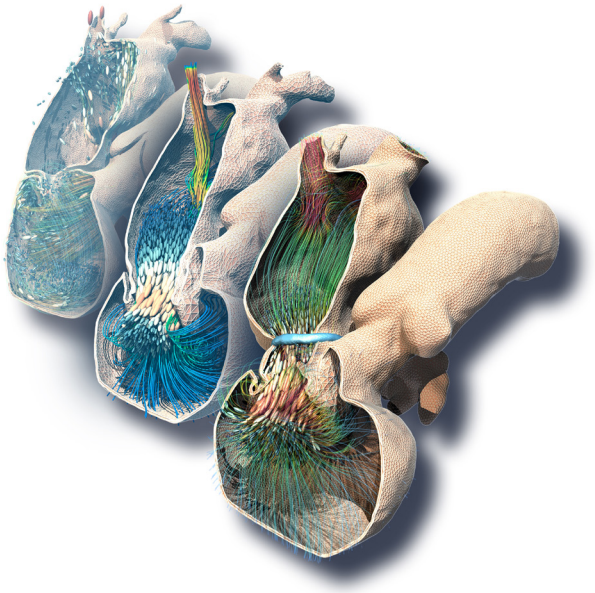
Fraunhofer
MEVIS

INSTITUTE FOR MEDICAL IMAGE COMPUTING

ANNUAL REPORT 2018

FRAUNHOFER MEVIS

ANNUAL REPORT 2018



Anatomical models enable blood flow analysis and interactive therapy simulation for individual patients with cardiac disease. The cover shows cutouts of virtual models representing different disease and therapy states (left to right): backflow of blood (regurgitation) due to a poorly closing left atrioventricular valve (mitral valve), an enlarged mitral valve ring (annulus) during the diastolic phase, and focused but not constricted flow after virtual ring implantation.

TABLE OF CONTENTS

FRAUNHOFER MEVIS AT A GLANCE

BRIEF PROFILE

The mission of Fraunhofer MEVIS is to pave the way towards a digital medicine that is more efficient and reliable, with higher success rates and reduced side effects. We are bridging between integrated diagnosis, intelligent interventions, multimodal imaging, and digitally encoded medical knowledge. Working closely together with our clinical, academic, and industrial partners worldwide, we strive to solve the complexity of healthcare and translate feasibility into availability to overcome the innovation gap[1].

Strategic Considerations

The roots of Fraunhofer MEVIS lie in the creation, quantitative analysis, and interactive exploration of medical image data in their specific clinical context. We believe that medical imaging shall no longer be regarded as a field on its own. Instead, image features must be quantitatively correlated to available clinical information in order to discover new relevant knowledge. Fraunhofer MEVIS is uniquely positioned by combining a deep understanding of clinical procedures and problems with a mastering of the technological value chain – from imaging physics and data generation to algorithm and platform development to validation, product certification, and clinical implementation. Two main strategic target areas are guiding our actions: *»integrated clinical decision support«* and *»intelligent minimally-invasive interventions«*.

We have built substantial expertise and a good reputation in the deep learning and artificial intelligence (AI) arena. This enables us to successfully cope whith the rapidly growing complexity in all diagnostic and therapeutic domains. While many groups worldwide are active in the field of medical AI, Fraunhofer MEVIS is one in a few that covers the complete process of knowledge generation such that AI will eventually become a powerful clinical tool in hospitals and medical practices. Solutions based on our collaborative and modular software platforms are used likewise in multi-centric clinical trials and pharmaceutical research. Below, we briefly describe the building blocks needed to fulfill our mission.

1 cf. chart on page 9

Clinical Commitment

Research and development at Fraunhofer MEVIS is guided by a clinical direction instead of being technologically or methodologically driven. Our work focuses on developing innovative solutions for computer-assisted medical processes and their industrial implementation for clinical use. Identifying and analyzing clinical issues demands a deep understanding of medical research and calls for close cooperation with our partners. Fraunhofer MEVIS maintains an international network of over 100 clinical partners. This clinical network is an essential source to understand user needs and to evaluate the potential clinical value and feasibility of developed solutions.

Industrial Collaboration

True innovation, the successful launch of solutions onto the market with tangible impact, is only possible through close collaboration with industrial partners with the necessary resources and market know-how to fuel the development of new technologies. Fraunhofer MEVIS functions as the link between clinicians and industry, aiming at technological advancement for clinical use. Transferring applied research to the industry is a pillar of the institute and a basis for future research. Partners for cooperation and clients for industrial research and development include large firms and small- or medium-sized ventures in medical technology, pharmaceutics, and related fields.

Certification

Successful introduction of innovative approaches onto the market requires adherence to specific regulations, such as the German Act on Medical Devices (MPG) or the approval guidelines of the United States Food and Drug Administration (FDA). Fraunhofer MEVIS is one of a small group of medtech research facilities worldwide that, in Bremen since 2005 and in Lübeck since 2012, has operated a quality management system according to the EN ISO 13485 (Medical Devices) standard with a special focus on implementing a software development

process in compliance with IEC 62304. The establishment of these quality management systems with the scope on design, development and production of software for medical products lays out well-defined steps for industrial cooperation and enables Fraunhofer MEVIS to provide market-ready solutions for commercial partners in the strongly regulated medical device market. In addition, Fraunhofer MEVIS also has experience with CE and FDA approval of software solutions for clinical environments.

