATION INTERFACE DIGITAL PATIENT MODEL

The efficient functioning of healthcare requires the availability of structured and semantically linked data from diverse clinical sources. However, clinical data is often stored in unstructured formats such as continuous text or raw data. To address this, virtual representations of patients called digital twins are being developed to enable the testing and optimization of therapies, minimize risks, and predict individual disease courses using computer models. The GAIA-X initiative aims to create a secure and trustworthy data infrastructure for Europe, facilitating the secure exchange of models, data and services. The project seeks to integrate digital twins into the GAIA-X ecosystem, enabling the sharing of health data between various healthcare institutions in Germany and other EU countries (Fig. 20).

#2.2.3 RESEARCH AREA: LIFE SUPPORT SYSTEMS – LSS

VITALS – VISUALIZATION OF THORAX-RELATED ANALYSIS OF LIFE-SIGNALS

During the VITALS project ICCAS and partners developed an emergency preclinical system capable of measuring and visualizing lung and cardiac activity. It utilizes a combination of electrical impedance tomography (EIT) and electrocardiography (ECG) to produce synchronized images that separate perfusion-related impedance changes from ventilation-related ones. These images can be used to verify balanced ventilation and perfusion in all lung areas, and to identify possible causes of oxygenation problems and accompanying respiratory or vascular issues in individual lung regions. The system has potential to greatly assist emergency medical professionals in assessing and treating patients in urgent situations (Fig. 21).

BRAINSAVER – DEVELOPMENT OF ROBUST METHODS FOR SENSOR POSITION EVALUATION AND INTERFERENCE-FREE BLOOD FLOW DETECTION

Developers of the project BRAINSAVER worked on a system, which aims to improve cardiopul-

monary resuscitation (CPR) outcomes in Germany. Currently, only about 10% of patients who receive CPR have acceptable neurological outcomes. To address this issue, a mobile system has been developed to monitor carotid artery blood flow during resuscitation. The system uses an ultrasound wearable designed to detect the carotid artery and examine movements within the vessels using Doppler sonography. By evaluating the waveform in the Doppler spectrogram, the effective arterial flow is calculated, providing real-time feedback on the resuscitation measures being performed. The recorded data can be further analyzed during subsequent therapy, allowing clinicians to adjust medication, coordinate therapy, and identify patients at higher risk for nerve damage. The non-invasive monitoring system has the potential to significantly improve resuscitation outcomes and patient survival rates.

#2.3 RESEARCH_DIVISION #INTRAOPERATIVE_ MULTIMODAL_IMAGING

LEAD
PD Dr. Claire Chalopin

SCIENTIFIC STAFF
Hannes Köhler, Marianne Maktabi, Annekatrin Pfahl, Michael Unger

PROJECTS
- Sorlic | Development of an Assistance System for the Intra-operative Planning of Flap Surgeries | Funding: BMWI – ZIM-Program
- MSI- Endoscopic | Endoscopic Multispectral Imaging with Real-time Pulse Oximetry System for Medical Applications | Funding: KARL STORZ SE & Co. KG
- HSI- Laparo/Endoscopy | Automated Tissue Recognition and Visualisation with Laparoscopic Hyperspectral Imaging | Funding: KARL STORZ SE & Co. KG
- Multiguard| Development of a Multispectral Patient Monitoring System | Funding: BMWI – ZIM-Program
- CortexMap | Development of a Novel Navigated Transcranial Magnetic Stimulation System for Non-invasive Mapping of the Motor Cortex| Funding: BMWI – ZIM-Program

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  DOI: 10.1364/BOE.452076

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  DOI: https://doi.org/10.1007/s00464-022-09282-y

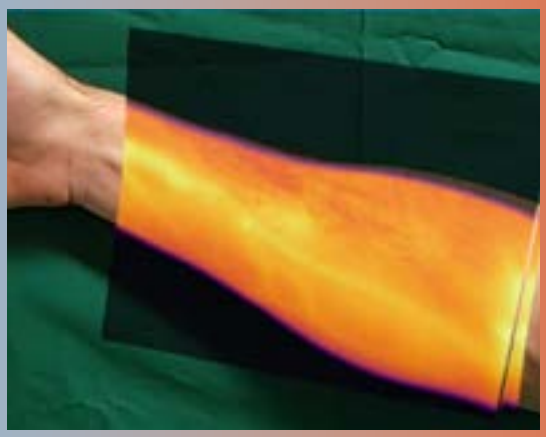

Fig. 23: Augmented reality image of the forearm overlaid with the equivalent thermal image using the Microsoft Hololens V2.

