



UNIVERSITÄT  
LEIPZIG

Faculty of Medicine

ICCAS

#SMART\_OR

#HYPER\_SPECTRAL\_IMAGING

#WORKFLOW #MR\_GUIDED\_INTERVENTIONS

#FOCUSED\_ULTRASOUND

#MEDICAL\_TECHNOLOGIES\_MADE\_SMART

#ROBOTICS #MODELBASED\_MEDICINE  
#PERSONALISED\_MEDICINE

#LIFE\_SUPPORT\_SYSTEMS



**ICCAS** #ANNUAL\_REPORT.2020

INNOVATION CENTER COMPUTER ASSISTED SURGERY

## **IMPRINT**

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ICCAS' 15 years of Research-Collage.

### **PHOTOS**

ICCAS | Innovation Center Computer Assisted Surgery  
Universität Leipzig | Medizinische Fakultät  
Universität Leipzig | Swen Reichhold  
Colourbox  
Deutsche Gesellschaft für Medizinische Physik | DGMP

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Simon Rosenow  
Christoph Zeumer

### **DISCLAIMER**

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**No responsibility can be accepted for the correctness of this information.**

**Leipzig, March 2021**

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## #PREFACE

Dear Friends and Colleagues,

2020 has been the most challenging year of the past 15 years overshadowed by the COVID-19 pandemic and related restrictions. Nonetheless, we were able to continue our crucial work in a goal-oriented manner with the outstanding support of our motivated employees.

ICCAS started in 2005 as a Research Center for Innovation funded through the BMBF program Unternehmen Region, which was established for supporting the new eastern states of Germany. After 15 years of successful research and development we are looking back at achievements of nearly 50 million euros in external funding, 468 peer-reviewed publications, 282 conference proceedings and two spin-off companies. In 2020, ICCAS has been established as an Institute at the Faculty of Medicine of Leipzig University. The two main research areas Computer-Assisted Image-Guided Interventions and Model-Based Medicine and intelligent OR are growing and a large number of multidisciplinary scientists are working interrelated and closely together towards the greater goal of the ultimate intelligent hybrid operating room for smart medical technologies in surgical and interventional care.

Despite significant and still ongoing lockdowns in 2020, ICCAS staff performed extraordinarily well mostly under difficult home office conditions. Online tools and electronic communication systems allowed us to continue with current running projects and we were able to stick to almost all of our objectives. Our funding bodies are mentioned with gratitude for flexible management of some delays. We would also like to cordially welcome Prof. Ivanova and her group supporting ICCAS research in the field of Biomedical Data.

Eight new projects were launched with a total value of more than 4.47 million euros. The large 6.75 million euro SONO-RAY BMBF project in collaboration with ONCO-RAY and the projects IMPACT and ENSEMBLE were successfully completed and results published. We are particularly proud of establishing three industry-funded projects in 2020. Karl Storz GmbH is funding a joint project of ICCAS and Diaspective Vison GmbH to develop Endoscopic Hyperspectral and Multi-spectral Imaging (HSI and MSI) techniques. This activity is significantly supported through preclinical studies by more than six clinical departments of University Hospital Leipzig (UKL) spearheaded by Prof. Ines Gockel, Director of the Department of Visceral Surgery, and her colleagues. Three patent applications have already come out of this exciting project. For our second industry-funded project avateramedical® GmbH Jena has contracted ICCAS for the modeling and simulation of



instrument positioning to facilitate the clinical introduction of their new surgical robotic system in close collaboration with Prof. Jens-Uwe Stolzenburg, Director of the Department of Urology at UKL, who is one of the inventors and founders of avatera. Finally, Janssen Cilag Deutschland GmbH, the pharma branch of Johnson and Johnson, funds an exciting project in the context of digital patient models for hematology in close collaboration with Prof. Uwe Platzbecker, Director of the Department of Hematology at UKL.

The newly developed Service-Oriented Device Connectivity (SDC) family of IEEE standards, in whose development ICCAS was involved and that became ISO standards, is currently extended to future medical communication systems. For this, ICCAS was initiator and founding member of the 5G Health Association.

ICCAS has been involved in numerous online events, offered networking opportunities and brought current research topics such as Artificial Intelligence into focus. The main effort was focused on the scientific organization of the BMT 2020, which took place for the first time as a virtual conference from 29 September to 1 October attracting more than 520 attendees. Our novel clinically interlinked format of the conference program became known as the "Leipzig Model". Additionally, the iSMIT Conference 2020, Chicago, was held online as well, stretched over 5 days in December 2020 spanning over 12 time zones on three continents, and was attended by more than 600 people.

We would like to thank everyone involved for the successful year 2020 and we are looking forward to meeting you in person again soon.

Stay safe and healthy!

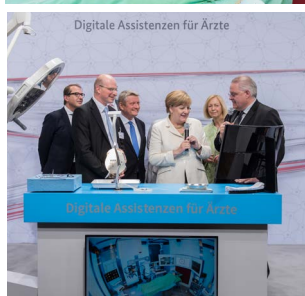
Kind regards

Prof. Dr. Andreas Melzer

Prof. Dr. Thomas Neumuth



# #ICCAS TIMELINE



## 2020

- 15<sup>th</sup> 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
- 6<sup>th</sup> 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
- 5<sup>th</sup> 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 17<sup>th</sup> 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
- 4<sup>th</sup> 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
- RESEARCH 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
- 3<sup>rd</sup> DORS
- Project start of Meta-ZIK SONO-RAY

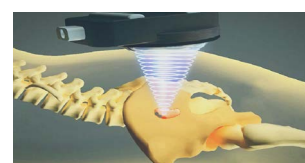
## 2015

- Launching of cooperation with several scientific and clinical institutions
- 10<sup>th</sup> anniversary of ICCAS with 2<sup>nd</sup> 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



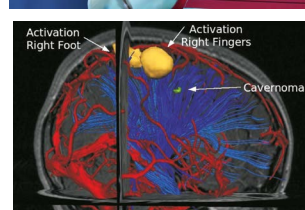
## 2012

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



## 2011

- ICCAS participates in the DICOM WG24 group
- ICCAS demo OR 2.0 opens
- RESEARCH AREAS: Model-Based Automation and Integration (Dr. Thomas Neumuth) and Standards (Prof. Heinz U. Lemke)
- Advisory Board founded



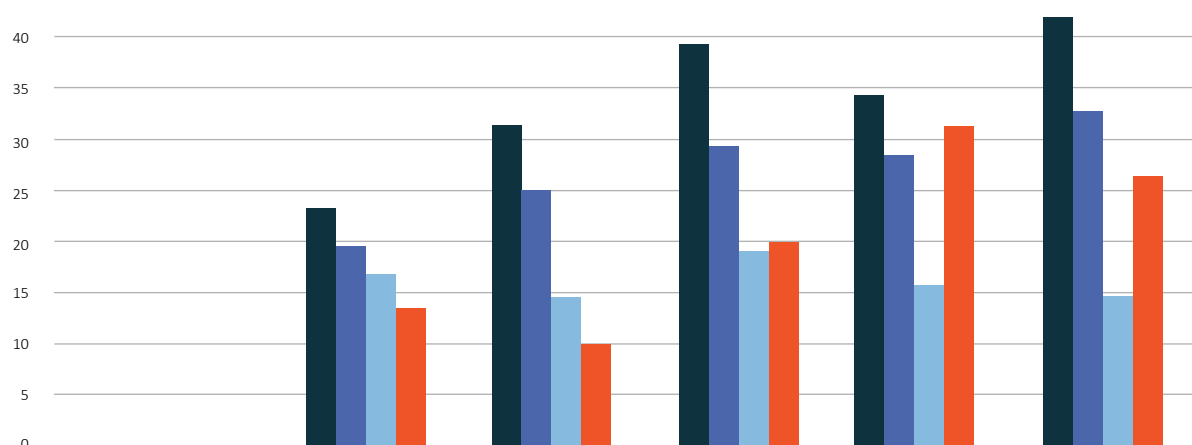
## 2010

- Surgical Planning Unit (SPU) opens
- ICCAS teams up with HTWK Leipzig – establishment of the Innovation Surgical Training Technology (ISTT) under professorship of Werner Korb



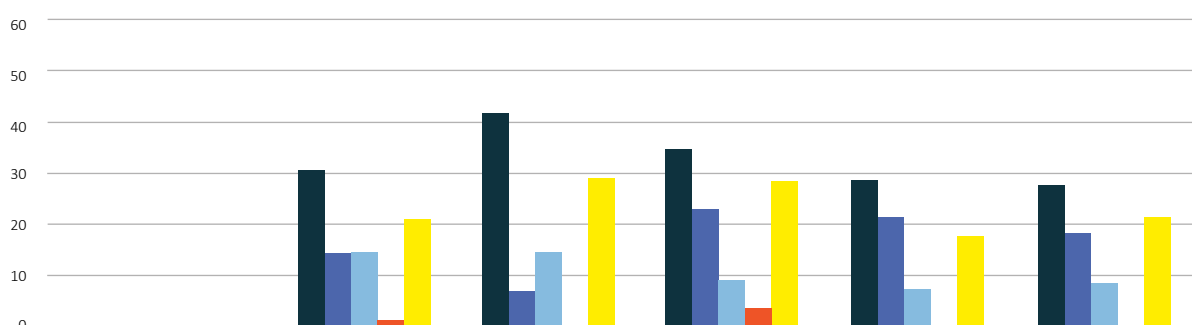
# #FACTS AND FIGURES

## HEADCOUNT



	2016	2017	2018	2019	2020
Research Associates	23	23	39	34	42
Research Associates (FTE)	19	25	29	28	33
Research Assistants	17	14	18	16	14
Guest Researchers	13	10	20	32	26

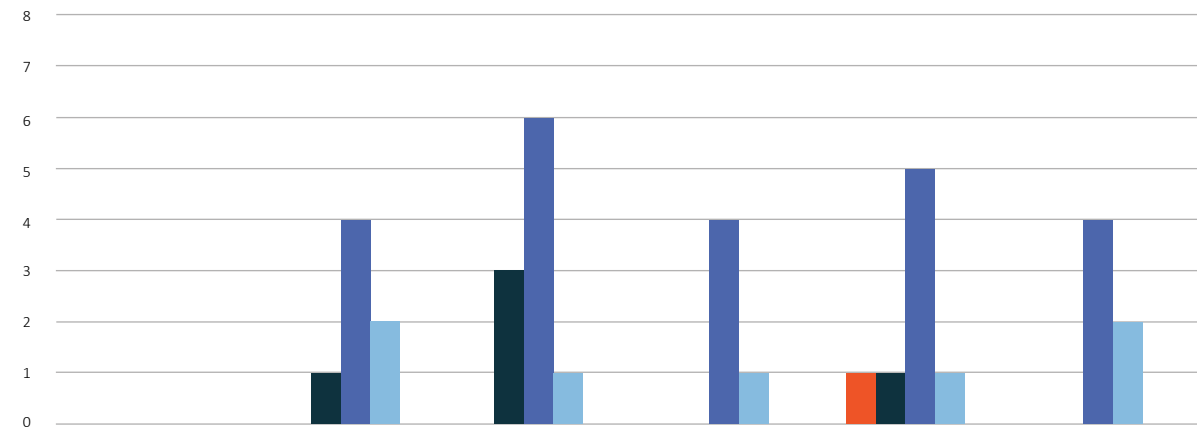
## PUBLICATIONS



	2016	2017	2018	2019	2020
Total	31	42	35	28	26
First- and Senior Authorship	14	7	22	21	18
Co-Authorship	15	15	9	7	8
Book Chapters	2	0	4	0	0
Conference Proceedings	21	29	28	18	21

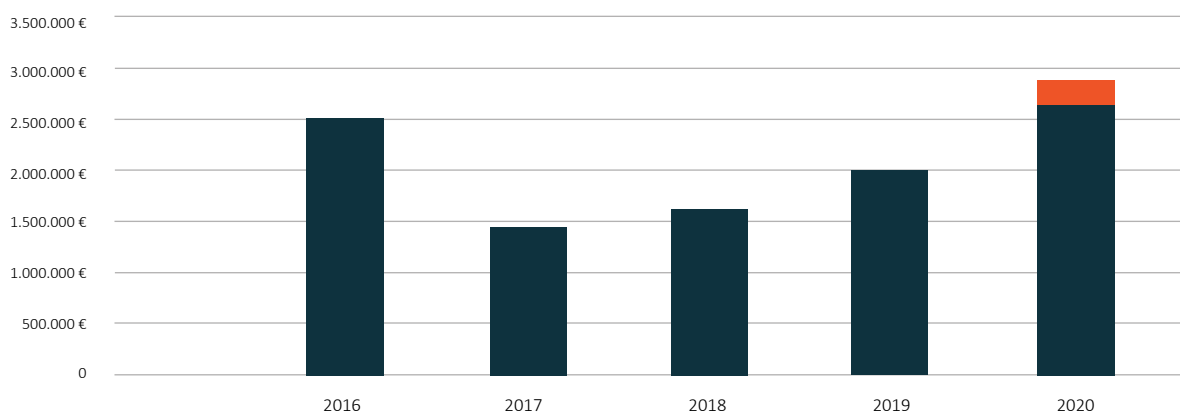


## GRADUATIONS



	2016	2017	2018	2019	2020
<span style="color: orange;">■</span> Habilitation	0	0	0	1	0
<span style="color: darkblue;">■</span> Doctoral theses	1	3	0	1	0
<span style="color: blue;">■</span> Master theses	4	6	4	5	4
<span style="color: lightblue;">■</span> Bachelor theses	2	1	1	1	2

## 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 in 2020.

# #SELECTED ACTIVITIES

## HIGHLIGHTS

### ICCAS BECOMES INSTITUTE | MAY 28, 2020 | ICCAS, LEIPZIG

ICCAS receives official recognition as an institute of the Leipzig University. After 15 years of outstanding research, the Innovation center has now been transformed into a scientific institution within the Faculty of Medicine. It is assigned to the clinical-practical teaching unit.



Successful 15 years for ICCAS. © ICCAS.

The whole ICCAS team would like to thank all those involved who have made this success possible!

### BMT 2020 WAS A SUCCESS | SEPTEMBER 29 - OCTOBER 1, 2020 | ICCAS, LEIPZIG

The first virtual Conference of the German Society for Biomedical Engineering (BMT 2020) was co-hosted by ICCAS in cooperation with the Verband der Elektrotechnik, Elektronik und Informationstechnik e.V. (VDE) from September 29<sup>th</sup> to October 1<sup>st</sup>. The event, which was certified by the Saxon State Chamber of Medicine (SLÄK) with a total of 18 continuing education points, was opened by a video message from the Federal Minister of

Health Jens Spahn. It also featured greetings from Saxony's Science Minister Sebastian Gemkow on ICCAS' 15<sup>th</sup> Anniversary.



BMT 2020 Chairmen Andreas Melzer (l.) and Thomas Neumuth (r.) © ICCAS

The online conference attracted more than 500 attendees, with the participation of clinicians being particularly noteworthy. The "Leipzig Model" increased the clinical input: additional physicians accompanied the sessions and gave lectures from their practical experience.

Artificial Intelligence, Personalized Medicine and the new Medical Device Regulation were among the main subjects of the conference as well as topics from the Active Assisted Living (AAL) Congress and the VDE BMT YoungNet initiative.