Software Platform

Fraunhofer MEVIS has initiated and developed a family of versatile, modular web-enabled software platforms that enable our partners and ourselves to build new solutions faster and to better adapt to new challenges. The MeVisLab development platform by Fraunhofer MEVIS and MeVis Medical Solutions AG is a tool for rapid prototyping, flexible development of clinical software solutions as well as developing products and methods for fields such as image analysis, visualization, and biophysical modeling. The joint use of MeVisLab at Fraunhofer MEVIS and partners in research, medicine, and industry promotes synergy and accelerates development. This supports the tight technological integration of clinics, research, and industry. MeVisLab provides a modular interface to 3D Slicer, a software platform for the analysis and visualization of medical images and for research in image-guided therapy. Slicer is a free, open source software available on multiple operating systems and extensible via plugins for adding algorithms and applications. Moreover, Fraunhofer MEVIS has developed the remote deep learning framework RedLeaf as an extension of MeVisLab, that allows for modular, distributed and reproducible pattern recognition on large medical datasets. Two additional platforms target specific application areas, with Histokat Web serving at multicentric research, development and validation of solutions in the field of computational pathology, and our deformable image registration library RegLib is used for multimodality, intraoperative, and follow-up image matching and motion correction.

Business Areas

Our four business areas align with our strategic directions as described above and focus on specific market segments and related industrial customers. A range of services and solutions can therefore be tailored and developed for these customer groups.

The planning and support of surgical and minimally invasive procedures, which has been a key focus of Fraunhofer MEVIS since its founding, is developed in the business area *»Image-Guided Therapy«*. A particular challenge here is to provide the operating physician all relevant information at the time he/she needs it. Customers are mainly hardware vendors that span a wide range of products from implants like valves and stents to catheters and needles, treatment devices like robots, focused ultrasound systems or linear accelerators (linacs), as well as navigation devices.

The business area *»Diagnostic Software«* is centered around the clinical challenge to ensure optimal therapeutic decisions and improved early detection, incorporating the constantly growing amount of multidisciplinary data on the one hand and the efficiency pressure for faster processing on the other. The customers in this segment are imaging device vendors, clinical IT companies, and specialized image analysis providers.

Within the area of diagnostic software, we have defined a specific business area around *»Computational Pathology«* as a field with special potential for growth, considerable technological development, and not least for becoming a game-changer in the field of precision medicine due to the enormous amount of information encoded in the digitized tissue sections. Customers are manufacturers and providers of digital pathology equipment, biotech companies, laboratories, as well as healthcare IT integrators. Our key focus is in modular pattern analysis and virtual multi-staining based on highly accurate deformable image registration, thereby building on existing digital pathology platforms.

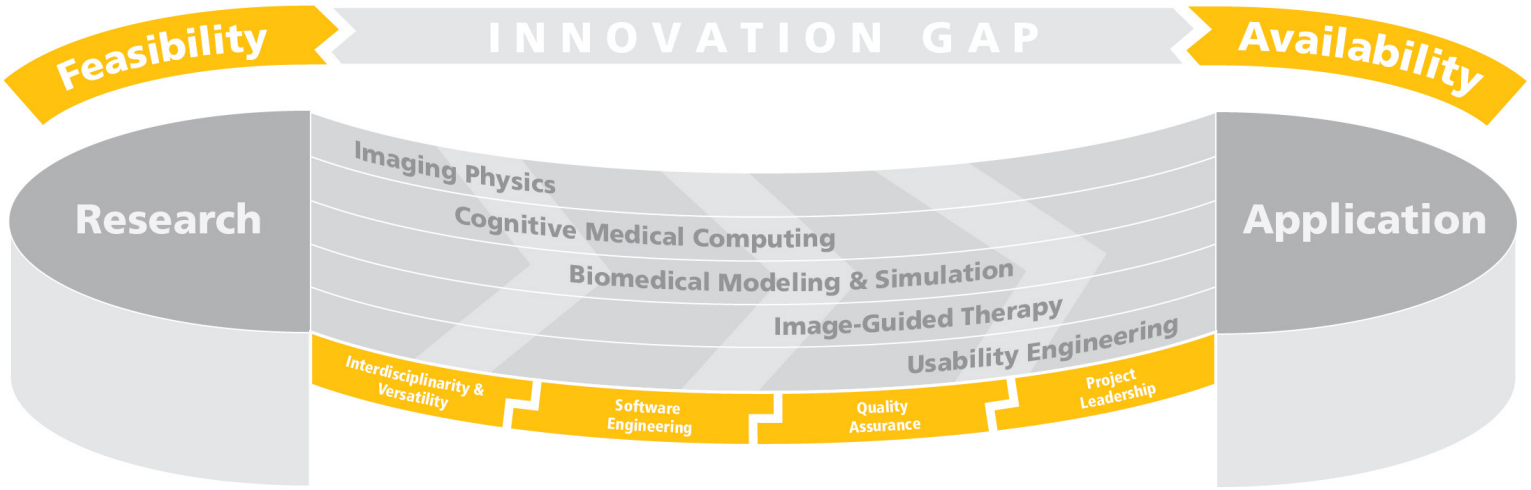
The business area *»Clinical Trials and Pharma«* emerged from the field of analysis software for image-based studies, combined with our web-based software platform developments, and is being expanded to a comprehensive range of services

Fraunhofer MEVIS – Partner in Translation

FROM FEASIBILITY TO AVAILABILITY

Research worldwide generates novel solution concepts, algorithms, and ideas with great innovation potential. These concepts demonstrate feasibility, but only a very small number reach actual clinical use.

To make novel ideas and concepts available in the clinical routine, the innovation gap must be bridged. Fraunhofer MEVIS is a key partner in this complex translational process.



Interdisciplinarity & Versatility

Fraunhofer MEVIS has a deep understanding of medical needs, academic research, and industrial challenges, the three key areas of innovation.

Software Engineering

Professional software development teams at Fraunhofer MEVIS offer short innovation cycles based on MeVisLab, RegLib, and Histology Toolkit, rapid prototyping and productization platforms.

Quality Assurance

Fraunhofer MEVIS's expertise in quality management and regulatory processes, including stringent testing and documentation, brings prototypes closer to becoming certified medical products.