Fig. 24: a) Endoscopic MSI system: I) hand-held camera, II) standard laparoscope, III) light cable, IV) imaging center including light source and computing unit, V) monitor.
b) Tissue oxygenation parameter image of a venously occluded finger.
c) Tissue hemoglobin content parameter image of a venously occluded finger.

#2.3.1 RESEARCH AREA: INTRAOPERATIVE_MULTIMODAL_IMAGING – IMI

SORLIC – DEVELOPMENT OF AN ASSISTANCE SYSTEM FOR THE INTRA-OPERATIVE PLANNING OF FLAP SURGERIES

The SORLIC project aims to develop a non-invasive system to assist in the planning of free flap transplantation for reconstructive surgeries. Traditional imaging methods involve the use of ionizing radiation and/or contrast agents, whereas this project uses infrared thermography to detect the blood vessels supplying the donor tissue. The goal is to provide a non-invasive alternative that enables the surgeon to identify the positions of the blood vessels supplying the donor tissue. A tool to support the surgeon during the planning process and the locations of the blood vessels was developed. An optimal position of the transplant will be visualized using augmented reality (Fig. 23).

MSI ENDOSCOPE – ENDOSCOPIC REAL-TIME PULSE OXIMETRY IMAGING SYSTEM FOR MEDICAL APPLICATIONS

The use of multispectral imaging (MSI) in surgery can provide valuable information beyond what can be seen with the naked eye. ICCAS collaborated with Diaspective Vision GmbH and KARL STORZ SE & Co. KG to develop an endoscopic system that can evaluate tissue perfusion in real-time (Fig. 24a). The system was tested at ICCAS, and the team also developed software to calculate and visualize tissue oxygenation (Fig. 24b) and hemoglobin content (Fig. 24c) as false-color images. The next focus will be on pulse parameters such as the pulsation index. Promising results were obtained in a preclinical study with healthy volunteers.

HSI – LAPARO/ENDOSCOPY: AUTOMATED TISSUE RECOGNITION AND VISUALISATION WITH LAPAROSCOPIC HYPERSPECTRAL IMAGING

The LYSIS project has developed a compact and efficient laparoscopic hyperspectral imaging (HSI) system to assess perfusion intraoperatively. Traditional laparoscopic HSI was limited due to lack of video or large setups, but the new system has a high spatial and spectral resolution. The system was evaluated in two clinical studies during gastrointestinal procedures, where in-vivo and ex-vivo HSI data were acquired and compared with measurements from an approved HSI-system for open surgery. Various registration methods for HSI data with the color video were tested, and the resulting information is visualized using augmented reality methods. The new laparoscopic HSI system has shown promising results, providing surgeons with valuable re-

Fig.25: In-vivo study setup for comparison of open (TIVITA Tissue) and laparoscopic (TIVITA Mini) HSI-System (left). Augmentation of in-vivo video data with HSI: The blue frame indicates the region visible in HSI, used to calculate the static color map representing the tissue oxygenation (top right). Semitransparent overlay of StO2 and the video after registration and post-processing (bottom right).

al-time perfusion information during laparoscopic procedures (Fig. 25).

MULTIGUARD – DEVELOPMENT OF A MULTISPECTRAL PATIENT MONITORING SYSTEM

The MultiGuard project aims to develop a non-invasive and contactless multispectral system to measure tissue perfusion and moisture in premature babies. The current standard methods for measuring these parameters, such as pulse oximetry and transcutaneous electrodes, have limitations. The system includes a multispectral measurement unit and image processing tools to compute and visualize physiological parameters such as perfusion and pulsatile parameters, hemoglobin, fat, and water content. The project is conducted in collaboration with Diaspective Vision GmbH, and the developed system will be evaluated at the neonatology department.