ICCAS' current research topics were presented in several sessions, which were chaired by the two conference chairmen Prof. Andreas Melzer and Prof. Thomas Neumuth. Among them were the sessions on "Medical Imaging" and "Robotics" as well as on "5G", "AI in Medicine", and "Model-based Personalized Medicine". During the conference, ICCAS was represented with a total of 14 unique contributions.

The ICCAS-team would like to thank all contributors for the successful course of the event and the important scientific exchange. Next year, the Hannover Medical School invites to

the 55<sup>th</sup> Annual BMT Meeting in Hannover in the hope of a real-life reunion.

## SELECTED EVENTS

### ICCAS STATUS SEMINAR 2019 | JANUARY 23, 2020 | ICCAS, LEIPZIG

At the annual Status Seminar, ICCAS took stock of the past year and presented its research results to numerous guests. Leipzig University's Prorector for Research Prof. Erich Schröger congratulated ICCAS for its 15<sup>th</sup> anniversary and praised its far-reaching visibility and networking. Following the oral reports from the research divisions, the scientists held demos at 7 stations providing insights into the (further) development of our project themes: imaging robotics, MR-guided interventions, medical technology networking, imaging procedures in accident and visceral surgery, cancer cell sensitization and digital therapy decisions.

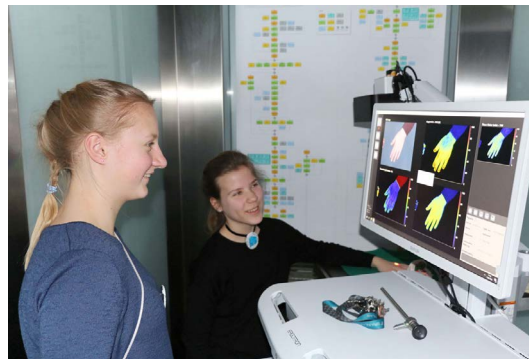


Status Seminar 2019. © ICCAS

### MY HOLIDAY ADVENTURE 'ICCAS' | FEBRUARY 13, 2020 | ICCAS, LEIPZIG

Within the framework of this year's holiday

program "My Holiday Adventure Leipzig" (MEFALE), children of employees of Leipzig University Medicine gained exciting insights into ICCAS' research activities. The young visitors had the opportunity to try out a medical robotics application and a hyperspectral imaging system themselves. For example, they took pictures of their hands with a hyperspectral camera, through which the skins' blood circulation was made visible thanks to this special type of imaging technology. The children kept the images as souvenirs.



Images of the hand with the hyperspectral camera system. © ICCAS

### PROF. THOMAS NEUMUTH IN UNI-LECTURE SERIES | MARCH 3, 2020 | UNIVERSITY LIBRARY, LEIPZIG



Prof. Thomas Neumuth speaks in front of Leipzig audience in the university-lecture series. © ICCAS

Prof. Thomas Neumuth gave a lecture on Digitization in Medicine to interested citizens in the full hall of the Bibliotheca Albertina. He

presented the healthcare of tomorrow: personalized, preventive, predictive and participatory, supported by the use of new technologies.

**PROF. ANDREAS MELZER AT THE EUROPEAN ROBOTICS FORUM (ERF) | MARCH 3 - 5, 2020 | MALAGA, SPAIN**



Dr. Gernot Kronreif, Dr. Tamás Haidegger and Prof. Andreas Melzer at the ERF-panel in Malaga.

Prof. Andreas Melzer participated in the European Robotics Forum (ERF) – the largest and most influential event in the field of robotics and artificial intelligence in Europe. He was involved in the workshop and plenary discussion on robotics in healthcare, where he elucidated the application potential of robotics for image-guided therapy and focused ultrasound to support minimally and non-invasive interventions.

**ICCAS – 5G PIONEER IN MOBILE MEDICAL TECHNOLOGY | MAY 14, 2020 | BMW PLANT, LEIPZIG**

Within the framework of the project “Trimodal 5G Pioneer Region Leipzig North” (Tri5G), Prof. Thomas Neumuth and a team of ICCAS scientists presented the research on emergency care using mobile medical technology in inter-

action with public 5G and campus networks. Tri5G aims to make the 5th generation mobile internet available for the automotive industry, logistics and IT companies as well as for scientific and public applications in the north of Leipzig. The City of Leipzig commissioned a feasibility study, whose results were presented at the BMW plant in Leipzig in May, 2020.



The MOMENTUM project team around Prof. Thomas Neumuth during the presentation of the Tri5G feasibility study.

**ROBOT DEMOS FOR MEDICAL PHYSICISTS | SEPTEMBER 9, 2020 | VIRTUAL**

**DGMP**  
**51. JAHRESTAGUNG**  
der Deutschen Gesellschaft für Medizinische Physik



51. Annual conference of © DGMP

Within the framework of this year's 51<sup>st</sup> Annual Meeting of the German Society for Medical Physics (DGMP), experts from the German Society for Biomedical Engineering (DGBMT) participated with two guest sessions. They provided insights into the latest research and development of various expert



committees and demonstrated medical robot applications from ICCAS and the German Cancer Research Center (DKFZ).

## PROJECT-RELATED EVENTS

### KICK-OFF PROJECT MPM AT ICCAS | MARCH 2, 2020 | ICCAS, LEIPZIG

The first meeting of all partners in the project 'Models for Personalized Medicine' (MPM) funded by The Federal Ministry of Education and Research with 5.1 million Euros took place at ICCAS. The joint project with seven local industrial partners aims to develop assistance applications for personalized tumor therapy. The partners introduced themselves and explained their intended research contributions.



The partners of the project Models for Personalized Medicine at the kick-off in Leipzig. © ICCAS

### ICCAS DEVELOPS INFORMATION SYSTEM FOR COVIDVAL PATIENT STUDY | APRIL, 2020 | LEIPZIG

The COVIDVAL PRO (patient reported outcome) system, developed by ICCAS for the COVIDVAL trial, is an information system for tracking and documenting the health status of SARS-COV-2 quarantined patients outside of clinical settings. Tracking begins from the time of SARS-COV-2 testing at the clinical facility, from which point on the system provides



© Colourbox

various electronic and paper-based communication channels for patients to document parameters relevant to the progression of their health status. This way patient data can be collected telemedically, so that personal consultations in the study center are minimized.

The COVIDVAL patient study has been funded by the Federal Ministry of Education and Research and it involves randomized conversion from ACE inhibitors to angiotensin receptor blockers (ARB) and use of ARB vs. placebo in SARS-COV-2 infection. (<https://covidval.de/>)

### STATUSWEBINAR COMPLETES SONO-RAY PROJECT | JUNE 18, 2020 | ONLINE



At the public status webinar of the expiring BMBF joint project SONO-RAY, the two partners OncoRay and ICCAS presented their final project results. Since 2016, the scientists around Prof. Andreas Melzer (ICCAS) and Prof. Mechthild Krause (OncoRay) have been researching on a new tumor therapy method that combines magnetic resonance-guided focused ultrasound and radiation therapy. They were



able to verify positive thermal and mechanical effects of FUS on cancer cells and developed a robotic system for the exact positioning of the ultrasound radiation therapy. In a pilot study in Dresden, the first patients with localized prostate cancer have been receiving treatment with FUS since September 29. The preliminary results are summarized in a recent publication and present a major step towards clinically oriented implementation of the combination therapy.

[Press release \(German\)](#)

#### **MEDICAL DEVICE EVALUATION VIA ARTIFICIAL INTELLIGENCE: ICCAS LAUNCHES A NEW PROJECT | 2020**

## **AIQNET** Medical Data Ecosystem

Due to the new Medical Device Regulation (MDR) of the EU, the requirements for reliable medical device data are continuously increasing. Currently, the market surveillance is often characterized by a lack of skilled personnel in industry and hospitals, cost pressure, legal uncertainty and IT systems with low interoperability. These aspects will be addressed in the AIQNET project (Artificial Intelligence for Clinical Studies). With the help of artificial intelligence, epidemiological, clinical, para-clinical and radiological data can be automatically analyzed and used for the performance evaluation of medical devices.

#### **ICCAS LEADS PLATFORM DEVELOPMENT TO SUPPORT THERAPY DECISIONS IN COMPLEX BLOOD CANCERS | NOVEMBER, 2020**



Janssen Germany aims to improve the treatment of blood cancer through the use of artificial intelligence (AI). To this end, the research-focused pharmaceutical company supports a research project in which ICCAS and the Clinic for Hematology Cell Therapy and Hemostaseology at Leipzig University Hospital serve as the leading technology partners. Together they are pursuing the goal of developing an AI-based digital health platform for therapeutic decision support for patients with complex blood disorders. The KAIT platform will be accessible to physicians in clinics and practices and provide them with evidence-based suggestions for individualized therapy strategies. In three years the KAIT platform will be available as a reliable and practical tool to support clinical routines.

[Press release \(German\)](#)

# #HONORS AND AWARDS



## **DR. ANDREA SCHENK JOINS ICCAS' SCIENTIFIC ADVISORY BOARD | FEBRUARY, 2020**

ICCAS welcomes Dr. Andrea Schenk as a new member of its scientific advisory board. She is member of the management board at the Fraunhofer Institute for Digital Medicine (MeVis). Her research activities focus on image processing of multimodal data as well as on clinical decision and image-based therapies.



## **PROF. ANDREAS MELZER BECAME FELLOW AT ACADEMY OF MEDICAL SCIENCES | 2020**

Prof. Andreas Melzer became fellow of the Academy of Medical Sciences (UK) and has been appointed as visiting Professor of the Korean National Cancer Center and as a member of the ERC SAP (Science after the Project) panel to evaluate the outcome of ERC Advanced Grants.



## **PROF. THOMAS NEUMUTH HAS BEEN ELECTED MEMBER OF THE EUROPEAN COMMISSION'S EXPERT PANEL "EXPAMED" | SEPTEMBER, 2020**

Prof. Thomas Neumuth has been appointed to the European Commission's expert panel "Expamed", which aims to improve regulation in the approval process of medical devices (MDR) and medical devices for in vitro diagnostics (IVDR).



## **ICCAS WELCOMES ITS FIRST FEMALE BOARD MEMBER | DECEMBER, 2020**

ICCAS is happy to announce another new board member. Prof. Ines Gockel – Head of the Clinic for Visceral, Thorax and Vascular Surgery at the University Hospital Leipzig (UKL) has already been working closely with ICCAS in the capacity of a clinical advisor.



## **TWO NEW ADDITIONS TO ICCAS' BOARD FROM THE HEART CENTRE LEIPZIG (HZL) | DECEMBER, 2020**

Prof. Gerhard Hindricks and Prof. Michael A. Borger will succeed Prof. Friedrich W. Mohr on the ICCAS Board. The ICCAS team welcomes the two clinical heart specialists from the Heart Centre Leipzig (HZL). Prof. Hindricks is an expert on cardiac arrhythmias and manages one of the largest European centers for the treatment of arrhythmias at the HZL. Prof. Borger's clinical focus lies in minimally invasive aortic and mitral valve operation and robot-assisted cardiac surgery at the HZL.

# #INTERRELATED RESEARCH

#INTRA  
IMAGIN



Interrelated research: [#Computer\\_Assisted\\_Image\\_Guided\\_Interventions](#)  
[#Model\\_Based\\_Automation\\_and\\_Intelligent\\_OR](#)  
[#Intraoperative\\_Multimodal\\_Imaging](#)  
[#Biomedical\\_Data\\_Analysis](#)

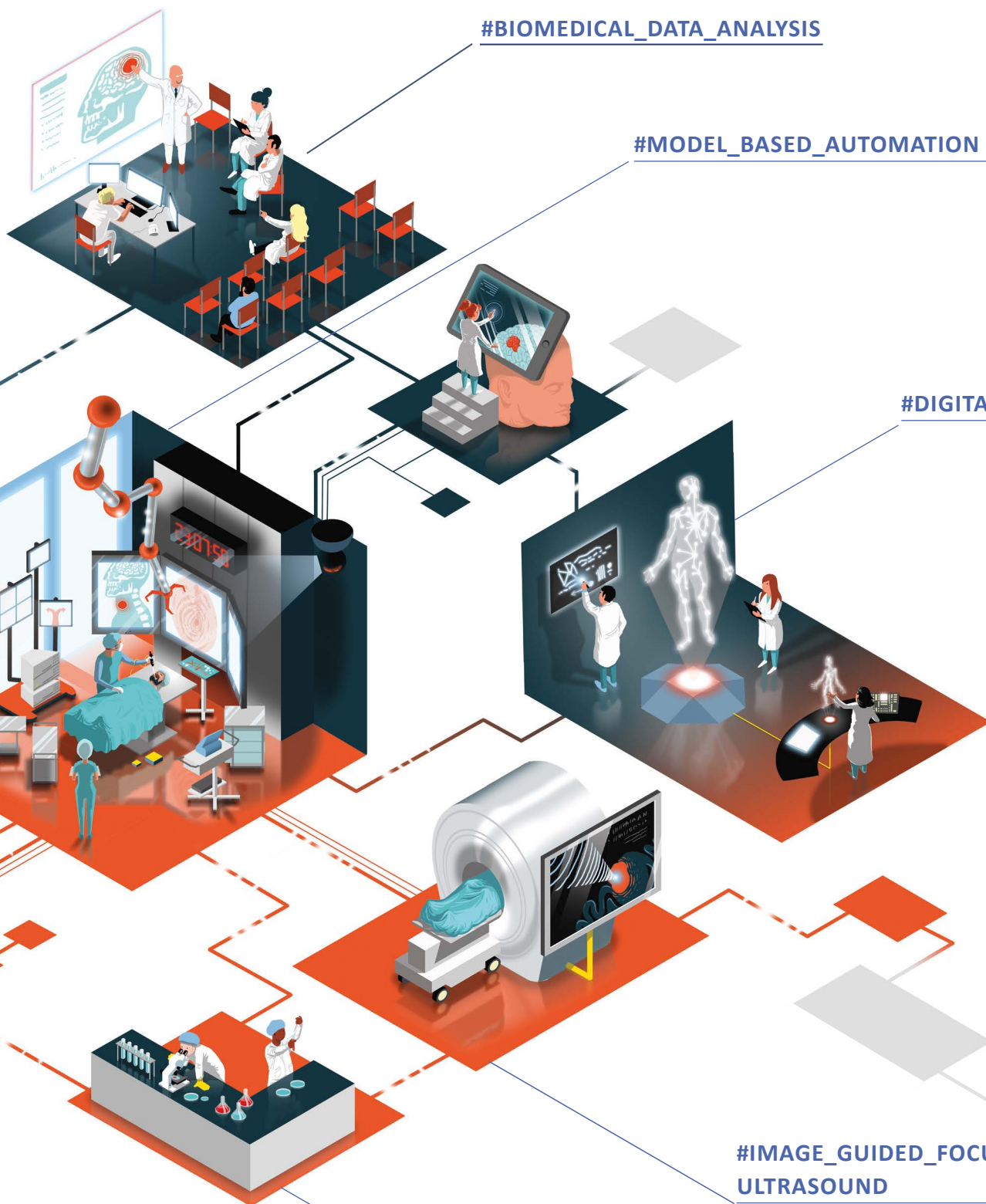
[#BIOMEDICAL\\_DATA\\_ANALYSIS](#)

[#MODEL\\_BASED\\_AUTOMATION](#)

[#DIGITAL\\_PATIENT\\_MODEL](#)

[#IMAGE\\_GUIDED\\_FOCUSED\\_ULTRASOUND](#)

[#MR\\_GUIDED\\_INTERVENTIONS](#)