Project Leadership

The project management competence at Fraunhofer MEVIS is a crucial ingredient to successful interdisciplinary and international research collaborations.

for the industry and for larger research consortia. Customers are pharmaceutical companies, contract research organizations (CROs), service and software providers for image analysis as well as researchers in hospitals, laboratories, and industry.

Additional business activities open up the potential for exploitation of the existing expertise in the field of imaging physics. We aim at bundling the offers of other areas of competence for the customer group of medical imaging device manufacturers. In magnetic resonance imaging (MRI), we offer our expertise to develop dedicated sequences for research, clinical and commercial customers.

Technology and Translation

The following scientific and supporting core competences form the pillars of our work in research, technology, and translation.

The process of creating medical images is addressed by our core competence »*Imaging Physics*«. This spans from improving image acquisition and creating new physiological information to automated motion tracking and quality assessment. The goal is to integrate image acquisition and post-processing to an optimized image analysis pipeline. Since April 2011, Fraunhofer MEVIS is operating an on own 3 Tesla MRI scanner for research and clinical studies.

The core competences »*Cognitive Medical Computing*« and »*Clinical Decision Support*« revolve around the extraction of information from medical images and other medical data. The previous technological focus of image processing has been extended to non-imaging data and, therefore, to the challenge of incorporating a broad range of relevant clinical information.

The main goals are to maintain and expand our competence in the automatic extraction of quantitative information in imaging and other big data scenarios and in efficient interactive solutions for decision support systems as well as for planning and support systems in image-guided therapy.

With our core competence »*Image Registration*« we aim at harmonizing images from different modalities, capture times, or patients, in order to evaluate the combined information. Fraunhofer MEVIS provides applicable image registration with a focus on robust, reasonable, accurate, and computationally highly efficient solutions.

Our core competence »*Modeling and Simulation*« enables us to incorporate knowledge of biophysical and biomedical processes to enhance the information within medical images. In addition to application driven developments, we perform basic research to enhance the technological capabilities. A particular focus for the next years will lie on validation of simulation results, in order to gain acceptance by industrial partners and physicians.

The capability of providing high quality, modular, reusable software components, efficient and well-integrated software applications and flexible deployment is developed and encapsulated in the core competence »*Custom Software Solutions*«.

The anchoring of Fraunhofer MEVIS in digital medical technology and the focus of its research activities towards clinical benefits are strengthened through the core competence »*Clinical Expertise*« and will be further developed as a long term USP.

A goal of our »*Science Communication*« is to create projects, exhibits, movies and workshops in which scientists contextualize their expertise and research in a broader sense and become inspired to relate facts, empirical data, and science to humanities, social realities, and values.

Links to Academic Institutions

In addition to the network of clinical partners, Fraunhofer MEVIS maintains a strong network of technological and academic partners. Currently, Fraunhofer MEVIS is connected with eight universities in Germany, the Netherlands, and the United States through twelve professorships:

- University of Bremen: Prof. Kikinis, Prof. Günther
- Jacobs University Bremen: Prof. Hahn, Prof. Preusser
- University of Applied Sciences Bremerhaven: Prof. Rascher-Friesenhausen
- University of Lübeck: Prof. Modersitzki
- Charité, TU Berlin: Prof. Hennemuth
- RWTH Aachen: Prof. Kiessling, Prof. Merhof, Prof. Schulz
- Radboud University Nijmegen: Prof. van Ginneken

- Harvard Medical School, Brigham and Women's Hospital: Prof. Kikinis

From its first days, Fraunhofer MEVIS maintains strong ties to the universities in the State of Bremen. The directors of the institute hold professorships at the University of Bremen and the Jacobs University Bremen. Further close cooperation exists through professorships in the fields Imaging Physics, Modeling and Simulation, and Medical Technology. The University of Bremen and Fraunhofer MEVIS intensified their partnership in computer science education through a new study focus Medical Computing starting in winter semester 2018/19.

With financial support of the State of Schleswig-Holstein and the European Union, the Fraunhofer MEVIS Project Group for Image Registration was established at the University of Lübeck in April 2010. The internationally renowned group addresses the core competence of state-of-the-art medical image registration in close cooperation with the Institute of Mathematics and Image Computing (MIC) at the University of Lübeck. Since July 2015, the project group is part of the Fraunhofer MEVIS mother institute in Bremen.

Since 2012, Fraunhofer MEVIS pursues a strategic partnership with the Diagnostic Image Analysis Group (DIAG) at the Radboud University Medical Center in Nijmegen, the Netherlands, an internationally renowned center of excellence for Computer-Aided Diagnosis (CAD).

In April 2017, Fraunhofer MEVIS opened a new site in Berlin with close links to the German Heart Center, the Charité – Universitätsmedizin, and the Technical University Berlin. Fraunhofer MEVIS researcher Anja Hennemuth was appointed professor for image-based therapy support at the Institute for Imaging Science and Computational Modelling in Cardiovascular Medicine.

In 2018 Fraunhofer MEVIS established a strategic cooperation with the Institute of Experimental Molecular Imaging (ExMI) at the RWTH Aachen headed by Prof. Fabian Kiessling. In close collaboration with the Comprehensive Diagnostic Center Aachen (CDCA), particular attention is paid to projects in the field of OMICS data. This includes the development of automated and standardized workflows for the detection, segmentation, and extraction of biomarkers in the fields of radiomics and quantitative pathology.

Own Building and New Name

In September 2016 started the planning and in September 2018 the construction of an own building for Fraunhofer MEVIS located on the campus of the University Bremen. The new institute building is funded in equal parts by the Federal Republic of Germany, the Federal State of Bremen, and the European Commission. It is planned to be ready in winter 2020/21.