CORTEXMAP – DEVELOPMENT OF A NOVEL NAVIGATED TRANSCRANIAL MAGNETIC STIMULATION SYSTEM FOR NON-INVASIVE MAPPING OF THE MOTOR CORTEX

The CortexMap project aims to develop a navigated transcranial magnetic stimulation (nTMS) system to map the brain motor cortex of patients with brain tumors non-invasively. To achieve this goal, new hardware components and software functionalities will be developed. An electromyography device with multiple electrodes will enable faster and more precise examinations, and automatic intensity adjustment and post-processing of motor evoked potentials (MEP) will lead to accurate mapping of the motor cortex. New visualization and data analysis features will support surgeons in interpreting the measurements, resulting in more efficient monitoring of patients.

#RESEARCH_GROUP
#BIOMEDICAL_DATA_ANALYSIS

LEAD
Prof. Galina Ivanova

SCIENTIFIC STAFF
Andreas Schneider, Max Schreiber, Jean-Baptiste Tylc

PROJECTS
- PostStroke | Mobile, Digital System to Strengthen Relapse Prevention, Health Competence and Self-reliance | Funding: Freistaat Sachsen – eHealthSax

- SaDIK | Secure Digital Data, Identities and Communication in Mobile Medical Care Applications | Funding: Governikus GmbH & Co. KG

SELECTED PUBLICATIONS

- Schmidt R, Geisler D, Urban D, Wagner M, Ivanova G, Neumuth T, Classen J, Michalski D. Topics Mentioned by Stroke Patients during Supportive Phone Calls-Implications for Individualized Aftercare Programs. Healthcare (Basel). 2022;10(12):2394.
  DOI: https://doi.org/10.3390/healthcare10122394

- Geisler D, Urban D, Schmidt R, Schreiber M, Tylcz J-B, Schneider A, Wagner M, Claßen J, Ivanova G, Michalski D. Case-Management-basierte und digital unterstützte Pflege in der Schlaganfallnachsorge – Leipziger Erfahrungen mit der Qualifikation der Durchführenden und inhaltlichen Ausgestaltung. In: Neurowoche. Berlin; 2022.

Fig. 22: Patient kit for analysis and support of patients after a stroke

POSTSTROKE MANAGER: MOBILE, DIGITAL SYSTEM TO STRENGTHEN RELAPSE PREVENTION, HEALTH COMPETENCE AND SELF-RELIANCE

ICCAS, the Clinic and Polyclinic for Neurology and the Department of General Medicine at the University of Leipzig Medical Faculty are developing the PostStroke-Manager, a patient-centered digital concept to improve post-stroke care. The implemented system includes a patient app, wearables as well mobile devices, general practitioner portal, and case manager portal, all embedded in a specially developed IT-infrastructure. The goal is to support stroke patients during their recovery in the first year after the first event. A pilot study is currently underway to test and optimize the system in different sectors, including acute hospitals and home environments. The long-term feasibility study involves over 35 stroke patients, 30 primary care physicians, and two stroke case managers. The PostStroke-Manager is being designed to enhance patient after stroke care and integrate the different involved in the treatment groups.

SECURE DIGITAL DATA, IDENTITIES AND COMMUNICATION IN MOBILE MEDICAL CARE APPLICATIONS

Sensitive medical data is often used in intersectoral medical care, whereby the secure access to these data is essential. Governikus, a company specializing in e-government, e-health, and e-justice, has developed several solutions for the German government and the GKV to authenticate authorized persons accessing sensitive data from various locations, including hospitals, clinics, homes, and abroad. The SaDIK project focus on the collaboration with Governikus to test and evaluate different solutions for high-security patient and medical staff authentication to ensure the safety access to medical data in intersectoral medical care.

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#SCIENTIFIC ACTIVITIES AND EVENTS

- The Digitaler Biosaxony Neujahrsempfang took place virtually on January 19, 2022, featuring a keynote speech from Thomas Neumuth on „2022- Big Leaps in Medical Innovation."

- The ICCAS Status Seminar 2022 was held virtually on March 10, 2022, with over 100 participants. Despite the challenges of the pandemic, the ICCAS research teams successfully completed six projects and launched eight new projects with funding exceeding 2.3 million euros.

- The ICCAS Status Seminar and Advisory Board Meeting 2022 took place virtually on March 9, 2022, with project presentations from established areas of research, including Computer-Assisted Image-Guided Interventions, Model-based Medicine, Intraoperative Multimodal Imaging, and Biomedical Data Analysis.

- The KLINET5G-PROJECT, funded by the Federal Ministry for Economic Affairs and Climate Action (BMWK), kicked off on May 2, 2022, to evaluate clinical networks via 5G.