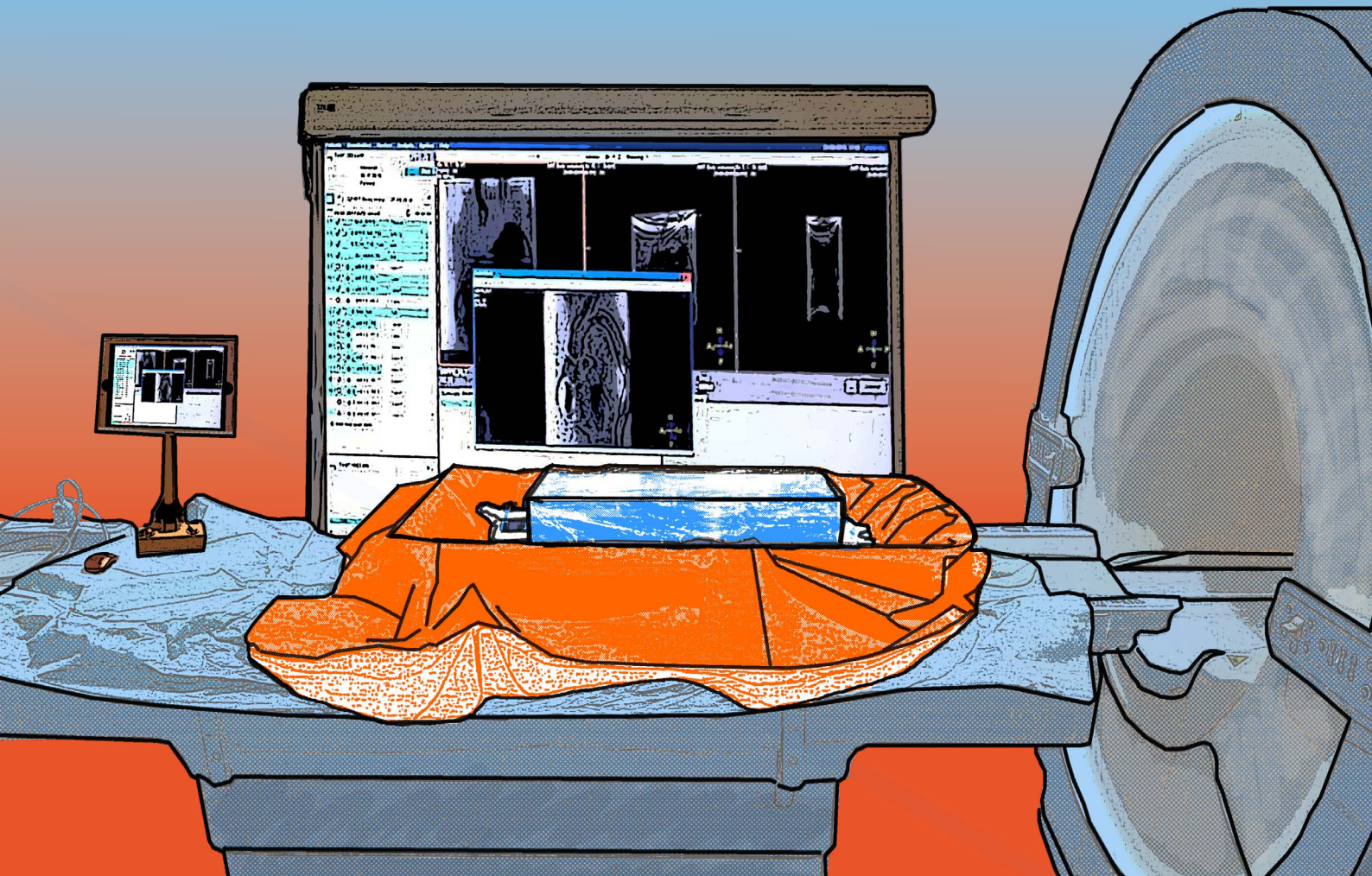




# ICCAS

## #COMPUTER\_ASSISTED\_IMAGE\_GUIDED INTERVENTIONS

Research focuses on new technologies in the field of MRI-guidance to enable minimally and non-invasive procedures for patient-friendly diagnosis and treatment. In addition to improved soft tissue contrast, advantages of MRI include the absence of iodine-containing contrast agents and ionizing radiation. The project work aims to develop innovative MR-compatible instruments, investigate suitable medical workflows with restricted patient access and communication in the MR environment. Application of focused ultrasound, transfer of minimally invasive catheter intervention and robotic assisted procedures are established 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

Nikolaos Bailis, Denis Gholami Bajestani, Johann Berger, Julian Donig, Erwin Immel, Lisa Landgraf, Christina Mulik, Ina Patties, Annekatrin Pfahl, C. Martin Reich, Upasana Roy, Michael Unger

## SELECTED PUBLICATIONS

- Hu S, Zhang X, Unger M, Patties I, Melzer A, Landgraf L. Focused Ultrasound-Induced Cavitation Sensitizes Cancer Cells to Radiation Therapy and Hyperthermia. *Cells* 2020; 9(12): 2595. DOI: [10.3390/cells9122595](https://doi.org/10.3390/cells9122595) / ISSN 2073-4409.
- Cao R, Huang Z, Nabi G, Melzer A. Patient-Specific 3-Dimensional Model for High-Intensity Focused Ultrasound Treatment Through the Rib Cage: A Preliminary Study. *J Ultrasound Med* 2020; 39(5): 883-899. DOI: [10.1002/jum.15170](https://doi.org/10.1002/jum.15170) / ISSN 0278-4297.
- Berger J, Unger M, Landgraf L, Melzer A. Evaluation of an IEEE 11073 SDC Connection of two KUKA Robots towards the Application of Focused Ultrasound in Radiation Therapy. *Current Directions in Biomedical Engineering*. 1. September 2019; 5(1): 149-52. DOI: <https://doi.org/10.1515/cdbme-2019-0038>.

# #COMPUTER\_ASSISTED IMAGE\_GUIDED INTERVENTIONS

## SCIENTIFIC RESEARCH AREAS AND RELATED PROJECTS:

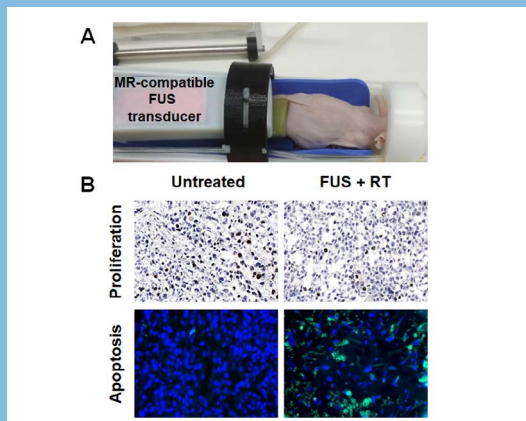
### #IMAGE\_GUIDED\_FOCUSED\_ULTRASOUND – IGFUS:

- [SONO-RAY](#) | Tumor Therapy Combined by MR-Guided Focused Ultrasound and Radiation Therapy | Funding: META-ZIK of BMBF
- [CURE-OP](#) | Oncological Therapy Platform for Combined Ultrasound Radiation Therapy | 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) in the treatment of uterine fibroids – collaborative project with UKL
- [LIFU](#) | Neuromodulation using transcranial ‘low intensity focussed ultrasound’ (LIFU) stimulation measured with EEG – collaborative project with MPI and Fraunhofer IBMT

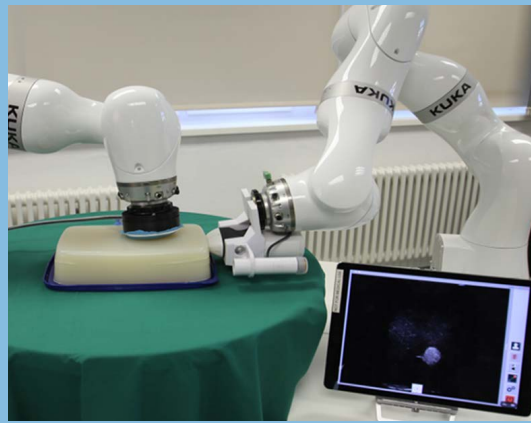
### #MAGNETIC RESONANCE-GUIDED INTERVENTIONS – MRGI

#### – LEAD: C. MARTIN REICH:

- [MR-Thrombosis-Theranostic](#) | MR-guided Minimally-invasive Diagnostics and Therapy of Thrombosis | Funding: BMBF
- [MR-Biopsy](#) | MR Safe Flexible Biopsy Forceps for Minimally Invasive Tissue Sampling | Funding: BMBF
- [MR-Stents](#) | MR-Guided Stent-Implantation | Funding: BMBF



In vivo study of FUS and RT. (A) Experimental set-up of FUS and tumor-bearing mouse. MR compatible FUS system developed by Fraunhofer IBMT. (B) Histology staining showed a reduction of proliferation and an increase of apoptosis in tumor tissue.



Dual-arm system consisting of two Kuka LBR robots holding the treatment head (left) and the imaging probe (Clarius L7, right). The procedure is planned and monitored using US-guidance in a custom-made phantom.

## RESEARCH AREA: IMAGE GUIDED FOCUSED ULTRASOUND – IGFUS

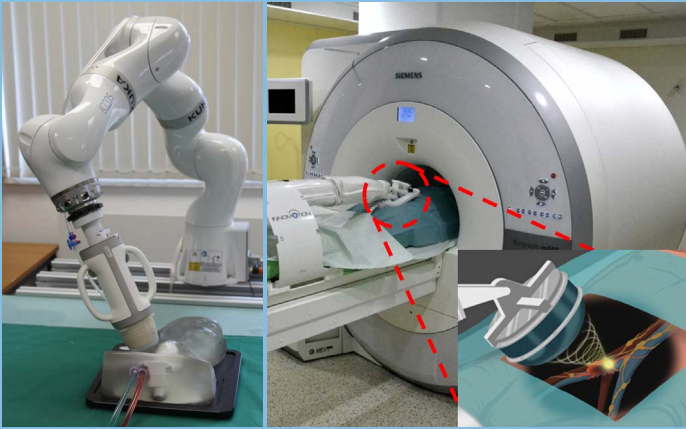
### SONO-RAY: FOCUSED ULTRASOUND (FUS) COMBINED WITH RADIATION THERAPY (RT) TO IMPROVE RADIOLOGICAL TREATMENTS

The Sono-Ray project, a joint project of ICCAS (Leipzig) and OncoRay (Dresden) funded by BMBF, started in October 2016 and was concluded in August 2020 to investigate the effects of focused ultrasound (FUS) to improve the treatment outcome of conventional treatments including radiation therapy (RT) and hyperthermia (HT). FUS describes a unique technique using ultrasound beams to generate heat or cavitation effects in a target tissue inside the body in a non-invasive way under image-guidance and quantifiable temperature control in real-time via magnetic resonance (MR) thermometry. Therefore, FUS demonstrated great potential to sensitize cancer cells to RT in both in vitro and in vivo studies.

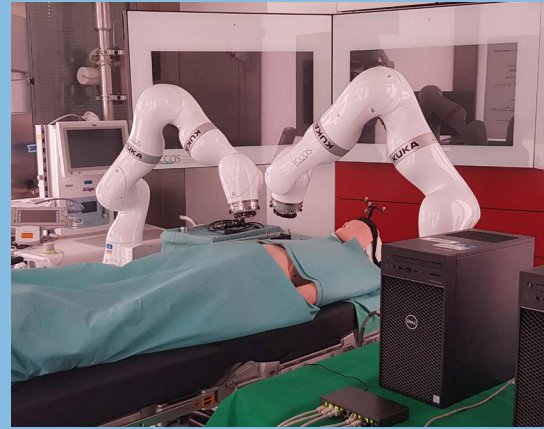
The intensive analysis started on in vitro cell cultures using ultrasound penetrable 96-well cell culture plates and different in vitro systems for high throughput FUS treatment which were developed in cooperation with Fraunhofer IBMT (St. Ingbert). Prostate cancer cells, glioblastoma, and head and neck cancer cell lines were treated with FUS and RT using in vitro systems and the effects on me-

tabolic activity, DNA damage, hypoxia, cell invasion, expression of proteins, and long-term clonogenic survival were determined. To validate the in vitro study, an animal experiment was performed using MR-compatible FUS system Diphys (developed by Fraunhofer IBMT) and computed tomography (CT)-guided RT platform in xenograft prostate cancer model in cooperation with Fraunhofer IZI (Leipzig). Follow-up of tumor growth and histological analysis were performed to evaluate the treatment outcome.

The in vitro results demonstrated a significant reduction of cell survival, invasion, and suppression of the growth of cancer cells. The results are in submission for publications. Histology staining of healthy organs demonstrated no damage to surrounding tissues after FUS exposure, confirmed the safety of our in vivo experimental set-up. The combination of FUS and RT led to a significant decrease in proliferation and an increase of apoptosis in prostate xenografts. For the clinical translation of the combined FUS and RT treatment, a system consisting of two Kuka robotic arms, holding an imaging probe and a therapeutic transducer respectively, was developed and evaluated. Robotic arm system with MR-compatible FUS system was successfully integrated into clinical PET-MR scanner allows precise FUS positioning and provide clinical feasibility.



Prototypical system consisting of a Kuka LBR iiwa robotic arm with the treatment head attached.



The setup of two KUKA Lbr iiwa 7 R800 robot arms (KUKA AG, Augsburg) in the demonstration OR at ICCAS Leipzig. Robots connected with IEEE 11073 SDC standard.

### CURE-OP – COMBINATIONAL ULTRASOUND AND RADIOTHERAPY ENHANCED ONCOLOGY PLATFORM

The project CURE-OP aims to prepare a commercially available high intensity focused ultrasound (HIFU) platform specifically designed for combinational cancer therapy. ICCAS will develop a robotic system that can deliver a broad range of ultrasound regimes (hyperthermia, thermal ablation, and cavitation) enabling different types of cancer polytherapy.

A Kuka LBR Med robotic arm was combined with Theraclion's HIFU treatment head. ICCAS is developing motion algorithms to ensure a stable acoustic coupling of the treatment head. Following the integration of the treatment head into the robotic system, an ex-vivo study will be conducted in cooperation with the ENT department of the University Hospital Leipzig to validate the system.

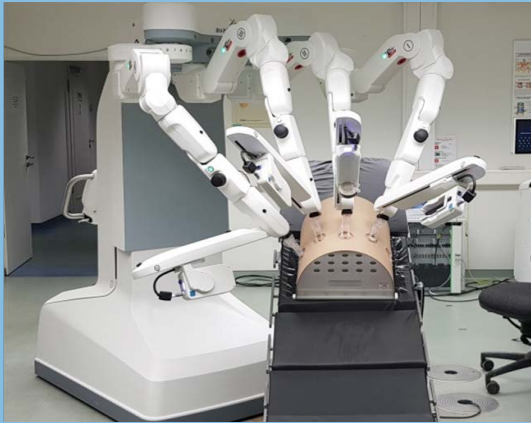
### IMAGING ROBOTICS

The robotics group at ICCAS aims for the integration of robotic systems into the clinical workflow of image-guided interventions. The main goal comprises the development of a robotic system that provides various functions to serve in multiple different use-cases and, thereby, improve acceptance in the medical domain. Utilizing the KUKA Lbr iiwa 7 R800 and

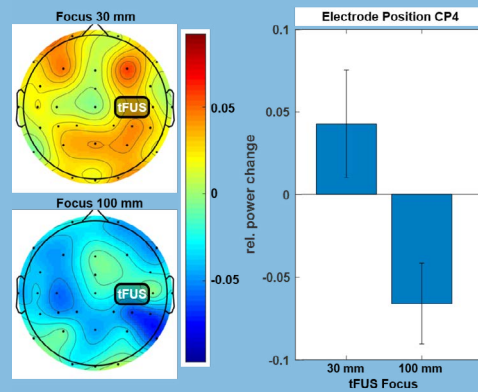
Med robotic arms and their collaborative concepts (direct user interaction during automated movement), shall reduce the complexity of handling the robots during surgical workflows. Using the IEEE 11073 SDC standard for medical device connectivity, the ICCAS researchers implemented a first demonstrator with two robot arms. The system communicates with any other SDC medical device and can, thereby, be utilized for many image-based use-cases. It was evaluated for ultrasound-guided biopsies and focused ultrasound ablations during the projects SONO-RAY and Cure-OP.