Exactly ten years after joining the Fraunhofer-Gesellschaft, on January 1, 2019, the former Fraunhofer Institute for Medical Image Computing MEVIS changed its official name to Fraunhofer Institute for Digital Medicine MEVIS (Fraunhofer-Institut für Digitale Medizin MEVIS). The new name, in short still Fraunhofer MEVIS, underscores the institute's mission to drive the transformation of tomorrow's digital, integrated precision medicine through systematic computer support.

Brief History

The current Fraunhofer MEVIS institute was founded in August 1995 as MeVis – Center for Medical Diagnostic Systems and Visualization, a non-profit limited liability company (gGmbH) at the University of Bremen. The founder Prof. Dr. Heinz-Otto Peitgen was appointed executive director, and an international scientific advisory board oversaw research. To expand the institute scientifically and economically, MeVis received a fixed basic funding from the State of Bremen. In 2006, the institute was renamed MeVis Research GmbH, Center for Medical Image Computing.

Since 1997, MeVis Research has produced several legally and financially independent spin-offs that were consolidated in 2007 into MeVis Medical Solutions AG, a publicly traded company that employs about 150 people. Aside from a few temporary declines in staff due to changes in personnel caused by the founding of a new company, the number of employees

of MeVis Research increased steadily from 10 to 51 full-time positions by the end of 2008.

On January 1, 2009, MeVis Research was incorporated into the Fraunhofer-Gesellschaft and renamed Fraunhofer Institute for Medical Image Computing MEVIS (Fraunhofer-Institut für Bildgestützte Medizin MEVIS). Prof. Dr. Heinz-Otto Peitgen was appointed Institute Director. The Advisory Board (Kuratorium) of Fraunhofer MEVIS convened on June 4, 2009, headed by Prof. Dr.-Ing. Erich. R. Reinhardt, at that time CEO of the Healthcare Sector of Siemens AG. Since early 2009, Fraunhofer MEVIS has been a member of the Fraunhofer Group for Information and Communication Technology (Fraunhofer-Verbund IuK).

In April 2010, the Fraunhofer MEVIS Project Group for Image Registration was established under the direction of mathematician Prof. Dr. Bernd Fischer at the University of Lübeck. In July 2013, Professor Fischer passed away following a short severe illness. The director of the MIC, Prof. Dr. Jan Modersitzki, was appointed new director of the Fraunhofer MEVIS Project Group for Image Registration in October 2014.

In October 2012, MEVIS founder Professor Peitgen retired after heading the institute for 17 years and his former deputy Prof. Dr. Horst K. Hahn succeeded as Interim Institute Director. Professor Hahn and Prof. Dr. med. Ron Kikinis were appointed new directors of Fraunhofer MEVIS in January and April 2014, respectively. Since then Fraunhofer MEVIS is under dual leadership.

During the transition phase of five years, the parent institute in Bremen (2009–2013) and the project group in Lübeck (2010–2014) have received funding from the States of Bremen and Schleswig-Holstein and have been co-financed by the European Regional Development Fund (ERDF). The mother institute in Bremen and the project group in Lübeck were positively evaluated by international review boards in May 2013 and 2014. They are under regular basic funding of the Fraunhofer-Gesellschaft since January 2014 and July 2015, respectively.

Between 2014 and 2018 the Fraunhofer MEVIS Advisory Board was chaired by Prof. Dr. Gábor Székely, Head of the Medical Image Analysis and Visualization Group at ETH Zurich. On June 20, 2018, Prof. Dr. Hans Maier, former President Diagnostic Imaging of Bayer Schering Pharma AG, was elected new chair of the Advisory Board with co-chair Walter Märzendorfer, former President Diagnostic Imaging of Siemens Healthineers.

The cornerstone of Fraunhofer MEVIS' new institute building located on the campus of the University of Bremen was laid on December 5, 2018.


KÖGEL
www.koegel-bau.de
Tel. 05731 7561-0
ZEITKAPSEL
Grundsteinlegung
Institutsneubau MEVIS
5. Dezember 2018

OPERATING AND ORGANIZATIONAL STRUCTURES

Fraunhofer MEVIS' interdisciplinary orientation is reflected in the institute's operating principles and organizational structure. Researchers are not bound to strict, hierarchically organized working groups, but act in a flexible network.

Three categories of strategic topics shape this network, with dedicated experts forming the nuclei of activities: organ- or disease-related clinical domains, technological core competences, and customer-oriented business areas.

Project teams are put together with team members from different technological and clinical credentials. This form of dynamic collaboration promotes cooperation and fosters cross-training, beneficial both to the individuals and to the institute as a whole.

Internal communication is governed by transparency and cooperation. Access to information is only restricted insofar as required by confidentiality agreements with customers or by legal constraints – otherwise sharing of information is encouraged and expected at all levels and is actively aided by exchange forums such as the social Wiki-based intranet (Confluence), morning meetings for all staff members and an active information policy by the leadership. Initiative by all staff members also beyond their current work assignment is highly encouraged.

To improve management, organization, and staff development, Fraunhofer MEVIS established a new mentoring system in August 2014. Management responsibility was extended to a group of experienced staff members who act as mentors or co-mentors for mentees. Responsibilities of the mentors include professional development of the mentee, coordination between institute and mentee's goals, as well as identifying and addressing of potential conflicts and problems.

Three male and three female persons of trust are elected from the staff to function as liaisons and mediators when needed.

As a result of the strategy process 2015/16, Fraunhofer MEVIS introduced a new structure of organizational entities (OEs) each with a responsible OE manager (OEV) as of April 2017.

The main objectives of the new OE structure are:

- clear allocation of responsibilities,
- delegation of project budgets, and
- strengthening of strategic focus.