- The MediNet project was started in April 2022 to establish connections between clinics, research, and companies. ICCAS operates a transfer center to support regional healthcare providers and companies with organizational and technical challenges in introducing novel products into the medical environment. ICCAS scientists are also developing a technical platform for clinical studies and innovative treatment strategies with networked medical devices.

- The Krebsmedizin Aktuell virtual event on April 6, 2022, featured lectures from Andreas Melzer on „Focused ultrasound in combination with RT as a precise additive radiosensitizing modality," and Thomas Neumuth on „Technology innovations in surgery: Current preclinical research topics."

- ICCAS participated in the ORNET booth presentations during the DMEA 2022 event in Berlin in April 2022.

- The Digital Health Conference took place in Leipzig on May 5, 2022, featuring a lecture from Thomas Neumuth on „Data-based innovations in medicine and research."

- The 51. Kongress der Deutschen Gesellschaft für Endoskopie und Bildgebende Verfahren e.V. was held in Potsdam from May 19-21, 2022, with Andreas Melzer chairing sessions on CTAC/DGBMT- Technologies and tools for the endoscopy of the future, and Collaborative robotics for ultrasound diagnostics and therapy.

- The ISMIT 2021 Conference took place in Oslo from May 30-31, 2022, with Andreas Melzer chairing the session on minimally and non-invasive therapy „Ultrasound and

MRI guided Focused Ultrasound Surgery," introducing the clinical MIS pioneer.

- Reinhard Fuchs presented a lecture on „Automated 3D thorax model generation and real-time endoscopic mitral valve simulator training" at the CARS 2022 conference in Tokyo from June 7-11, 2022.

- Andreas Melzer chaired the Imaging Robotics session at the Hamlyn Symposium on Medical Robotics in London from June 26-29, 2021.

- The 3MPFUS project, funded with 7.9 million euros by the Federal Ministry of Education and Research, kicked off on July 21, 2022, at ICCAS in Leipzig, with a duration of three years.

- ICCAS hosted a group of students from Mücheln on July 5, 2021, providing a tour and brief introduction to robotics and the demo operating room.

- Andreas Melzer was the course director for the HO5 Ultrasound at the European Association for Endoscopic Surgery and other Interventional Techniques conference in Krakau from July 5-8, 2022.

- Max Rockstroh participated in the Tage der digitalen Technologie 2022 event in Berlin from August 29-30, 2022.

- Claire Chalopin, Hannes Köhler, and Annekatrin Pfahl represented ICCAS at the Euromicro DSD/SEAA virtual conference from August 29-September 2, 2022.

- Prof. Dr. Jürgen Meixensberger retired as the director of the clinic for neurosurgery at the University Hospital Leipzig in September 2022, having been the founding director of ICCAS and the Executive Director from 2005 to 2014.

- The IMI group represented ICCAS during the Barrett Charity Dinner in Leipzig on September 10, 2022, which aimed to raise funds for research on therapy of Barrett Cancer.

- Andreas Melzer gave a lecture on „MR-Safety and Compatibility Testing of Medical Implants" and chaired several sessions at the BMT conference in Innsbruck from September 28-30, 2022.

- Galina Ivanova took partat the Lotse-Tagung-Schlaganfall event in Güthersloh on September 1, 2022.

- ICCAS demonstrated the MOMENTUM Ambulance at the Healthcare Hackathon in Mainz from September 14-17, 2022, with presentations by Christoph Georgi, Clemens Möllenhoff, Tobias Papst, and Max Rockstroh.

- Max Rockstroh gave a lecture on „Networking technologies in hospitals for better communication and better processes“ at the Future of Industrial Engineering Day in Dortmund on September 21, 2022.

- The Regions4PerMed project held its final meeting at ICCAS in Leipzig on September 22, 2022, with a demonstration tour hosted by Claire Chalopin, Johann Berger, Stefan Franke, Ivan Matyash, Alexander Oeser, Annekatrin Pfahl, and Michael Unger.

- Andreas Melzer chaired the Ultrasound in Surgery session and gave several lectures at the ARCE 2022 conference in Timisoara from September 28-October 1, 2022.

- Andreas Eger participated in the IEEE International Ultrasonic Symposium, held virtually in Venice from October 10-13, 2022.