### PREPOSITIONING AVATERA

Under commission by the avateramedical GmbH (<https://www.avatera.eu/home>), ICCAS is investigating the possibilities to optimize the positioning principles of a novel robotic system for laparoscopic interventions. In cooperation with the urology department of the University Hospital Leipzig, the requirements for the pre-positioning of the system at the OR-table were defined and transferred into robotic workspace simulations. The aim of this work is to provide an intuitive procedure for the docking process of the robot at the OR-table and an optimized positioning for 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 (<https://www.itk-engineering.de/>



The avatera robot positioned on a body phantom at ICCAS.



Transcranial low intensity focused ultrasound modulate EEG activity depending on stimulation depth.

branchen/robotik/), to isolate the best parameters for efficient positioning, including 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. In a preliminary investigation, the most reasonable positions were tested on a body phantom, to derive a defined workflow for easy arm positioning and overall robot handling. In consequence, ICCAS developed a guidance manual for the side docking of the system for radical prostatectomies. A user validation with probands of varying expertise is planned for Q1 - Q2 2021.

### NON-INVASIVE MAGNETIC-RESONANCE-GUIDED FOCUSED ULTRASOUND (MRGFUS) IN THE TREATMENT OF UTERINE FIBROIDS

Since 2017, we have successfully established a fibroid-treatment-center in the University Hospital Leipzig. Our aim is to provide an optimized individual treatment to patients with symptomatic uterine fibroids, offering all modern therapy options including MR-g-HIFU (Profound medical Sonalleve MR-HIFU System). To date over 300 patients have been screened and 46 of these became a MR-HIFU-treatment. The patients were treated in a clinical setting, under analgesia and sedation. All patients were discharged on the next day after treatment without any significant complaints. Symptom control was accomplished

for about 2/3 of the patients and 3 successful pregnancies were also achieved. In addition a multisession HIFU-Treatment of an extensive desmoid tumor of the thoracoabdominal wall has taken place with satisfying symptom reduction.

### NEUROMODULATION USING TRANSCRANIAL 'LOW INTENSITY FOCUSED ULTRASOUND' (LIFU) STIMULATION MEASURED WITH EEG

Previous studies suggested tFUS for non-invasive modulation of neuronal activity, which might allow therapeutic applications. We used a custom-made tFUS system (IBMT) that allows to position a focal ultrasound spot in a given brain volume by adjusting the focus depth. Preliminary data acquired with four scalp electrodes showed a differential modulation of EEG activity depending on the stimulation depths, i.e. alpha synchronization for focus 30 mm, desynchronization for 100 mm. In a second experiment with denser EEG recordings we now confirm these results. It seems that the cortical stimulation (30 mm) synchronizes local neuronal activity leading to increased ongoing oscillations, while the deeper stimulation focus maybe activates thalamic projection neurons thus desynchronizing cortical background rhythms.





Experimental interventional MRI interaction setup at Nuclear Medicine Clinic of University Hospital Leipzig, which allows direct control of the scanner by the physician.



Silicone arterial vessel phantom with a connected porcine heart for ex-vivo studies.

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

### MR-THROMBOSIS-THERANOSTIC – MR-GUIDED MINIMALLY-INVASIVE DIAGNOSIS AND THERAPY OF THROMBOSES

Blood clots disturb the physiological blood flow and can become detached as thromboembolism – in worst case migrate and cause a life-threatening pulmonary embolism. In MR-THROMBOSIS-THERANOSTICS the beneficial features of MR imaging (excellent soft tissue contrast, adjustable tissue weighting & real-time imaging) are used to improve interventional thrombosis treatment and theragnostics. These features can be used for visual acquisition of thromboembolisms trapped by implanted vena cava filters (VCF) and therefore lead to better decisions regarding the further course of the treatment. To ensure conformity with regulations regarding MR safety and biocompatibility, novel medical instruments and corresponding workflows need to be developed. The visualisation concept uses resonant circuits to locally enhance the MR signal, rather than the commonly used mechanism of disturbing artefacts caused by shielding properties. A silicone-based patient model of a human arteriovenous vessel system is manufactured. It allows in-vitro testing of devices and workflows in cooperation with

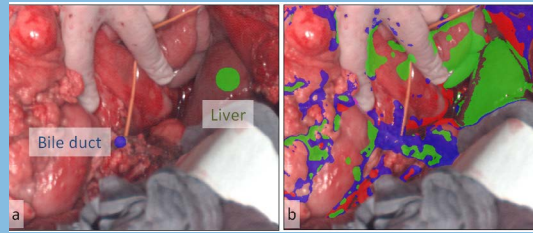
the University Hospital Leipzig. An attached pulsatile flow pump and integrated thrombus simulation ensure lifelike testing conditions. Additionally, an interventional MRI setup was developed with the Department of Nuclear Medicine, ensuring real time control and communication between physician and technical staff during MR-guided interventions.

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

Endomyocardial biopsy (EMB) is a procedure for diagnosis of tumor, acute myocarditis or transplant rejection. EMB is usually conducted using X-ray fluoroscopy implying ionizing radiation and nephrotoxic contrast agents, implying drawbacks for medical staff and patients. Goal of the joint project MR-BIOPSY is to overcome these disadvantages by transfer of EMB procedures into the magnetic resonance imaging (MRI) environment. Therefore, a worldwide first MR compatible, flexible biopsy forceps containing novel MRI markers is developed. In an iterative process, the MRI visibility of forceps and markers are obtained, while ensuring conformity of components with MR safety regulations like ASTM and ISO standards. Feasibility of the intervention is guaranteed by development of a corresponding clinical workflow in cooperation with the Department of Cardiology of University Hospital Leipzig. A hybrid patient model consisting of a



Vessel phantom on patient table with Magnetic resonance (MR) during visualization tests at the Department of Nuclear Medicine.



Automatic identification of the bile duct in human tissue. Left: manual annotations of the liver (green) and the bile duct (blue). Right: the pixels of the image automatically labeled as liver and bile duct are respectively represented in green and blue.

porcine heart connected to a life-size silicone model of a human arterial vessel system was manufactured. First prototypes showed promising results in test settings and will be subject to ex-vivo-studies to evaluate the visibility and usability of the forceps and the workflow in a realistic setting.

## MR-STENTS – MR-GUIDED STENT-IMPLANTATION

Coronary heart disease and associated myocardial infarction is one of the main causes of death in Germany. The recommended therapy by the National Disease Management (NVL) guideline is minimally invasive catheter-guided stent implantation, which is usually performed using X-ray fluoroscopy. As a high risk group, children with congenital heart disease (e.g. coarctation of the aorta) are commonly treated by stent implantation. The aim of the project MR-STENTS is to enable a MRI-guided stent intervention by developing MR compatible devices together with OEM medical device manufacturers. Novel MR markers are developed to visualize multiple instruments during an MR-guided stent implantation. These markers are based on resonant circuits and work with corresponding MR sequences. A specially designed MRI-safe stenosis-phantom is manufactured to investigate the visibility and applicability in accompanying tests during the development process. It allows for a realistic simulation of

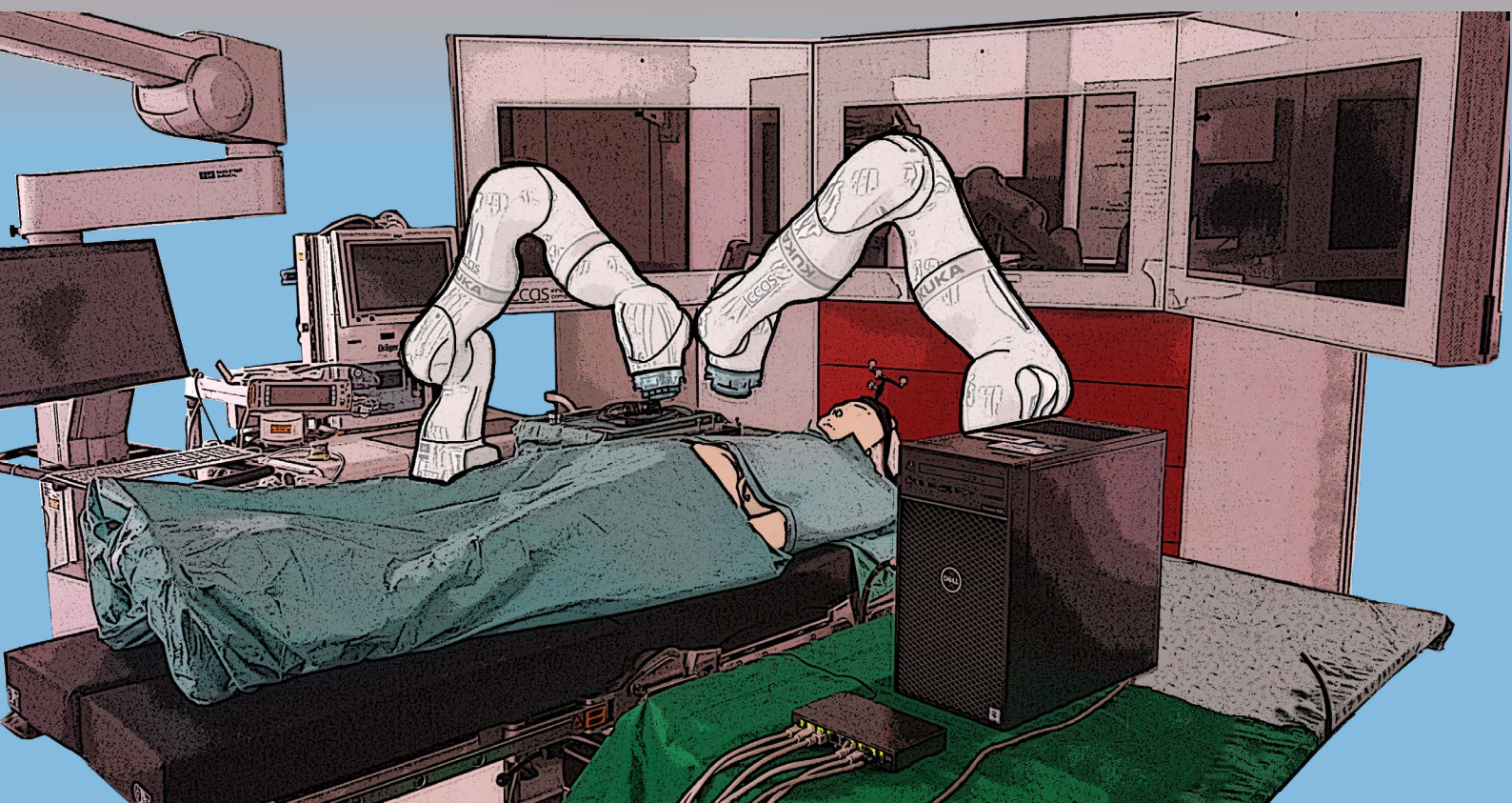
stent implantation and serves as training environment to validate a dedicated workflow for MRI-guided stent implantation. In the further course of the project, the findings should serve as framework for treatment of additional use-cases like stenting of the esophagus, liver, and lung.



# ICCAS

## #MODEL\_BASED\_MEDICINE AND #INTELLIGENT\_OR

Research pioneers the development of biomedical information systems and data analysis technologies, medical communication technologies, digital twins, and biomedical sensors which expand the functioning of current medical devices or create completely new support. Work is in progress on a 'smart' operating theater adapted to the needs of surgeons. Goal is the qualitative and quantitative improvement of clinical workflows by advancing clinical efficiency and increasing patient safety. This also includes the development of non-invasive image-based assistance systems for new diagnosis and biomonitoring in emergency medicine.





## 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.’



## SCIENTIFIC STAFF

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## SELECTED PUBLICATIONS

- Bieck, Richard, Katharina Heuermann, Markus Pirlich, Juliane Neumann, and Thomas Neumuth. “Language-Based Translation and Prediction of Surgical Navigation Steps for Endoscopic Wayfinding Assistance in Minimally Invasive Surgery.” *International Journal of Computer Assisted Radiology and Surgery* 15, no. 12 (December 1, 2020): 2089–2100. <https://doi.org/10.1007/s11548-020-02264-2>.
- Neumann, Juliane, Christine Angrick, Celina Höhn, Dirk Zajonz, Mohamed Ghanem, Andreas Roth, and Thomas Neumuth. “Surgical Workflow Simulation for the Design and Assessment of Operating Room Setups in Orthopedic Surgery.” *BMC Medical Informatics and Decision Making* 20, no. 1 (December 2020): 145. <https://doi.org/10.1186/s12911-020-1086-3>.
- Neumuth, Thomas, Clemens Bulitta, Frank Edelmann, Steffen Hamm, Alfons Mittermaier, Max Rockstroh, Ann-Christin Schleser, and Christoph Thümmeler. *5G Health – The Need for 5G Technologies in Healthcare*. Leipzig, Germany: 5G Health Association, 2020. DOI 10.13140/RG.2.2.10915.27687.

# #MODEL\_BASED\_MEDICINE AND #INTELLIGENT\_OR

## SCIENTIFIC RESEARCH AREAS AND RELATED PROJECTS:

### #MODEL\_BASED\_AUTOMATION:

- **MOMENTUM** | Mobile Medical Technology for Integrated Emergency Care and Accident Medicine | Funding: BMBF
- **COMPASS** | Comprehensive Surgical Landscape Guidance System for Immersive Assistance in Minimally-invasive and Microscopic Interventions | Funding: BMBF
- **ENSEMBLE** | Development of a scalable and magnetic resonance (MR)-compatible blood circulation model | Funding: BMWi – ZIM-program

### #DIGITAL\_PATIENT\_MODEL:

- **MPM** | Models for Personalized 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
- **PAPA-ARTIS** | Paraplegia Prevention in Aortic Aneurysm Repair by Thoracoabdominal Staging with 'Minimally-Invasive Segmental Artery Coil-Embolization': A Randomized Controlled Multicentre Trial | Funding: European Union – H2020 – GA-no. 733203

### #LIFE\_SUPPORT\_SYSTEMS:

- **VITALS** | Visualization of Thorax-related Analysis of Life-Signals | Funding: BMWi – ZIM-program
- **IMPACT** | Data integration and modeling for improved multiparametric monitoring of blunt thoracic trauma | Funding: BMBF – KMU innovativ
- **Brainsaver** | Development of robust methods for sensor position evaluation and interference-free blood flow detection | Funding: BMWi – ZIM-program
- **AutoCuff** | Software development of a complete medical system consisting of cuff suction device and cuff controller | Funding: BMWi – ZIM-program





Presentation of the MOMENTUM project during a meeting at the BMW-plant Leipzig (from left to right: Albrecht Bloße, Jan Gabel, Max Rockstroh, Thomas Neumuth and Holger Groß).