The OEVs are by default mentor for the respective OE members. The mentees can freely choose their OE as well as the co-mentor. OEVs as well as additional colleagues bear specific strategic responsibility to the institute, especially for business areas and core competences. Alloced budgets must be explicitly used for appropriate strategic objectives. Objectives and budgets are coordinated by the OEVs in consultation with the institute directors and the financial management.

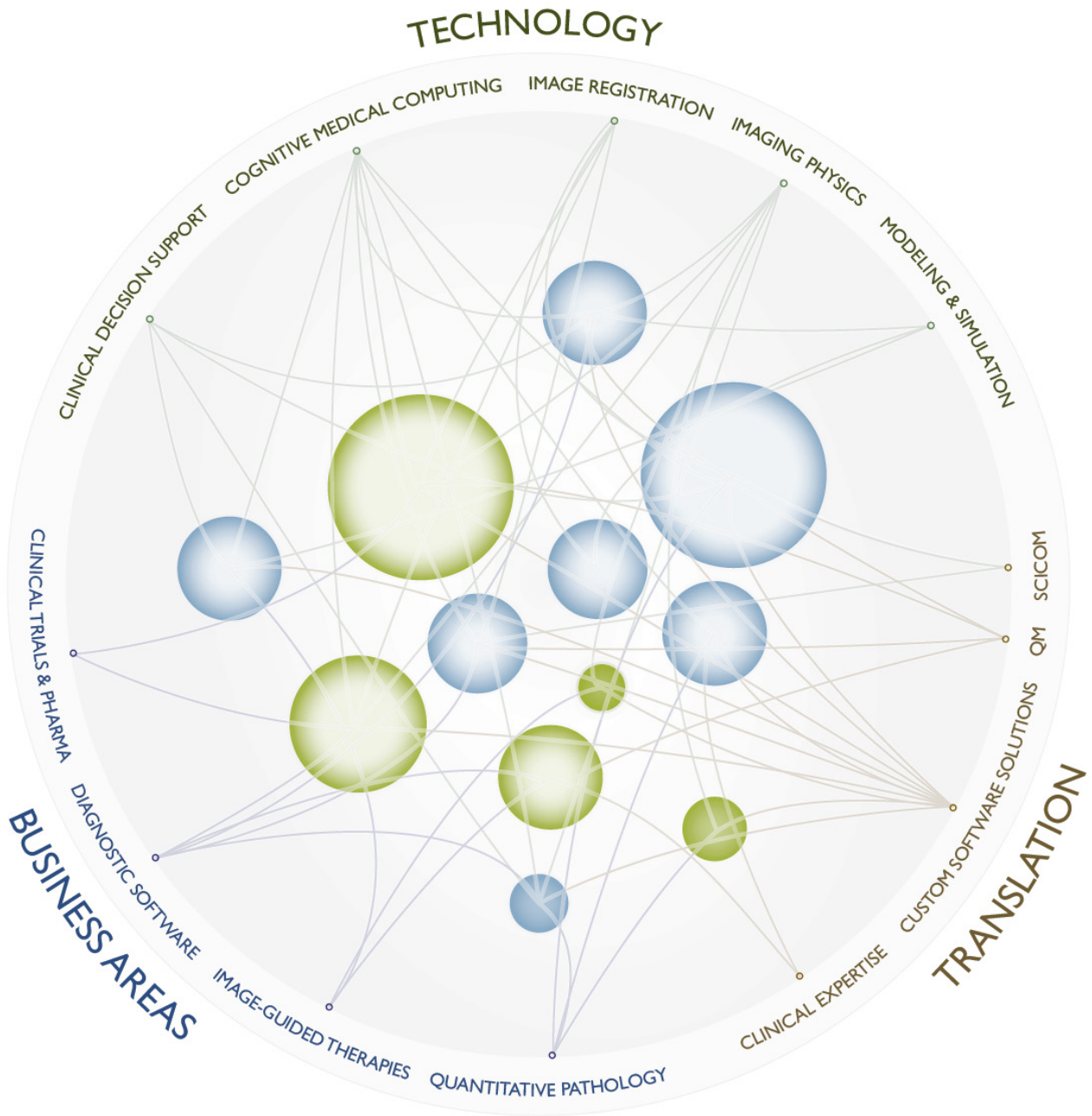
Overall responsibility for the institute is organized in a central leadership and administration structure. The heads of the institute

- Prof. Dr.-Ing. Horst K. Hahn (Institute Director),
- Prof. Dr. med. Ron Kikinis (Institute Director), and
- Dipl.-Betrw. Thomas Forstmann (Head of Administration)

are assisted in operational and strategic tasks by the OEVs and five leadership committees for human resources (LH), valorization (LV), research (LR), finance (LF), and quality management (LQ).

The Advisory Board (Kuratorium, cf. next section) of Fraunhofer MEVIS is composed of persons with backgrounds in medicine, science, business, and research funding. It advises the management of Fraunhofer MEVIS in issues of scientific focus, strategic orientation, and clinical as well as industrial translation.

Illustration of the institute's operating principle and organizational structure. Project teams of various size, topic and funding are dynamically put together with team members from different technological and clinical credentials.


TECHNOLOGY
COGNITIVE MEDICAL COMPUTING
IMAGE REGISTRATION
IMAGING PHYSICS
MODELING & SIMULATION
CLINICAL DECISION SUPPORT
TRANSLATION
SCICOM
QM
CUSTOM SOFTWARE SOLUTIONS
CLINICAL EXPERTISE
QUANTITATIVE PATHOLOGY
IMAGE-GUIDED THERAPIES
DIAGNOSTIC SOFTWARE
CLINICAL TRIALS & PHARMA
BUSINESS AREAS

ADVISORY BOARD

In Bremen on June 20, 2018, the Fraunhofer MEVIS Advisory Board (Kuratorium) met for the tenth time. Prof. Dr. Alexander Kurz, Executive Vice President Human Resources, Legal Affairs and IP Management of the Fraunhofer headquarters in Munich, gave a talk concerning the current state of affairs of the Fraunhofer-Gesellschaft. The institute director Prof. Dr.-Ing. Horst K. Hahn reported on developments in the focus and structure of the institute and outlined medium-term prospects and strategic plans. Focal points were the strategic topics:

- Integrated Diagnostics,
- Intelligent Computer-Assisted Interventions, and
- Imaging Physics Innovation.