- Andreas Melzer co-organized and moderated the General Issues-Neuro session and gave lectures on MRI-guided cardiovascular interventions and focused ultrasound neuromodulation, and combined 3D printed and silicone moulded vascular phantoms to develop and train catheter-based MRI-guided interventions

- IMRI 13TH INTERVENTIONAL MRI SYMPOSIUM , held on October 14 – 15, 2022 in Leipzig, was co-organized by Andreas Melzer, who also moderated the session on General Issues- Neuro. He gave two lectures on „Towards MRI-guided cardiovascular interventions and focused ultrasound neuromodulation“ and „Combined 3D printed and silicone moulded vascular phantoms to develop and train catheter-based MRI-guided interventions“.

- Andreas Melzer was a panelist at the 8th International Symposium on Focused Ultrasound, held on October 23 – 27, 2022 in Rockwell. He discussed technology gaps and how technology breakthroughs can lead to broader adoption.

- Andreas Melzer gave a lecture on „Image-guided interventions and robotics“ at the Bioengineering Autumn School held on October 26 – 28, 2022 in Herrsching am Ammersee.

- In November 2022, Thomas Neumuth was appointed to the PK2 Doctoral Committee of the Faculty of Medicine.

- The final event of the Models for Personalized Medicine (MPM) project was held on November 29, 2022 at ICCAS in Leipzig. The successful cooperation of all project partners was appreciated.

- On November 11, 2022, Thomas Neumuth co-organized the „Shaping the Future of Hematology“ event together with Prof. Uwe Platzbecker (University Hospital Leipzig) and Alexander Oeser. Neumuth gave a lecture on „The Impact of AI in Hematology-Curse or Blessing?“.

- Richard Bieck gave a lecture on „Konzept und Entwicklung von Simulationsbasierten Maschinellen Lernmodellen für die Entscheidungsunterstützung in der Wirbelsäulen-Chirurgie“ at the SIMLE event held on November 30 – December 1, 2022 in Leipzig.

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#UNIVERSITY COURSES

LEIPZIG UNIVERSITY

Computer Assisted Surgery
Faculty of Mathematics and Computer Science
Lecture and practical course

System Innovation in Medicine
Faculty of Mathematics and Computer Science
Lecture and seminar

Development of Medical Products
Faculty of Mathematics and Computer Science
Lecture

POL-1-Course | Infectiology and immunology
Faculty of Medicine
Lecture

POL-2- Course | Emergency and acute medicine
Faculty of Medicine
Course

LEIPZIG UNIVERSITY OF APPLIED SCIENCES (HTWK)

Project Management for Engineers
Faculty of Electrical Engineering and Information Technology, Mechanical and Energy Engineering
Lecture and practical course

Systems Engineering
Faculty of Electrical Engineering and Information Technology
Lecture

OTTO VON GUERICKE UNIVERSITY MAGDEBURG

Development of Medical Products
Faculty of Mathematics and Computer Science
Lecture

#GRADUATIONS

BACHELOR DEGREES

Darija Grisanova
„Integration of Automatic Classification Tools of Hyperspectral Imaging Data."
Magdeburg University

Robin Kutzner
„Untersuchung des Einfusses von Bewegung auf die Präzision des Handtrackings der HoloLens 2."
Leipzig University of Applied Sciences (HTWK)

Diana Pretzsch
„Augmented Reality in der medizinischen Reanimation: Analyse zur Verbesserung der Benutzerfreundlichkeit für ein Microsoft HoloLens Interface."
Leipzig University of Applied Sciences (HTWK)

Erik Semmler
„Visualisierungsverfahren für Daten eines technischen Leitstandes im medizinischen Umfeld."
Leipzig University of Applied Sciences (HTWK)

Tim Stelzner
„Entwicklung eines interaktiven Diagnosewerkzeugs für die automatische Identifikation & Exploration von Gewebe-Anteilen der lumbalen Wirbelsäule aus MRT-Bilddaten."
Leipzig University

Tom Wahl
„Modellierung und Implementierung eines kollaborativen Robotersystems im IEEE11073 Standard und Validierung der Netzwerkkommunikation für die beispielhafte Anwendung in ultraschallgestützten Biopsien."
Leipzig University of Applied Sciences (HTWK)

#GRADUATIONS

MASTER DEGREE

Henner Baberowsky
„Erkennung von Verwandtschaft in Fingerabdrücken mithilfe neuronaler Netze.“
Leipzig University
Leipzig University of Applied Sciences (HTWK)