MOMENTUM – Mobil technology for Emergency Care and Trauma Medicine.

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

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

The emergency medical care of patients inside and outside the hospital is based on a complex system of interdependent processes involving many different actors (e.g. doctors, paramedics, nurses) as well as a large number of different medical devices and IT systems. Especially the treatment outside of specialized medical facilities (e.g., hospital, community health center, medical office) requires the quick and easy availability of medical resources, smooth access to information as well as the availability of medical expertise.

In the MOMENTUM project, medical technology is being developed that can be used not only in preclinical emergency care at the scene of the accident, but also in the hospital heterogeneous technologies of networked medical technology inside an ambulance and IT systems will be integrated into a mobile infrastructure using 5G-technology. As a result, medical-technical resources, technologies and information of the hospital can virtually be used on site and data can be transmitted to the hospital before the patient even arrives there. This not only allows a more precise diagnostic

assessment of the patient-specific situation, but also a much higher precision in the initial diagnosis on site. The end-to-end availability of clinical information throughout the entire process chain – from the scene of the accident to the trauma room to the operating theater – can improve patient care and make it more efficient. In addition, the information collected at the scene of the accident and during transport can be coordinated for further treatment and be used seamlessly in the hospital. The availability of a high-performance network enables the distribution of computing power either from the device to the ambulance or directly to the higher-level infrastructure (Mobile Edge Cloud – MEC). The results of the MOMENTUM project should help to set new standards in emergency care. The transmission of relevant information from the site to the hospital allows a new type of supply chain between ambulance and trauma room and enables new kinds of medical applications at the scene of accident and a better preparation in the trauma center.

After an analysis of the use cases at the accident site and in the clinic with all project partners, an overall architecture concept was developed with a strong focus on IT security and flexibility in the used communication technology. First measurements with public 5G mobile cell networks were carried out and the integration of medical technology in the ambulance with the ISO/IEEE11073-SDC standard family was implemented. Furthermore,



The COMPASS principle for vision- and language-based navigation assistance in minimally-invasive surgery.



Combined representation of aortic surface models.

the setup of an ambulance with 5G-Small-Cell was planned and will be put into practice next year.

In a next step, the basic communication technology in the ambulance based on a mobile small cell will be implemented. Another use case is the development of mobile and stationary display methods in the clinic and at the accident scene.

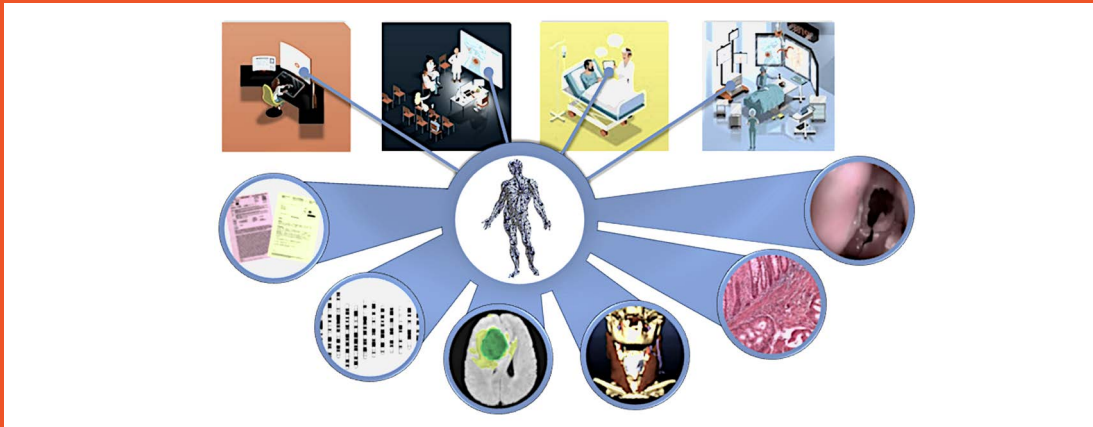
### **COMPASS – COMPREHENSIVE SURGICAL LANDSCAPE GUIDANCE SYSTEM FOR IMMERSIVE ASSISTANCE IN MINIMALLY-INVASIVE AND MICROSCOPIC INTERVENTIONS**

In the project COMPASS, a new technology for immersive assistance in minimally invasive and microscopic interventions is developed to convert navigation systems into fully acknowledged surgical actors. The goal is to identify, model and predict the surgeon's navigation process for the provision of assistance functions. The focus is on the development of an artificial navigation awareness for endoscopically guided minimally invasive procedures. The starting point is a machine-understandable description of surgical navigation during inspection of anatomical structures that are visited. Initially, navigation steps were described in natural language (NLP) in order to create an instruction-like commentary on the movement of the endoscope from one

navigation step to the next. Then neural machine translation model was trained to predict future navigation steps of the endoscope. We successfully showed that a verbalized description of the endoscope movement could be reproduced. This represents the first step in the implementation of a comprehensible navigation aid through navigation awareness. Further studies will involve computer vision aspects that use the provided description mechanism to improve classification functions to better locate the endoscope. Additionally, computed image properties will also reinforce sentence descriptions.

### **ENSEMBLE – DEVELOPMENT OF A SCALABLE AND MAGNETIC RESONANCE (MRI) COMPATIBLE BLOOD CIRCULATION MODEL**

Artificial surgical phantoms enable surgeons to improve their skills and dexterity outside of real surgeries. For the training of catheter-based surgeries, a training model with a realistic vascular tree and an active blood circulatory system is required. In the project ENSEMBLE such a phantom was developed, by using CT images and automatically segmented blood vessel areas throughout combined data sets. The phantom should represent the density, thickness, and elasticity of real vessel walls with a maximum degree of branching. Together with a pump and a blood-like fluid, the vascular 3D model was used to manufacture



The project Models for Personalized Medicine develops multimodal knowledge graphs, machine learning methods, and applications to assist cancer treatment workflows.

an MR conditional blood circulation phantom for surgical training and education.

The focus of the project was the development of an automatic segmentation procedure by means of statistical form models. For this purpose, semi-automatically segmented CT-images were used as training data. These were represented by surface landmarks that were transformed into a common coordinate system. With the Iterative Closest Point (ICP) algorithm, corresponding landmarks were detected, and a 3D shape model could be generated considering the typical shape of the aorta (statistical mean). During automatic segmentation, the shape model was adapted to the specific variations of the aortas' shape in the actual patient-specific image data. The resulting aorta 3D-representation was then used to manufacture an artificial, scalable and MR conditional blood circulation model for surgical training.

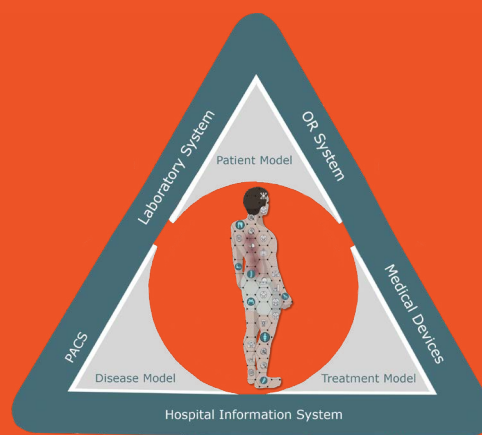
## RESEARCH AREA: DIGITAL PATIENT MODEL – DPM

### MPM – MODELS FOR PERSONALIZED MEDICINE

Healthcare is changing due to social challenges in the area of tension between cost efficiency through standardization and therapy effective-

ness through personalization. Therapy-relevant information, for example in interdisciplinary, oncological treatment, covers the entire range from omics data, imaging, and laboratory values to the inclusion of living conditions. For efficient healthcare, the data must be available in daily clinical practice and decision support systems must seamlessly integrate into established clinical workflows.

The aim of the project is, therefore, to create a scientific and methodological basis for model-based, personalized cancer treatments that can be used in a large variety of clinical settings. The project addresses scientific questions in the field of knowledge modeling and data semantics. Clinical knowledge, such as guidelines, scoring systems and studies, is translated into formal models. The overall modular architecture of our approach enables the combination of a large variety of methods and formal models of general medical knowledge. For individual patients, related data are represented in a knowledge graph based on the Resource Description Framework (RDF). Within this graph, semantics is maintained by a set of established and newly developed ontologies. The data representation also references clinical reports and information systems, such as Patient Data Management Systems (PDMS) or Picture Archiving and Communication Systems (PACS). The patient-related information is maintained by software, called Digital Medical Twin. Ba-



Digital Patient Model for Clinical Studies.

sed on the formalized clinical knowledge and the interlinked patient data, it can provide multimodal analyses, data-based predictions, or risk warnings to provide reasoned evidence to complex clinical questions via this novel data interface.

The developed models and the data interface serve as a basis for applications for personalized tumor therapy. So that we can provide a common understanding of work processes, patient data and decision-making processes as the basis for integration into clinical practice. The complexity of medical data and clinical processes requires the development of tailored applications for the respective clinical scenarios and user groups along the tumor treatment chain. For example, the project assists interdisciplinary therapeutic decisions for cancer patients with an intelligent environment for the cooperative clinical decision making. Additionally, an assistance system is developed for the improvement of patient informed consent to treatment measures by interactive, personalized illustrations of the tumor and the potential treatment risks.

The project demonstrates the applicability and added value of selected assistance systems as well as the integration of these applications based on interoperable models in cooperation with regional SME partners and the clinical users.

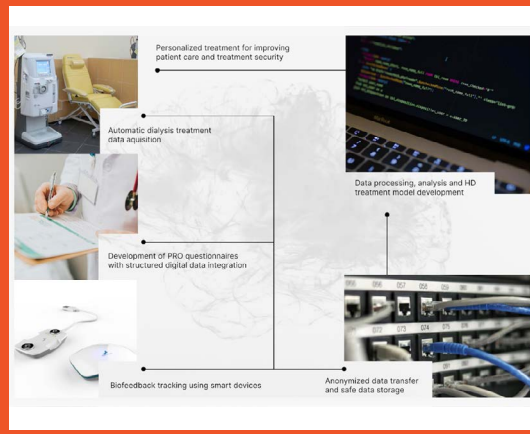
## AIQNET – THE MEDICAL DATA ECOSYSTEM

Due to the new Medical Device Regulation of the EU, the requirements for reliable medical device data are continuously increasing. To prove their continuous safety and performance, a market observation of the products based on clinical studies is explicitly required, which also includes a comparative quality and performance evaluation. The acquisition, storage, and analysis of clinical data in compliance with the data protection regulations are essential for this evaluation. Therefore, AIQNET, a medical data ecosystem that ensures compliance with legal and ethical frameworks through state-of-the-art architecture and security technologies, will be conceptualized and developed in the project. Within the framework of the platform, a database will be created, which enables both the clinics and medical device manufacturers to use clinical data for research and development effectively and in compliance with the EU regulatory framework.

In cooperation with the University Hospital Leipzig, Division of Spine Surgery, ICCAS will develop a “Digital Patient Model”. The model integrates different perspectives on treatment and the patient. The aim is to improve AI-supported clinical quality and performance assessment based on previous knowledge about the patient and the treatment. This



The development of the KAIT platform is based on the close co-operation of clinical experts, knowledge engineers and developers in order to effectively use the innovative developments of the respective disciplines.



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.

includes aspects of diagnosis and the disease, information on therapies and the specific characteristics of the patient.

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

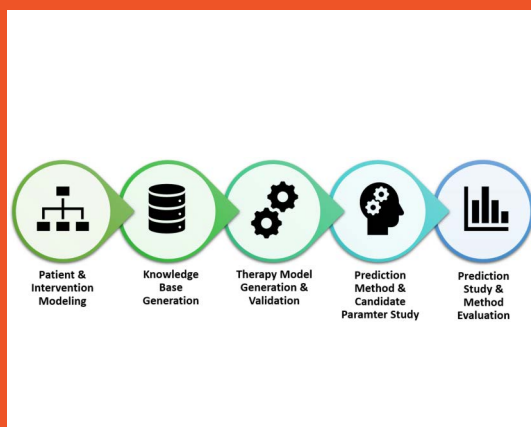
The medical field of hematology is characterized by heterogeneous diseases and considerably varying patient disease courses. Nonetheless, therapeutic decisions mostly rely on the administration of the same therapeutic regimen to this utterly diverse patient population. Due to the continuous effort of providing personalized medicine in various clinical fields, there's now more patient and disease data available than ever before. While this is a truly desirable situation, considering all that information during clinical decision-making introduces real challenges for the physicians. To overcome the flaws of this potential information overload, the KAIT platform aims to provide extensive assistance in the way that clinical data is managed, processed and represented. The system will utilize methods of knowledge engineering, data mining and machine learning to gather, evaluate and analyze multimodal information from medical case reports, clinical trial data, research publications as well as clinical practice guidelines to generate extensive knowledge bases. Through data-driven approaches, the system will then actively assist the physician during reasoning

tasks to derive optimal treatment strategies for each individual patient. KAIT thus supports the transformation towards truly personalized therapies in hematology.

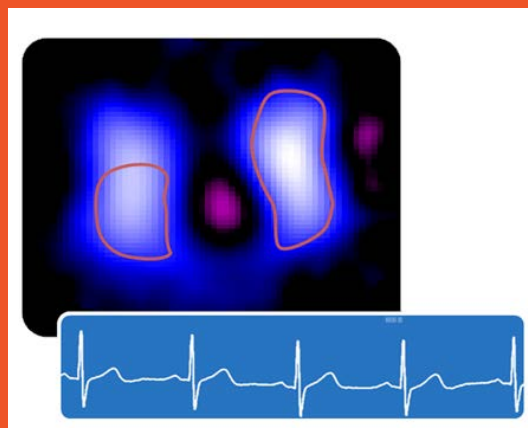
### **PRODIAL – PATIENT-REPORTED OUTCOME, BIODATA AND PROCESS DATA TO EVALUATE DIALYSIS TOLERABILITY**

While haemodialysis treatment affects only 0.1% of the total population, it requires 5 to 10% of the total health care costs in industrialized countries. Although the complex and long-term treatment ensures life-sustaining detoxification, it does not prevent 5 to 10 times higher mortality of affected end-stage renal disease patients compared to the general population. Current quality and process control measures of hemodialysis treatment are based on a general evaluation of biochemical and procedural measures that do not take into account the patient perspective in terms of mortality and dialysis tolerance. To address this issue, the ProDial project aims to develop methods for the individual analysis of dialysis treatments. Therefore, time-synchronous data streams of various treatment aspects will be gathered and evaluated. This includes patient and therapy characteristics, biomedical real-time feedback, process information and patient reported outcomes (PRO). Based on this collection, novel mechanisms for finding significant correlations between the referenced data categories enable the development of personalized real-time dialysis





Overview of the modeling approach and development stages.



Simulated Electrical-Impedance-Tomography tidal reconstruction image and Perfusion-Map overlay with synchronous ECG-measurement.

treatment procedures in the long-term. These data-based algorithms can then be integrated into modern and intelligent dialysis centers to enable truly personalized real-time treatment monitoring and risk prevention.