Prof. Dr. Tobias Preusser and Prof. Dr.-Ing. Anja Hennemuth gave the Advisory Board a deeper insight into MEVIS' current research on computer assistance for intelligent interventions and in cardiovascular medicine. The members of the Advisory Board praised the developments at Fraunhofer MEVIS, gave valuable advice for future priority setting and articulated their appreciation and thanks to the institute's personnel.

At this year's meeting, Prof. Dr. Hans Maier, former President Diagnostic Imaging of Bayer Schering Pharma AG, has been elected as new chair of the Advisory Board. Walter Märzendorfer, former President Diagnostic Imaging of Siemens Healthineers. of Siemens Healthineers, will continue to hold the co-chair. The boards of the Fraunhofer-Gesellschaft and of Fraunhofer MEVIS thanked the previous chairman Prof. Dr. Gábor Székely, Head of the Medical Image Analysis and Visualization Group at ETH Zurich. Astrid Lurati, Hospital Director of the Charité – Universitätsmedizin Berlin, was newly appointed to the Advisory Board.

Chair

Prof. Dr. Hans Maier (since 2009)
formerly Bayer Schering Pharma AG, Berlin

Co-Chair

Walter Märzendorfer (since 2009)
formerly Siemens Healthineers, Forchheim

Industry

Marcus Kirchhoff (2012–2018)
MeVis Medical Solutions AG, Bremen

PD Dr. med. Christian Meisel (since 2016)
Roche Diagnostics GmbH, Penzberg

Stefan Widensohler (as of 2019)
Krauth Invest GmbH & Co. KG, Hamburg

Dr. Christoph Zindel (as of 2019)
Siemens Healthcare GmbH, Forchheim

Medicine

Prof. Dr. med. Ruth Knüchel-Clarke (as of 2019)
Institute for Pathology, RWTH Aachen

Astrid Lurati (since 2018)
Executive Board
Charité – Universitätsmedizin, Berlin

Prof. Dr. med. Mathias Prokop (since 2014)
Radboud University Medical Centre
Nijmegen, The Netherlands

Prof. Dr. med. Ulrich Sure (2009–2018)
Department of Neurosurgery, Essen University Hospital

Science

Prof. Dr. Craig Garner (since 2017)
German Center for Neurodegenerative Diseases (DZNE)
Charité – Universitätsmedizin, Berlin

Prof. Dr. Dr. h.c. Jürgen Hennig (since 2009)
Department of Radiology, Medical Physics
University Medical Center Freiburg

Prof. Dr. Gábor Székely (since 2009)
Image Science Division, ETH Zurich

University of Bremen

Prof. Dr. Jens Falta (since 2010)
Dean of Faculty Physics / Electrical Engineering
University of Bremen

Prof. Dr. Kerstin Schill (since 2014)
Faculty Mathematics / Computer Science, University of Bremen
Rector of Hanse-Wissenschaftskolleg, Delmenhorst

Jacobs University Bremen

Dr. Alexander Ziegler-Jöns (since 2010)
Science & Technology Transfer
Jacobs University Bremen

Research Funding

Dr. Ursula Niebling (since 2009)
Bremen Senator of Science, Health and Consumer Protection
Department of Scientific Planning and Research Promotion, Bremen

Dr. Bernd Roß (as of 2019)
Ministry of Education, Science and Culture
State of Schleswig-Holstein, Kiel

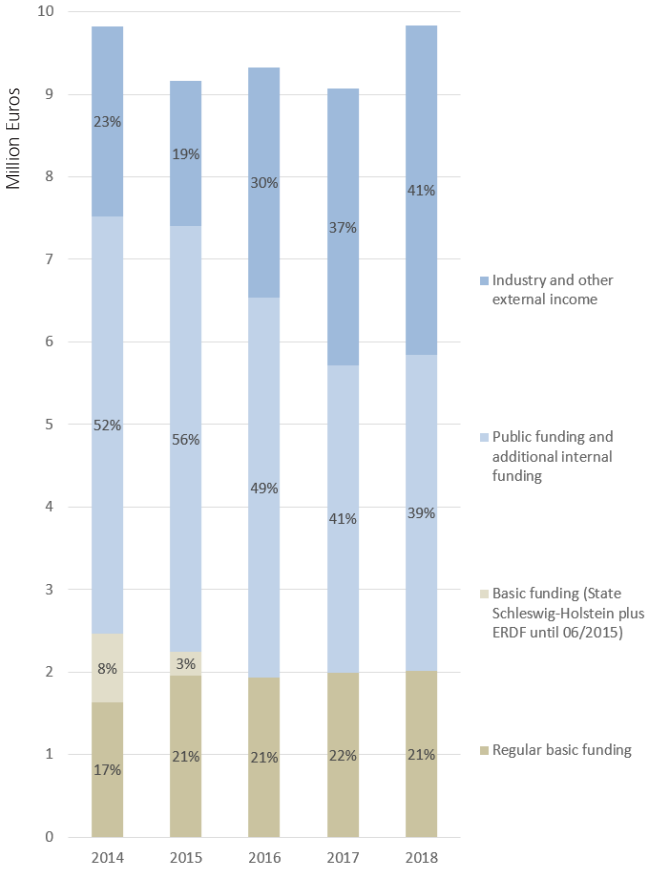
Attendees of the tenth assembly of the Fraunhofer MEVIS Advisory Board in Bremen on June 20, 2018.