Lorenz Gunreben
„Entwicklung und Evaluation eines Augmented-Reality basierten Interaktionskonzeptes zur Steuerung eines kollaborativen Robotersystems bei bildgestützten Interventionen.“
Leipzig University

Marie Hartung
„Komprimierung und Generierung von Fingerabdrücken für die Verwandtschaftserkennung mit Hilfe von Neuronalen Netzen.“
Leipzig University of Applied Sciences (HTWK)

Marie-Sophie von Braun
„Image Stitching for Real-Time Laparoscopic Hyperspectral Imaging.“
Leipzig University

Leo Wawrzyniak
„Einsatz künstlicher Intelligenz zur Untersuchung hyperspektral aufgenommener histologischer Schnitte mit kolorektalen Karzinom.“
Leipzig University of Applied Sciences (HTWK)

Jan Christian Westerhoff
„Simulation von Vitalparametern zur Geräteentwicklung und Evaluation von Systemen im Bereich von SDC.“
Leipzig University

DOCTORATE DEGREE

Shaonan Hu
„Focused Ultrasound-Induced Cavitation Renders Cancer Cells Susceptibleto Radiation Therapy, Hyperthermia and Testosterone Treatment.“
Leipzig University

Philipp Liebmann
„Intraoperative process monitoring using generalized surgical process models.“
Leipzig University

Alexander Oeser
„Distributed Knowledge Modeling and Integration of Model-Based Beliefs into the Clinical Decision-Making Process.“
Leipzig University

Michael Unger
„Developments of Infrared Thermography-based Tools to Assist Surgical Procedures and Workflow.“
Leipzig University

#PUBLICATIONS

PAPERS

FIRST- AND SENIOR AUTHORSHIP

Alshirbaji TA, Aldeen Jalal N, Docherty PD, Neumuth T, Moeller K. Neural Network Classification of Surgical Tools in Gynecological Videos. Current Directions in Biomedical Engineering. 2022;8(2):644–7. Impact factor: 0.62

Alshirbaji TA, Jalal NA, Docherty PD, Neumuth PT, Moller K. Improving the Generalisability of Deep CNNs by Combining Multi-stage Features for Surgical Tool Classification. Annu Int Conf IEEE Eng Med Biol Soc. 2022: 533–6. Impact factor: 0,00

Alshirbaji TA, Jalal NA, Docherty PD, Neumuth T, Möller K. Robustness of Convolutional Neural Networks for Surgical Tool Classification in Laparoscopic Videos from Multiple Sources and of Multiple Types: A Systematic Evaluation. Electronics. 2022;11(18):2849. Impact factor: 2.690

Berger J, Unger M, Keller J, Reich CM, Neumuth T, Melzer A. Design and validation of a medical robotic device system to control two collaborative robots for ultrasound-guided needle insertions. Front Robot AI. 2022;9:875845. Impact factor: 0,71

Bieck R, Heuermann K, Sorge M, Neumuth T, Pirlich M. Saliency-assisted multi-label classification for explainable deep learning applications in endoscopic ENT navigation. Current Directions in Biomedical Engineering. 2022;8(2):596–9. Impact factor: 0.62

Buyer J, Oeser A, Grieb N, Dietz A, Neumuth T, Stoehr M. Decision Support for Oropharyngeal Cancer Patients Based on Data-Driven Similarity Metrics for Medical Case Comparison. Diagnostics (Basel). 2022;12(4):999. Impact factor: 3.992

Chalopin C, Nickel F, Pfahl A, Köhler H, Maktabi M, Thieme R, Sucher R, Jansen-Winkeln B, Studier-Fischer A, Seidlitz S, Maier-Hein L, Neumuth T, Melzer A, Müller-Stich BP, Gockel I. [Artificial intelligence and hyperspectral imaging for image-guided assistance in minimally invasive surgery]. Chirurgie (Heidelb). 2022; 0: 0-00. Impact factor: 0.920

Dussel N, Fuchs R, Reske AW, Neumuth T. Automated 3D thorax model generation using handheld video-footage. Int J Comput Assist Radiol Surg. 2022; 17(9): 1707-1716. Impact factor: 3.421