#### **PAPA-ARTIS – PARAPLEGIA PREVENTION IN AORTIC ANEURYSM REPAIR BY THORACOABDOMINAL STAGING WITH ‘MINIMALLY-INVASIVE SEGMENTAL ARTERY COIL-EMBOLIZATION’: A RANDOMIZED CONTROLLED MULTICENTRE TRIAL**

The repair of large thoracoabdominal aortic aneurysms employs endovascular surgery with stent grafting. A successful intervention still poses risks of paraplegia or death due to ischaemic reactions in the spinal cord. In a new procedure supplying segmental arteries of the aorta are preemptively closed to counter ischemic effects. Inside the multi-centric clinical PAPA-Artis EU project, the patient is computationally modelled to investigate the spinal perfusion and the clinical outcome. We aim to generate a patient-specific representation of the treatment process. Main patient parameters like demographics and imaging data were analysed using workflow analysis steps. The patient model is later used to form a therapy model for the PAPA-Artis EU clinical trial.

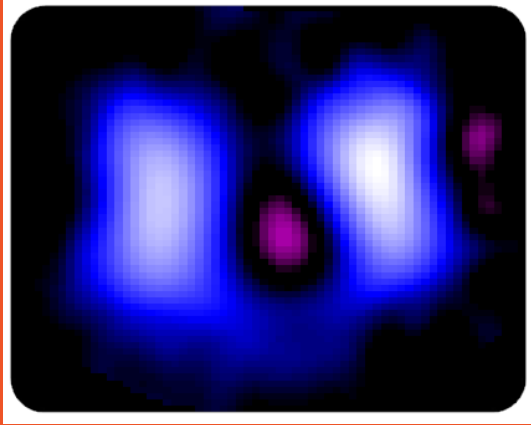
#### **RESEARCH AREA: LIFE SUPPORT SYSTEMS – LSS**

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

The project VITALS is a follow-up project of IMPACT. The aim of the project is to develop a system for preclinical emergency use, which can measure and visualize lung and heart activity simultaneously. For this purpose, a device is to be developed that enables Electrical Impedance Tomography (EIT) and Electrocardiography (ECG) using the same sensor technology. The subsequent combination can be used to separate the small perfusion-related impedance changes of EIT-images from high-value ventilation-related impedance changes. The resulting perfusion map can be used for further analysis, e.g. Ventilation-Perfusion-Overlap. In the case of existing oxygenation problems, first statements about the cause and accompanying conclusions about respiratory or vascular-relevant problems can thus be made.

##### **IMPACT – DATA INTEGRATION AND MODELING FOR IMPROVED MULTIPARAMETRIC MONITORING OF BLUNT THORACIC TRAUMA**

The Goal of IMPACT was to develop a mobile lung monitoring system for preclinical emer-



Electrical-Impedance-Tomography tidal reconstruction image; blue/white areas of the image highlight increasing impedance during measurement and signify ventilated areas of the lung.

gency use. With the help of the system, medical staff should be able to visualize pulmonary ventilation of a patient with a non-invasive, radiation-free and location-independent method. The monitoring analysis is based on the technique of electrical impedance tomography. ICCAS' part of the project was to develop and implement the analysis algorithms for lung monitoring. Their main components were methods for instantaneous, patient-specific EIT-reconstructions that don't require an explicit baseline. Furthermore, developers implemented analysis algorithms to enable the verification of spontaneous ventilation in both lungs and show whether the patient requires mechanical ventilation, while also visualizing whether the ventilation tube was placed correctly. Independently from those issues, other functions allow the detection and visualization of the presence, location and size-changes of existing pneumothoraces. After completion of the project, the developments were taken over by the company Fritz Stephan and are now in the transfer to product maturity.

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

In Germany, at least 50,000 people require re-animation every year, but only about 10% of

patients who have received cardiopulmonary resuscitation (CPR) leave the clinic with acceptable neurological results. In the course of this project, a mobile system is to be developed that can be used to measure the blood-flow in the brain vessels during CPR. This in turn shall enable an evaluation about the effectiveness of the compressions and a real-time feedback on the performed resuscitation activity. Further evaluation of automatically logged data can be analyzed during the following therapy and enables clinicians to adjust medication, coordinate therapy and identify patients with higher neural damage risk.

#### **AUTOCUFF – SOFTWARE DEVELOPMENT OF A COMPLETE MEDICAL SYSTEM CONSISTING OF CUFF SUCTION DEVICE AND CUFF CONTROLLER**

The aim of the AutoCuff project is the development of a system for automatic secretion removal and pressure control for a cuff balloon. In intubated, long-term ventilated patients, foreign matter and secretions above the occluding cuff balloon are removed using cuff suction devices. However, the mutual influence of the balloon overpressure and negative pressure for removal can lead to tissue damage or leakage. For this purpose, the project will develop a combination device that controls both pressure control loops simultaneously. By means of an interoperable interface, external medical devices will be notified in selected scena-

# #BIOMEDICAL\_DATA\_ANALYSIS

## LEAD

PROF GALINA IVANOVA

## SCIENTIFIC STAFF

Till Handel, Max Schreiber, Jean-Baptiste Tylcz

## PROJECT

- **PostStroke** | Mobile, digital system to strengthen relapse prevention, health competence and self-reliance | Funding: Freistaat Sachsen – eHealthSax

## SELECTED PUBLICATIONS

- Prost A, Handel T, Martin R, Schreiber M, Rothmaler K, Urban D, Geisler D, Tylcz J-B, Iacovazzi D, Ivanova G, Claßen J, Michalski D. PostStroke-Manager – Entwicklung eines multidisziplinären, strukturierten Nachsorge-Konzeptes für Schlaganfall-Patienten durch digitale Unterstützung und Implementierung eines regionalen Schlaganfall-Lotsen-Programms. **Online DGN-Abstracts 2020.**
- Prost, A, Rothmaler K, Handel T, Geisler D, Urban D, Martin R, Schreiber M, Tylcz J-B, Iacovazzi D, Ivanova G, Claßen J, Michalski D. Der PostStroke-Manager: Untersuchung der Machbarkeit eines kombinierten Schlaganfallnachsorge-Konzeptes aus digitaler Unterstützung und Schlaganfall-Lotsenbetreuung mithilfe von Patient-reported Outcomes. 2020 19. Deutscher Kongress für Versorgungsforschung (DKVF). doi: 10.3205/20dkvf407.

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

The Research Group Biomedical Data Analysis is dedicated to the development of new methods and tools for the investigation of complex biomedical processes and systems.

It unifies know-how in the areas of designing algorithms, analytical pipelines and modelling of complex biomedical processes as well as the efficient software implementation and finally the integration into various diagnostic, therapeutic and preventive applications.

Our know-how ranges from the design of studies, the support of data acquisition, the analysis of large amounts of data and the development of individualized methodologies and software to the preparation of demonstrators and prototypes which can be transferred into marketable products.

The fields of medical algorithms, multimodal neuroimaging as well as mHealth and eHealth are a special focus of the group.



<https://www.iccas.de/poststroke/>

# #INTRAOPERATIVE\_ MULTIMODAL\_IMAGING

rios to communicate alarms and warnings.

## LEAD

**PD DR CLAIRE CHALOPIN**

## SCIENTIFIC STAFF

Hannes Köhler, Marianne Maktabi, Michael Unger

## PROJECTS

- **LYSIS** | Development of a Laparoscopic Hyperspectral Imaging System | Funding: BMBF – KMU innovativ
- **SORLIC** | Development of an Assistance System for the Intra-Operative Planning of Flap Surgeries | Funding: BMBF – KMU innovativ
- **MSI** | Endoscope – 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

## SELECTED PUBLICATIONS

- Köhler H, Kulcke A, Maktabi M, Moulla Y, Jansen-Winkel B, Barberio M, Diana M, Gockel I, Neumuth T, Chalopin C. Laparoscopic system for simultaneous

high-resolution video and rapid hyperspectral imaging in the visible and near-infrared spectral range, J. Biomed. Opt. 2020 Aug; 25(8):086004. doi: 10.1117/1.JBO.25.8.086004.

- Maktabi M, Köhler H, Ivanova M, Neumuth T, Rayes N, Seidemann L, Sucher R, Jansen-Winkel B, Gockel I, Barberio M, Chalopin C. Classification of Hyperspectral Endocrine Tissue Images Using Support Vector Machines, Int. J. Med. Robot. 2020 Oct;16(5):1-10. doi: 10.1002/rcs.2121. Epub 2020 May 29.

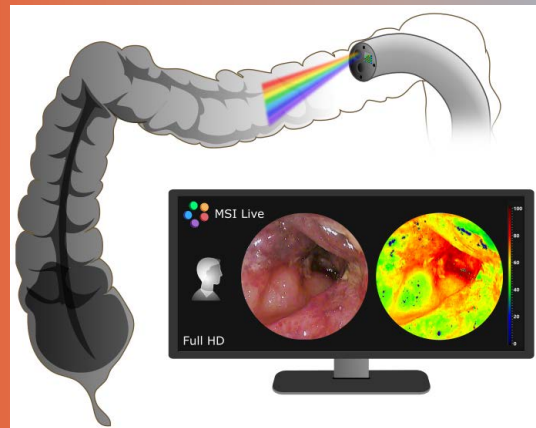
## LYSIS – DEVELOPMENT OF A LAPAROSCOPIC HYPERSPECTRAL IMAGING SYSTEM

Hyperspectral imaging (HSI) is a contactless and non-invasive optical imaging method which showed promising results for applications in the surgery. The goal of this project performed in collaboration with the company Diaspective Vision GmbH is the development and clinical evaluation of a HSI laparoscopic system and computer-assisted approaches to automatically identify tissues and organs in minimal-invasive operations.

The LYSIS prototype developed by Diaspective Vision was technically evaluated at ICCAS. It is the first system with high spatial and spectral resolutions and simul-



Augmented reality image of the forearm overlaid with the equivalent thermal image using the Microsoft HoloLens V2.



Application of the flexible MSI endoscope during colonoscopy or visceral surgery. The system simultaneously provides a color video and pseudo-color parameter images representing the perfusion state of the tissue in real-time and full HD.

taneous color video. The first acquisition of fresh resected tissue was performed at the hospital. Moreover, approaches using Machine Learning and Deep Learning methods for automatic tissue identification were developed and firstly evaluated on HSI data acquired with an HSI system dedicated to open surgeries. Different medical applications were investigated: the discrimination of the parathyroid gland and bile duct from surrounding tissue in in vivo HSI data and the recognition of cancer cells in HSI histological slides of tissue probes of Barrett's tumor. The next step of the project is the integration of the functionalities for automatic tissue identification with the software of the LYSiS system and the evaluation of the prototype in the operating room on resected tissue.

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

The aim of project SORLIC is the development of a system to assist during the planning of free flap transplantation in reconstructive surgeries. These surgeries require knowing the positions of the blood vessels supplying the donor tissue. Conventional imaging techniques use ionizing radiation and/or contrast agents (angio CT/MRI, ICG angiography, or DSA). As a non-invasive al-

ternative, infrared thermography will be used to detect the blood vessels supplying the donor tissue. A tool will be developed to support the surgeon during the planning of the procedure. Furthermore, the blood vessels and the planning results will be visualized using augmented reality.

#### **MSI ENDOSCOPE – ENDOSCOPIC MULTISPECTRAL IMAGING WITH REAL TIME PULSE OXIMETRY SYSTEM FOR MEDICAL APPLICATIONS**

In recent years, spectral imaging methods have been introduced into the clinical field for perfusion imaging and tissue classification. New hyperspectral systems providing high spectral and spatial resolution have been investigated in the research. Due to low temporal resolution and complex setups, their usage in minimally-invasive procedures is limited. Therefore, a flexible endoscope for real-time pulse oximetry based on multispectral imaging is devised in this project. KARL STORZ SE & Co KG, Diaspective Vision GmbH, and the ICCAS are cooperation partners. The tasks of ICCAS are the development and visualization of new pulse oximetry parameters and the conduction of pre-clinical and clinical trials with medical partners.

#### **HSI – LAPARO/ENDOSCOPY: AUTOMATED TISSUE RECOGNITION AND**





Prototype of the compact laparoscopic HSI system (bellow) and hyperspectral parameter image automatically registered the with the colour video (above right).

## VISUALISATION WITH LAPAROSCOPIC HYPERSPECTRAL IMAGING

Hyperspectral imaging (HSI) can support intraoperative perfusion assessment, the identification of tissue structures, and cancerous lesions. The practical use of HSI for minimal-invasive surgery is currently limited, due to missing video, or large set-ups. To address these limitations, compact and rapid laparoscopic HSI with a high spatial- and spectral-resolution is currently developed in the LYSiS project.

This project aims to acquire and analyse HSI data with the new laparoscopic HSI-system in the clinical context. Methods for the registration of the HSI data with the colour videos and automated, intraoperative classification of tissue with hyperspectral data will be developed and evaluated. The resulting information will be visualised using augmented reality methods.

# #PUBLICATIONS

## PAPERS

### FIRST- AND SENIOR AUTHORSHIP

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Language-based translation and prediction of surgical navigation steps for endoscopic wayfinding assistance in minimally invasive surgery.

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Gaebel J, Bockelmann C, Dekorsy A, Wendlandt R, Musiol T, Neumann J, Neumuth T, Rockstroh M

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Girrbach F, Petroff D, Schulz S, Hempel G, Lange M, Klotz C, Scherz S, Giannella-Neto A, Beda A, Jardim-Neto A, Stolzenburg JU, Reske AW, Wrigge H, Simon P  
Individualised positive end-expiratory pressure guided by electrical impedance tomography for robot-assisted laparoscopic radical prostatectomy: a prospective, randomised controlled clinical trial.

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Chirurg 2020; 91(2): 150-159

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Focused Ultrasound-Induced Cavitation Sensitizes Cancer Cells to Radiation Therapy and Hyperthermia.

Cells 2020; 9(12): 2595

ISSN 2073-4409

Köhler H, Kulcke A, Maktabi M, Moulla Y, Jansen-Winkeln B, Barberio M, Diana M, Gockel I, Neumuth T, Chalopin C

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Maktabi M, Köhler H, Chalopin C, Neumuth T, Wichmann Y, Jansen-Winkeln B, Gockel I, Thieme R, Ahle H, Lorenz D, Bange M, Braun S

Semi-automatic decision-making process in histopathological specimens from Barretts carcinoma patients using hyperspectral imaging (HSI).

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## #PUBLICATIONS

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 Robot-assisted Ultrasound-guided Tracking of Anatomical Structures for the Application of Focused Ultrasound.  
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### CO-AUTHORSHIP

Jansen-Winkel B, Germann I, Koehler H, Mehdorn M, Maktabi M, Sucher R, Barberio M, Chalopin C, Diana M, Moulla Y, Gockel I  
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 Hyperspectral Imaging (HSI) in Acute Mesenteric Ischemia to Detect Intestinal Perfusion Deficits.  
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 Cancer Patients During Aftercare.  
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 ISSN 2234-943X

# #PUBLICATIONS

## CONFERENCE PROCEEDINGS

Berger J, Keller J, Unger M, Landgraf L, Melzer A. A Collaborative and Integrated Robotic System for the Application in Image-Guided Interventions. 54th Annual Conference of the German Society for Biomedical Engineering (BMT); 2020.

Bieck R, Neumuth T. Cognitive Situation Awareness For Intelligent Navigation Assistance in Minimally-Invasive Endoscopic Surgery-A System Design Approach. In: 49th Annual Conference of the German Society of Endoscopy and Imaging Technologies. Stuttgart; 2020.

Cooney GS, Barberio M, Diana M, Sucher R, Chalopin C, Köhler H. Comparison of spectral characteristics in human and pig biliary system with hyperspectral imaging (HSI). In: Current Directions in Biomedical Engineering. 2020.