THE INSTITUTE IN FIGURES

Budget and Earning Trends

The overall earnings in 2018 rose by 760 T€ to 9 828 T€. The industrial earnings, therein, increased significantly by +19% compared to the previous fiscal year (PFY). This is mainly due to our broadened customer base and due to our strategic work base with Siemens and Varian. Our basic funding grew marginally by +1% to 2 015 T€ (PFY: 1 993 T€). Earnings from public and internal sources increased by +3% compared to the previous year.

The overall budget grew by +5%. This is mainly due to the rise in other costs (+574 T€; mostly extraordinary effects) and increased salaries (+436 T€), i.e. the operating budget (OB) increased by +11% to 9 577 T€. To the contrary the investment budget (IB) decreased by -5% to 251 T€.



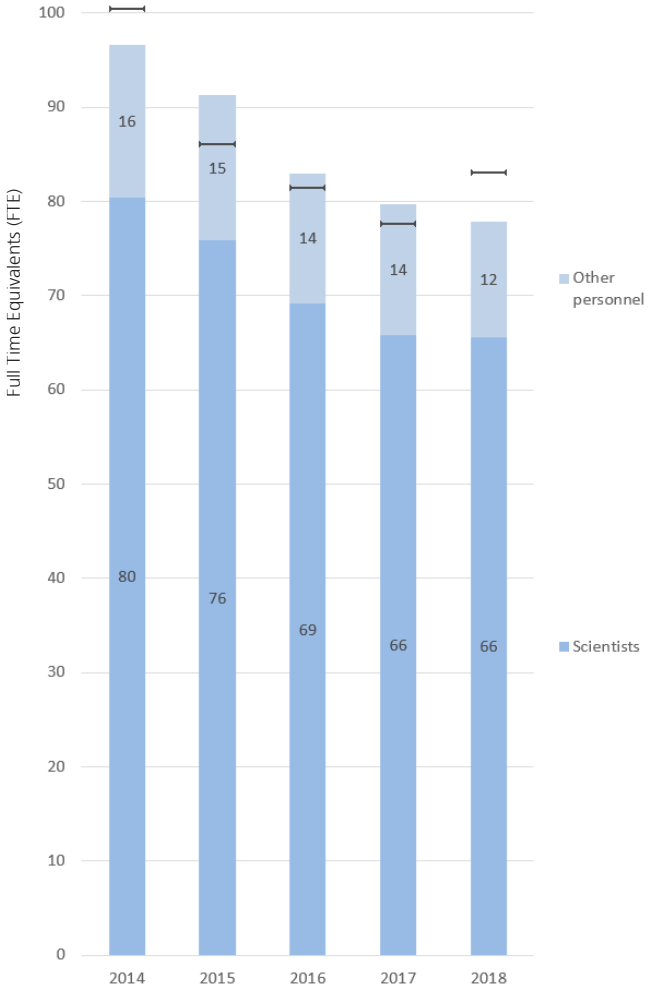
Earnings in million euros in the period from 2014 to 2018.

Operating Budget (OB), Investment Budget (IB) and Total Budget in T€:

	2014	2015	2016	2017	2018
OB:	9 404	8 951	8 917	8 567	9 577
IB:	414	207	407	500	251
Total:	**9 818**	**9 158**	**9 324**	**9 067**	**9 828**

Human Resources

The overall average number of persons employed by Fraunhofer MEVIS fell slightly in 2018. This is due to several personal career decisions. During the course of 2018, 22 new members joined the institute, such that at the end of the year, the institute was larger by a net of 6.3 full time equivalents (FTE) compared to the previous year. We expect a further personnel growth in 2019.



Development of employment figures for scientists and other personnel shown as annual average FTE between 2014 and 2018. The horizontal lines indicate the staff FTE at the end of the year.

THE FRAUNHOFER-GESELLSCHAFT

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

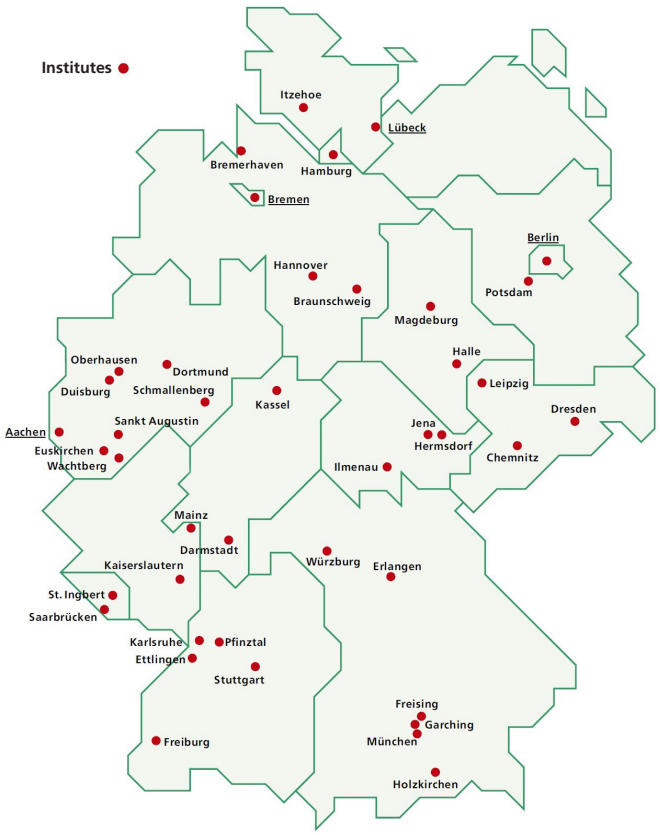
At present, the Fraunhofer-Gesellschaft maintains 72 institutes and research units. The majority of the more than 26,600 staff are qualified scientists and engineers, who work with an annual research budget of 2.5 billion euros. Of this sum, almost 2.1 billion euros is generated through contract research. Around 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Around 30 percent is contributed by the German federal and state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.