Esmail Karar M, Ahmed Shouman M, Chalopin C. Adversarial Neural Network Classifiers for COVID-19 Diagnosis in Ultrasound Images. Computers, Materials & Continua. 2022;70(1):1683–97. Impact factor: 3.860

Fuchs R, Van Praet KM, Bieck R, Kempfert J, Holzhey D, Kofler M, u. a. A system for real-time multivariate feature combination of endoscopic mitral valve simulator training data. Int J Comput Assist Radiol Surg. 2022; 17(9): 1619-163. Impact factor: 3.421

Gaebel J, Mehlhorn S, Oeser A, Dietz A, Neumuth T, Stoehr M. Clinical decision support models for oropharyngeal cancer treatment: design and evaluation of a multi-stage knowledge abstraction and formalization process. Int J Comput Assist Radiol Surg. 2022; 17(9): 1643-1650. Impact factor: 3.421

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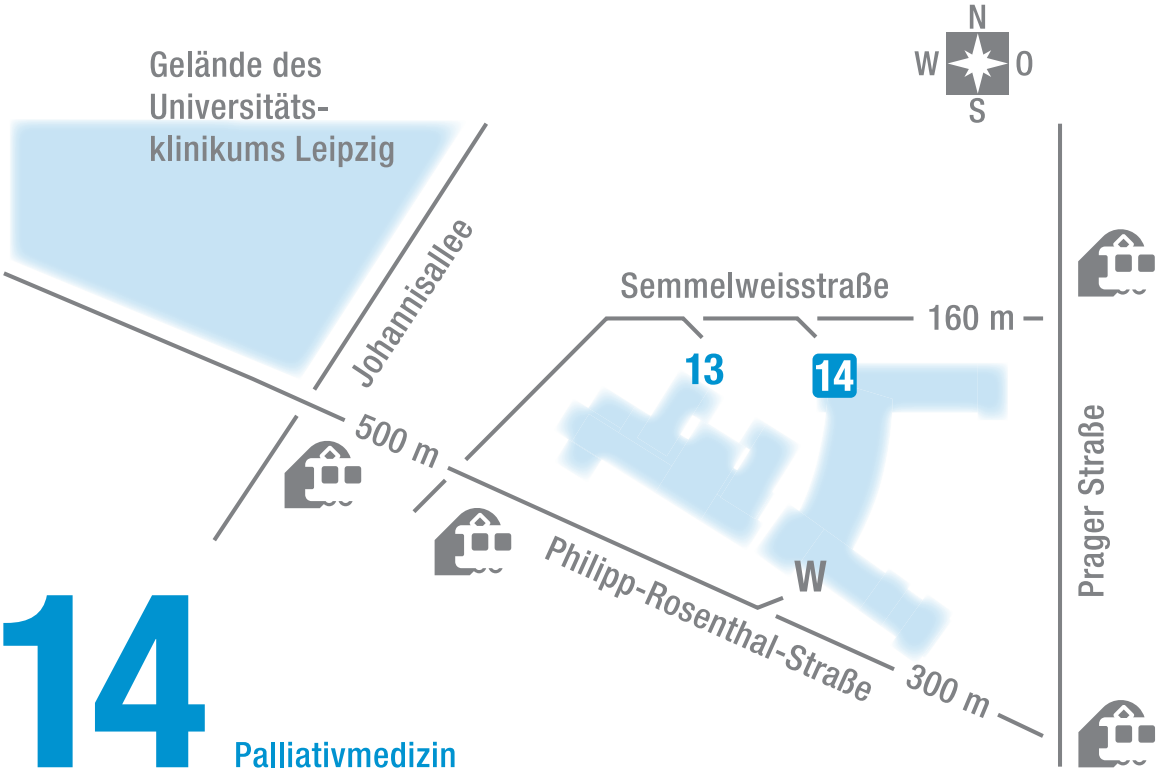

14 Palliativmedizin

UNIVERSITÄT LEIPZIG
Medizinische Fakultät

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

Europäische Kommission

ZIM impulse für wachstum Zentrales Innovationsprogramm Mittelstand

ZENTREN FÜR INNOVATIONSKOMPETENZ UNTERNEHMEN REGION
Die BMBF-Innovationsinitiative Neue Länder

Freistaat Sachsen

Diese Maßnahme wird mitfinanziert durch Steuermittel auf der Grundlage des vom Sächsischen Landtag beschlossenen Haushalts.