Gholami Bajestani D, Pfahl A, Reich CM, Immel E, Melzer L, Lenk K, u. a. Development of in-vitro Vessel Phantoms for MRI-guided Interventions. Chicago; 2020.

Gholami Bajestani D, Pfahl A, Reich CM, Immel E, Neumann A, Hammerschmidt R, u. a. Development of in-vitro Vessel Phantom for Computer-assisted MRI-guided Thrombectomy and Vena Cava Filter Implantation. Leipzig; 2020.

Pfahl A. Acquisition of Clinical Workflow of EMB for Development of Computer-assisted MRI-guided Interventions. 54th Annual Conference of the German Society for Biomedical Engineering; 2020 Sep 29; Leipzig.

Prost A, Rothmaler K, Handel T, Geisler D, Urban D, Martin R, u. a. Der PostStroke-Manager: Untersuchung der Machbarkeit eines kombinierten Schlaganfallnachsorge-Konzeptes aus digitaler Unterstützung und Schlaganfall-Lotsenbetreuung mithilfe von Patient-reported Outcomes. In: 19 Deutscher Kongress für Versorgungsforschung (DKVF). 2020.

Reich CM. Developing an Intuitive and Feasible Setup for In-room Control During MRI-guided Interventions. 32nd Annual 2020 SMIT Congress; 2020 Dez 3; Leipzig.

Reich CM. Developing an Intuitive and Feasible Setup for In-room Control During MRI-guided Interventions. 54th Annual Conference of the German Society for Biomedical Engineering; 2020 Sep 30; Leipzig.

Reich CM. New MR instruments and ancillary systems for MR guided procedures. 54th Annual Conference of the German Society for Biomedical Engineering; 2020 Sep 30; Leipzig.

Reich CM. Realising MRI-guided Interventions: Technical Challenges. 51. Jahrestagung der Deutschen Gesellschaft für medizinische Physik; 2020 Sep 10; Leipzig.

# #EVENTS

Stöhr M, Mehlhorn S, Oeser A, Dietz A, Gaebel J, Cypko Ma. Development of a treatment supporting system for oropharyngeal carcinoma. In Estrel Congress Center Berlin; 2020.

Unger M, Berger J, Gerold B, Melzer A. Robot-assisted Ultrasound-guided Tracking of Anatomical Structures for the Application of Focused Ultrasound. 32nd Annual SMIT Congress. 2020.

Unger M, Berger J, Gerold B, Melzer A. Robot-assisted Ultrasound-guided Tracking of Anatomical Structures for the Application of Focused Ultrasound. 54th Annual Conference of the German Society for Biomedical Engineering (BMT); 2020.

Zhang X, Hu S, Patties I, Landgraf L, Melzer A. Radiosensitization of human cancer cells with in vitro focused ultrasound. 54th Annual Conference of the German Society for Biomedical Engineering (BMT); 2020.

## EVENTS

### IN-HOUSE EVENTS

#### ICCAS STATUS SEMINAR AND ADVISORY BOARD MEETING 2020

January 22, 2020 | ICCAS

Demonstrations at seven ICCAS stations on the overarching project topics: Imaging Robotics, MR-Guided Interventions, Medical Technology Networking, Imaging Techniques in Trauma and Visceral Surgery, Cancer Cell Sensitization and Digital Therapy recommendations.

#### VISIT FROM REPRESENTATIVES OF THE TOWN COUNCIL LEIPZIG

January 24, 2020 | ICCAS

- Reinhard Fuchs | Demonstration in Medical Robotics
- Stefan Franke | Demonstration at the Intelligent OR
- Jan Gaebel | Demonstration of the Digital Patient Model
- Marianne Maktabi | Demonstration in Hyperspectral imaging

#### 16th MEFALE (MEIN FERIEABENTEUER LEIPZIG) 2020

February 13, 2020 | ICCAS

- Marianne Maktabi | Demonstration in Hyperspectral Imaging
- Johann Berger | Demonstration in Medical Robotics

## #EVENTS

### DGBMT BOARD MEETING

September 28 | ICCAS, Biotechnological & Biomedical Center (BBZ), Leipzig & virtual

- Stefan Franke | Presentation of the Intelligent OR, ICCAS
- Johann Berger | Demonstration in Medical Robotics, ICCAS
- Andreas Melzer, Thomas Neumuth | BMT 2020 Board Meeting, BBZ & virtual

### Status Seminar of the Department of Otolaryngology, Head and Neck Surgery of the University

Hospital Leipzig and ICCAS

December 1 | virtual

Albrecht Bloße, Claire Chalopin, Stefan Franke, Jan Gaebel, Thomas Neumuth, Max Rockstroh

## CONFERENCES, SYMPOSIA, WORKSHOPS

### WINTER MEETING OF THE EUROPEAN ASSOCIATION FOR ENDOSCOPIC SURGERY (EAES)

January 24, 2020 | Krakow, Poland

- Andreas Melzer | Cooperation talks

### DGBMT BOARD MEETING

January 28 - 29, 2020 | Frankfurt

- Andreas Melzer, Thomas Neumuth | the organization of BMT 2020 in Leipzig and discussion of the program for the conference

### INNOSPACE-CONFERENCE 'RAUMFAHRTTECHNOLOGIEN UND -DIENSTLEISTUNGEN FÜR DIE GESUNDHEITSWIRTSCHAFT'

February 5, 2020 | Stuttgart

- Andreas Melzer | Representation of ICCAS

### SENIOR CITIZENS' ACADEMY OF THE UNIVERSITY LEIPZIG (SENIORENAKADEMIE DER UNIVERSITÄT LEIPZIG)

March 3, 2020 | Leipzig

- Thomas Neumuth | lecture: Digitalisierung in der Medizin

### EUROPEAN ROBOTICS FORUM (ERF) 2020

March 3, 2020 | Malaga

- Andreas Melzer | lecture: The application potential of robotics for image-guided therapy and focused ultrasound to support minimally and non-invasive interventions

### CARS 2020 COMPUTER ASSISTED RADIOLOGY AND SURGERY 34TH

June 23 – 27, 2020 | Munich, virtual

- Andreas Melzer | Session chair: Robot-assisted Image-guided Therapy
- Thomas Neumuth | Session chair: Imaging Informatics – Advanced Processing; Image-guided Interventions and Therapy



- Johann Berger, Michael Unger, Andreas Melzer | lecture: Development of an integrated robotic dual-arm system for image-guided interventions
- Richard Bieck | lecture: Language-based translation and prediction of surgical navigation steps for endoscope tracking in minimally-invasive surgery
- Julianne Neumann | lecture: BPMNSIX.io – a web-based surgical workflow modeling tool with ontology integration

### **28TH INTERNATIONAL CONGRESS OF THE EUROPEAN ASSOCIATION FOR ENDOSCOPIC SURGERY (EAES)**

June 24 – 27, 2020 | virtual

- Andreas Melzer | online class: Ultrasound for Surgeons

### **JOINT RESEARCH WORKSHOP ON ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES BETWEEN THE GERMAN FEDERAL MINISTRY OF ECONOMICS AND ENERGY (BMWi) AND THE FRENCH MINISTRY FOR EUROPE AND FOREIGN AFFAIRS (MEF)**

July 3, 2020 | virtual

- Thomas Neumuth | impulse talk: Potential of Artificial Intelligence (AI) in healthcare

### **6TH INTERNATIONAL (ONLINE) SUMMER SCHOOL ON AI AND BIG DATA**

July 7-8, 2020 | virtual

- Thomas Neumuth | lecture: AI applications in oncology

### **JOINT VIRTUAL MEETING OF THE AMERICAN AND CANADIAN ASSOCIATIONS OF PHYSICISTS IN MEDICINE (AAPM | COMP)**

July 12 – 16, 2020 | virtual

- Andreas Melzer | invited lecture: Molecular Imaging (PET and MRI) guided Focused Ultrasound, a potential future application?

### **EUROPEAN CONGRESS OF RADIOLOGY (ECR) 2020**

July 15 – 19, 2020 | virtual

- Andreas Melzer | Representation of ICCAS

### **LAUNCH MEETING OF INNSPACE-NETWORK SPACE2HEALTH INITIATIVE**

September 2, 2020 | virtual

- Andreas Melzer | Member of the Steering Committee on the Translation of Medical Technology for Deep Space Missions

### **51. ANNUAL MEETING OF THE GERMAN SOCIETY FOR MEDICAL PHYSICS (DGMP) 2020**

September 9 – 12, 2020 | virtual

- Andreas Melzer | Head of the Joint DGMP Guest Session on the Challenges of MR-guided Interventions from a physical and technical point of view
- Johann Berger | Live robotic presentation

# #EVENTS

## GERMAN SOCIETY OF MEDICAL PHYSICS DGMP ANNUAL CONFERENCE

September 9 – 11, 2020 | virtual

- Andreas Melzer chair of the DGBMT special Session and Invited Lecture

## 19TH ANNUAL MEETING OF THE GERMAN SOCIETY FOR COMPUTER- AND ROBOT-ASSISTED SURGERY (CURAC) 2020

September 17 – 19, 2020 | virtual

- Gary Sean Cooney | Comparison of sSpectral Characteristics in Human and Pig Biliary System with Hyperspectral Imaging (HSI)

## 54TH ANNUAL CONFERENCE OF THE GERMAN SOCIETY FOR BIOMEDICAL ENGINEERING (BMT 2020)

September 29 – October 1, 2020 | virtual

- Andreas Melzer, Thomas Neumuth | Congress Chairmen; Conference Opening & Closure; speech about DGBMT Fellow and 15 Years ICCAS
- Andreas Melzer | keynote chair: Ultrasound-Neuromodulation; What can BME do for Deep Space Mission? ; Organspende und Organersatzverfahren; lectures: MR guided Focused Ultrasound for moving Organs; 3D Printing for Respiratory Support System; session chair: Imaging; Medical robotics; Panel MDR
- Thomas Neumuth | keynote chair: AI in Medicine; panel chair: Panel Artificial Intelligence; session chair: 5G in Medicine; Modelbased Personalised Medicine
- Stefan Franke | session chair: Modelbased Personalised Medicine
- Denis Gholami Bajestani | poster: Development of in-vitro Vessel Phantom for Computer-assisted MRI-guided Thrombectomy and Vena Cava Filter Implantation
- Johann Berger | lecture: A Collaborative and Integrated Robotic System for the Application in Image-Guided Interventions
- Jan Gaebel | lecture: Requirements for 5G Integrated Data Transfer in German Prehospital Emergency Care
- Marianne Maktabi | lecture: Semi-automatic decision-making process in histopathological specimens from Barrett's carcinoma patients by Hyperspectral imaging (HSI)
- Annekatrin Pfahl | poster: Acquisition of Clinical Workflow of EMB for Development of Computer-assisted MRI-guided Interventions
- C. Martin Reich | lecture: New MR instruments and ancillary systems for MR guided procedures
- C. Martin Reich & Michael Unger | lecture: Developing an Intuitive and Feasible Setup for In-room Control During MRI-guided Interventions
- Max Rockstroh | lecture: Towards an integrated emergency medical care using 5G networks
- Upasana Roy | lecture: Magnetic resonance imaging-guided thermal Therapy with Focused Ultrasound in Preclinical MRI
- Michael Unger | lecture: Robot-assisted Ultrasound-guided Tracking of Anatomical Structures for the Application of Focused Ultrasound
- Xinrui Zhang | lecture: Radiosensitization of human cancer cells with in vitro focused ultrasound

### **REGIONS4PERMED: “PERSONALISING HEALTH INDUSTRY” CONFERENCE**

October 15 – 16, 2020 | virtual

- Thomas Neumuth | Member of the Advisory Board

### **32ND ANNUAL CONFERENCE OF THE INTERNATIONAL SOCIETY FOR MINIMALLY INVASIVE THERAPY: SMIT 2020**

December 03 – 10, 2020 | virtual

- Andreas Melzer | General Secretary iSMIT | invited lecture: MRgFUS technology
- Denis Gholami Bajestani | presentation: Development of in-vitro Vessel Phantoms for MRI-guided Interventions
- C. Martin Reich | presentation: Developing an Intuitive and Feasible Setup for In-room Control During MRI-guided Interventions
- Michael Unger | presentation: Robot-assisted Ultrasound-guided Tracking of Anatomical Structures for the Application of Focused Ultrasound

## **PRESENTATIONS AT FAIRS**

### **16. LEIPZIG RESEARCH FESTIVAL OF LIFE SCIENCES**

January 30, 2020 | Leipzig

- Priya Giri | poster: The hyperspectral imaging patient data management and analysis framework HSldb
- Shaonan Hu | poster: In vitro effects of cavitation induced by focused ultrasound in prostate cancer cells
- Marianne Maktabi | poster: Classification of Barrett’s carcinoma specimens by hyperspectral imaging
- Annekatrin Pfahl | poster: Analysis and development of clinical workflow for minimally invasive magnetic resonance (MR) – guided interventions

### **72ND ANNUAL CONGRESS OF THE GERMAN SOCIETY OF UROLOGY (DGU): POST-BEST-OF DGU 2020**

September 29 – October 29, 2020 | virtual

- Andreas Melzer | Session chair “Urology 2030”; invited BMT Lecture: Modern radiology – already a one-stop-shop?

### **EUROPEAN COLORECTAL CONGRESS 2020**

November 29 – December 2, 2020 | virtual

- Marianne Maktabi | presentation: Detection of tumor movements, preliminary studies

# #EVENTS

## PROJECT- AND COOPERATION WORK

### SDC IMPLEMENTATION MEETING

January 16, 2020 | Lübeck

- Max Rockstroh | Meeting of OR.NET partners

### KÜNSTLICHE INTELLIGENZ FÜR KLINISCHE STUDIEN (KIKS) – PROJECT KICK-OFF MEETING

January 21, 2020 | Stuttgart

- Thomas Neumuth, Julianne Neumann | Specifying ICCAS' contribution through the sub-project AI-QNET

### MAGNETIG RESONANCE (MR) KICK-OFF MEETING

January 22, 2020 | Leipzig

- Andreas Melzer | Defining the research concept for Leipzig site

### MODELS FOR PERSONALIZED MEDICINE KICK-OFF MEETING

March 2, 2020 | ICCAS

- MPM-Group | Meeting of project partners and project aim declarations

### 5G\_EHEALTHSAX PROJECT MEETING

March 5, 2020 | Leipzig

- Thomas Neumuth | Presentation of the MOMENTUM project

### TRIMODAL 5G PIONEER REGION LEIPZIG NORTH (TRI5G)-PROJECT EVENT AT BMW PLANT

May 14, 2020 | Leipzig

- MOMENTUM Project team | presentation: Current research on emergency care using mobile medical technology in interaction with public 5G and campus networks

### PROJECT LYSIS – MILESTONE MEETING WITH DIASPECTIVE VISION & THE ASSOCIATION OF GERMAN ENGINEERS (VDI)

June 8, 2020 | online

- LYSiS-Group | Presentation of the project's progress thus far and discussion on its following stages

### MR-STENTS MID-TERM MILESTONE MEETING WITH PROJECT PARTNERS

June 9, 2020 | online

- MR-Stents-Group | Discussion of the project's standings midway its running time

### SONO-RAY-STATUSSEMINAR

June 18, 2020 | online

- Andreas Melzer | ICCAS' final report
- Xinrui Zhang | Presentation on the Thermal and Mechanical Effects of Focused Ultrasound on Cancer Cells – in vitro and in vivo



- Upasana Roy | Platform for Preclinical MRI-Guided Thermal Therapy with Focused Ultrasound in 7 Tesla MRI
- Johann Berger | An Integrated Robotic System for Focused Ultrasound Radiation Therapy

#### **MR-TROMBOSE – MILESTONE MEETING**

July 23, 2020 | online

- MR Group | Presentation of the project's progress thus far

#### **BRAINSAVER PROJECT KICK-OFF MEETING**

September 9, 2020 | ICCAS

- Brainsaver Team | Meeting of project partners and project aim declarations

#### **LERNENDE SYSTEME: ANNUAL MEETING OF WORKING GROUP 6: HEALTH CARE, MEDICAL TECHNOLOGY, CARE**

September 24, 2020 | online

- Thomas Neumuth | Member

#### **OR.NET E.V. ANNUAL GENERAL MEETING**

November 11, 2020 | online

- Thomas Neumuth & Max Rockstroh | Meeting

#### **PROJECT KAIT SC MEETING**

November 17, 2020 | online

- KAIT Project Partners | Discussion of the project topics

# #UNIVERSITY COURSES

## LEIPZIG UNIVERSITY

### Computer Assisted Surgery

Faculty of Mathematics and Computer Science  
practical course

### Development of Medical Products

Faculty of Mathematics and Computer Science  
lecture

### Introduction to Computer Assisted Surgery

Faculty of Medicine  
lecture

### Medical Planning and Simulation Systems

Faculty of Mathematics and Computer Science  
lecture

### Surgical Navigation, Mechatronics and Robotics

Faculty of Mathematics and Computer Science  
lecture

### System Innovation in Medicine

Faculty of Mathematics and Computer Science  
lecture and seminar

## LEIPZIG UNIVERSITY OF APPLIED SCIENCES (HTWK)

### Developing Medical Products

Faculty of Electrical Engineering and Information Technology  
lecture and seminar

### Project Management for Engineers

Faculty of Electrical Engineering and Information Technology, Mechanical and Energy Engineering  
lecture and seminar

### System Engineering

Faculty of Electrical Engineering and Information Technology  
lecture

# #GRADUATIONS

## MASTER DEGREES

### Johannes Keller

„Entwicklung und Evaluation eines vernetzten Robotersystems für die Applikation von fokussiertem Ultraschall unter Verwendung des IEEE 11073 SDC Kommunikationsstandards“

Leipzig University

### Tobias Pabst

„Konzeption und Implementierung eines Machine-Learning-Systems zur Erkennung ähnlicher Fingerabdruckmerkmale von verwandten Personen“

Leipzig University of Applied Sciences (HTWK)

### Lukas Schmierer

„A Practical Approach for a Decentralized Electronic Health Record“

Leipzig University

### Gregor Thürk

„Entwurf und Konzeption eines Remote Access Alert Distribution and Assignment Systems unter Verwendung der IEEE 11073 SDC-Standardfamilie für den Einsatz in Intensivstationen“

Leipzig University of Applied Sciences (HTWK)

## BACHELOR DEGREE

### Roman Leipe

„Entwicklung eines Unterstützungssystems für die Langzeitbehandlung von Hypophysenadenomen“

Leipzig University

### Loris Rauch

„Webbasierter HSI-Gewebeatlas. Implementierung eines Webbasierten Gewebeatlasses für hyperspektrale Daten“

University of Applied Sciences Zwickau (WHZ)

# #ORGANIZATION

## EXECUTIVE DIRECTOR



**Melzer, Andreas**

Human Medicine &  
Dentistry

## VICE DIRECTOR



**Neumuth, Thomas**

Computer Science,  
Electrical Engineering

## STAFF

Adler	Nadine	Human Medicine
Alshirbaji	Tamer Abdulbaki	Biomedical Engineering
Athner	Katrin	Business Management
Bailis	Nikolaos	Chemistry, Human Medicine
Berger	Johann	Computer Science
Bieck	Richard	Computer Science
Bloße	Albrecht Martin	Pedagogy
Buschbacher	Peter Ralph	Informatics
Buyer	Julia	Human Medicine
Cabal Aragón	Jesús Guillermo	Electrical Engineering
Chalopin	Claire	Medical Imaging
Claußner	Jessica	Hospital Hygiene
Condori Alagón	Héctor	Bioinformatics and Physics
Cooney	Gary	Medicinal Chemistry
de Hoop	Tom	Human Medicine
Donig	Julian	Technical Radiology
Dussel	Nadine	Medical Engineering
Eger	Andreas	Mathematics and Physics
Fischer	Marcus	Humanities
Fitzner	Anne	Office Communication
Franke	Stefan	Computer Science
Fuchs	Reinhard	Electrical Engineering and Information Technology
Gaebel	Jan	Computer Science
Georgi	Christoph	Computer Science
Gholami Bajestani	Denis	Medical Engineering and Technical Mathematics
Giri	Priya	Mathematics
Girrbach	Felix	Human Medicine
Glaser	Bernhard	Computer Science
Handel	Till	Physics
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Landeck	Tobias	Human Medicine
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Lindenmeyer	Adrian	Mechanical Engineering
Maktabi	Marianne	Computer Science
Matyash	Ivan	Mechanical Engineering
Mehlhorn	Stefanie	Human Medicine
Melzer	Andreas	Human Medicine and Dentistry
Melzer	Leon	Media Technology
Menge	Alina	Biochemistry
Meschke	Tim	Business Informatica and Mathematics
Mrongowius	Julia	Medical Engineering
Mulik	Christina	Medical Engineering
Neumann	Juliane	Computer Science
Neumann	Anja	Computer Science
Neumuth	Thomas	Computer Science and Electrical Engineering
Oeser	Alexander	Media Management
Pabst	Tobias	Computer Science
Pabst	Tobias	Computer Science
Patties	Ina	Biology
Petrova	Raya	Biomedical Engineering
Pfahl	Annekattrin	Medical Engineering
Prull	Alexander	Computer Science
Pysarczuk	Vincent	Human Medicine
Rauch	Loris	Health Informatics
Reich	Martin	Sensorics and Cognitive Psychology
Reske	Andreas	Human Medicine
Richter	Jonas	Computer Science
Rockstroh	Max	Computer Science
Roy	Upasana	Physics
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Schneider	Daniel	Physics
Scholz	Kathrin	Humanities
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Schreiber	Max	Mathematics
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Ziemann	Martin	Human Medicine



# #ORGANIZATION

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### Dr. Harald Busse

- Medical Physicist at the Department of Diagnostic and Interventional Radiology, Leipzig University Hospital

### Prof. Dr. Christian Etz

- Senior Physician Aortic Surgery, Heart Center Leipzig; Director of the Saxonian Incubator for Clinical Translation (SIKT), Leipzig University

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- Senior consultant for oral and maxillofacial surgery and plastic surgery

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- Head of the Medical Physics Section of the Department of Nuclear Medicine, Leipzig University Hospital

**Prof. Dr. Sebastian Stehr**

- Director of the Department for Anesthesiology and Intensive Care, Leipzig University Hospital

# #COOPERATIONS

## NATIONAL COOPERATION PARTNERS

### Industry

- ACL GmbH
- ADMEDES GmbH
- Bavaria Medizin Technologie GmbH
- Biotype Diagnostic GmbH
- C.R.S. iiMotion GmbH
- Diaspective Vision GmbH
- Dornheim Medical Images GmbH
- Draeger AG & Co. KGaA
- Effigos AG
- EPflex Feinwerktechnik GmbH
- Fritz Stephan GmbH
- GADV – Gesellschaft für Automatisierung mit Datenverarbeitungsanlagen mbH
- Gesundheitsforen Leipzig GmbH
- GMC Systems mbH – Gesellschaft für medizinische Computersysteme mbH
- GTV – Gesellschaft für Technische Visualistik mbH
- healthcare Consulting GmbH
- HEBUmedical GmbH
- Ilara GmbH
- inomed Medizintechnik GmbH
- ITP GmbH – Society for intelligent textile products
- KARL STORZ SE & Co. KG
- KLS Martin Group – Gebrüder Martin GmbH & Co. KG
- LeFx GmbH
- LOCALITE GmbH
- METRAX GmbH, PRIMEDIC
- MR:comp
- NOTARZTDIENSTE.DE GmbH
- Nuromedia GmbH
- OFFIS – Institute for Information Technology e. V.
- Opttris GmbH
- PHACON GmbH
- qcmed – Quality Consulting Medical GmbH
- Siemens Healthcare GmbH, Siemens Healthineers
- steute Technologies GmbH & Co. KG
- SurgiTAIX AG
- Synagon GmbH
- tecVenture GmbH
- UniTransferKlinik Lübeck GmbH
- VISUS Health IT GmbH

- voice INTER connect GmbH
- WEINMANN Emergency Medical Technology GmbH + Co. KG

## Science

- AG Non-Invasive Cardiac Imaging
- Carl Gustav Carus University Hospital, Faculty of Medicine, OncoRay – National Center for Radiation Research in Oncology
- ERNW Research GmbH
- FIRST – The Fraunhofer Institute for Computer Architecture and Software Technology, Fraunhofer Institute for Applied Optics and Precision Engineering (IOF), Fraunhofer Institute for Biomedical Engineering (IBMT), Fraunhofer Institute for Cell Therapy and Immunology (IZI), Fraunhofer Institute for Digital Medicine (MEVIS), Fraunhofer Institute for Integrated Circuits (IIS), Fraunhofer Institute for Manufacturing Engineering and Automation (IPA), Fraunhofer Institute for Open Communication Systems (FOKUS), Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute (HHI)
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- Georg-August-University of Göttingen, University Medical Center Göttingen (UMG), Institute for Diagnostic and Interventional Radiology
- Heidelberg University Hospital, Department of Otorhinolaryngology, Head and Neck Surgery, Department of Radiology
- Heinrich-Braun-Clinic (HBK) gemeinnützige GmbH
- Helmholtz Center Dresden Rossendorf (HZDR), Department of Neuroradiopharmaceuticals
- Jena University Hospital, Division Information Technology (IT), Department for ENT
- Johanniter-Unfall-Hilfe e.V.
- Leipzig Heart Center
- Leipzig University of Applied Sciences (HTWK), Faculty of Engineering (EIT), Institute for Electronics and Biomedical Information Technology (EBIT)
- Leipzig University, Center for Biotechnology and Biomedicine (BBZ), Faculty of Mathematics & Computer Science, Institute of Computer Science, Faculty of Medicine, Clinical Trial Centre (ZKS), Institute of Anatomy, Medical Informatics, Statistics and Epidemiology (IMISE), Saxon Incubator for Clinical Translation (SIKT)
- Max Planck Institute for Human Cognitive and Brain Sciences Leipzig, Department of Neurology
- OR.NET e.V.
- RWTH Aachen University, Helmholtz-Institute for Biomedical Engineering, Faculty of Electrical Engineering and Information Technology, Chair for Medical Information Technology (MedIT), Faculty of Mechanical Engineering, Chair of Medical Engineering
- Technical University of Munich (TUM), Department of Informatics, Chair of Robotics, Artificial Intelligence and Real-time Systems, Department of Mechanical Engineering, Chair of Micro Technology and Medical Device Technology (MIMED), Institute of Automation and

# #COOPERATIONS

Information Systems (AIS), School of Medicine, Chair of Research Group Minimally Invasive Interdisciplinary Therapeutical Interventions (MITI), University Hospital rechts der Isar, Clinic and Polyclinic for Surgery, Department Visceral Interventions

- University Frankfurt, Center for Radiology
- University Hospital Leipzig, Clinic of Conservative Dentistry and Paradontology, Department of Anesthesiology and Intensive Care, Department of Diagnostic and Interventional Radiology, Department of Neurosurgery, Department of Nuclear Medicine, Department of Oral and Maxillofacial Surgery, Department of Orthopaedic, Traumat and Plastic Surgery, Department of Otolaryngology, Head and Neck Surgery, Department of Radiooncology, Department of Urology, Department of Visceral, Transplantation, Thoracic and Vascular Surgery, Medical Department IV – Cardiology, Medical Department V – Angiology
- University Hospital Regensburg, Department Internal Medicine II
- University Hospital Schleswig-Holstein, Department of Orthopedics and Traumatology, Office of Information Technology
- University Medical Center Göttingen (UMG), Clinic for Cardiology and Pneumology
- University Medical Center Knappschaftskrankenhaus Bochum, Clinic for Anesthesiology, Intensive Care and Pain Therapy
- University of Bremen, Department of Communications Engineering
- University of Lubeck, Institute for Electrical Engineering in Medicine (IME), Institute for Software Engineering and Programming Languages (ISP), Institute of Medical Informatics (IMI), Institute of Telematics (ITM)
- University of Rostock, Faculty of Computer Science and Electrical Engineering, Institute for Applied Microelectronic and Data Processing Technology (IMD)
- Zuse Institute for Information Technology Berlin (ZIB)

## INTERNATIONAL COOPERATION PARTNERS

### Industry

- GE HealthCare – Minn, USA
- Image Guided Therapy (IGT) – Pessac, France
- INSIGHTEC Ltd. – Tirat Carmel, Israel
- MeDrea Medical Science & Technology Ltd. – Chongqing, China
- MR Instruments Inc. – Minneapolis, USA

### Science/Politics

- ASSR – Association of the Samaritans of the Slovakian Republic
- Children's National Medical Center (CNMC)
- Chongqing University of Technology (CQUT)
- Danish Emergency Management Agency DEMA



- Delft University of Technology, Faculty of Mechanical, Maritime and Materials Engineering, Department of BioMechanical Engineering
- Estonian Ministry for Social Affairs, Estonian Health Board
- Federal Public Service (FPS) Health, Food Chain Safety and Environment
- French DG for Civil Protection and Crisis Management
- Harvard Medical School (HMS), Brigham and Women's Hospital
- Higher Institute of Applied Technology of Kinshasa (ISTA)
- Inselspital, University Hospital Bern, University Clinic for Ear, Nose and Throat Diseases (ENT), Head and Neck Surgery
- Institute of Image-Guided Surgery (IHU)
- International Clinical Research Center of St. Anne's University Hospital (FNUSA-ICRC)
- IRCAD France – Research Institute against Digestive Cancer
- Italian Civil Protection Department
- Medical University of Graz, Institute for Medical Informatics, Statistics and Documentation (IMI)
- Memorial Sloan Kettering Cancer Center (MSKCC)
- Menoufia University, Department of Computer Science and Engineering
- New York Presbyterian Brooklyn Methodist Hospital, Department of Radiology
- Romanian Ministry of Internal Affairs
- Sant'Anna – School of Advanced Studies, The BioRobotics Institute
- Swiss Federal Institute of Technology Zurich (ETH), Computer Vision Laboratory
- The Chaim Sheba Medical Center at Tel HaShomer
- University of Bern, ARTORG Center for Biomedical Engineering Research
- University of Dundee, Institute for Medical Science and Technology (IMSaT)
- University of Guanajuato, Department of Electrical Engineering
- University of Trento, Department of Information Engineering and Computer Science
- University of Turin, Department of Surgical Sciences
- University Trondheim, Department of Imaging and SINTEF Medical Technology





UNIVERSITÄT  
LEIPZIG

Medizinische Fakultät

Gefördert durch:



Bundesministerium  
für Wirtschaft  
und Energie



GEFÖRDERT VOM

Bundesministerium  
für Bildung  
und Forschung



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