Locations of Fraunhofer Institutes in Germany. Currently, Fraunhofer MEVIS has major sites in Bremen (headquaters), Lübeck, Berlin and Aachen plus additional offices in Hamburg, Heidelberg, Nijmegen and Boston.

THE YEAR 2018

CHRONICLE

January 5-7, 2018
Fraunhofer MEVIS participates at the 4th Raw Science Film Festival in Santa Barbara, CA and wins »Industry Award for Best Immersive Media«.

January 15-16, 2018
Project meeting of the imaging core of the »Nationale Kohorte« (NAKO) at Fraunhofer MEVIS in Bremen.

January 17-19, 2018
Fraunhofer MEVIS co-organizes and chairs in cooperation with Charité Berlin and Deutsche Röntgengesellschaft e.V. a two-day symposium and one-day expert meeting »New Horizons: The Future of Medical Ultrasound«.

January 26-27, 2018
Fraunhofer MEVIS hosts a hands-on workshop on radiomics and machine learning for young radiology scientists within the program »Forscher für die Zukunft« (FFZ) of the Deutsche Röntgengesellschaft e.V.

February 10, 2018
Fraunhofer MEVIS researchers Markus Wenzel and Hans Meine instruct a one-day course on »Deep Learning for Image Understanding« at SPIE Medical Imaging Conference in Houston, TX.

February 22-23, 2018
Symposium on cooperation between the Diagnostic Image Analysis Group, Nijmegen and Fraunhofer MEVIS in Bremen.

April 6-7, 2018
Two-day institute retreat at the seminar hotel Kunze-Hof close to the Jadebusen.

May 15, 2018
Andrea Schenk, Stephan Zidowitz and Alexander Köhn receive the Joseph-von-Fraunhofer-Preis 2018 for their work on software-assistance in liver surgery at the annual meeting of the Fraunhofer-Gesellschaft in Berlin.

June 5, 2018
Fraunhofer MEVIS takes part in an exchange between art and science at »The Art of Complexity« event at the Fraunhofer-Forum in Berlin.

June 8, 2018
Fraunhofer MEVIS co-organizes in cooperation with Asklepios Klinik Barmbek the workshop »Cognitive Computing in Medicine and Radiology: Meet the Experts« in Hamburg.

June 20, 2018
Tenth meeting of the Fraunhofer MEVIS Advisory Board (Kuratorium) in Bremen.

June 27, 2018
In cooperation with the foundation for »MINT-Entertainment-Education-Excellence« (MINTEEE), Fraunhofer MEVIS provides filmmakers insights into the future of medicine and hospitals in a one-day workshop »Science Meets Fiction«.

July 2-5, 2018
Fraunhofer MEVIS holds four-day workshop on medical imaging for pupils within the program of the »Sommerakademie« of the University of Bremen.

July 4-6, 2018
Science night »Systems Biology Meets Digital Medicine« at Fraunhofer MEVIS as part of the 7th International Conference on Systems Biology of Mammalian Cells (SBMC 2018) held at Jacobs University Bremen and chaired by Tobias Preusser.

July 17, 2018
Milestone meeting of the Fraunhofer ATTRACT project »General MR Framework for Research and Industry« (GEMRI).

August 13-15, 2018
Fraunhofer MEVIS holds three-day workshop on medical imaging within the 21st Informatica Feminale of the University Bremen.

September 5, 2018
Groundbreaking ceremony for Fraunhofer MEVIS' new institute building on the campus of the University of Bremen.

September 5-7, 2018
Fraunhofer MEVIS and Charité organize an ESMRMB training course on MR image processing at TU Berlin.

September 8-9, 2018
Simultaneous launch of movie »Digital Medicine, Arts, and STEAM: BEFORE US LIES ETERNERDY« at Ars Electronica in Linz and Nanyang Technological University in Singapore.

October 3, 2018
Fraunhofer MEVIS joins the initiative »Maus Türöffner-Tag« by WDR's »Die Sendung mit der Maus« and opens the doors of its MRI center.

October 8-10, 2018
Fraunhofer MEVIS offers a hands-on workshop on medical imaging, registration and navigation for the
Fraunhofer Talent School in Bremen.

October 15, 2018
The University of Bremen and Fraunhofer MEVIS intensify their partnership in computer science education through a new study area »Medical Computing«.

November 25-30, 2018
Fraunhofer MEVIS presents itself at the »104th Scientific Assembly and Annual Meeting of the Radiological Society of North America« (RSNA) in Chicago, USA.

December 5, 2018
Laying of the cornerstone for Fraunhofer MEVIS' new institute building on the campus of the University of Bremen.

HIGHLIGHTS 2018

Ultrasound Symposium at Charité Berlin

About 100 participants and international experts from medicine, science, and industry discussed the potential of ultrasound technologies and solutions for medical diagnosis and therapy at the Charité Berlin in a 2-day symposium and a 1-day expert meeting from January 17 to19, 2018. The international symposium »New Horizons: The Future of Medical Ultrasound« addressed the current state and future potential of ultrasound technologies and solutions for medical diagnosis and therapy. The symposium was organized in cooperation between the Arbeitsgemeinschaft Ultraschall of the Deutsche Röntgengesellschaft e. V., the Ultrasound Center of the Charité, and Fraunhofer MEVIS. It took place in the reconstructed ruin of Charité's former Rudolf Virchow lecture hall and was certified by Ärztekammer Berlin with 8 CME points category A.

Workshops at SPIE Medical Imaging 2018

Fraunhofer MEVIS organized and held two workshops at the SPIE Medical Imaging Conference 2018 taking place in Houston, Texas from February 10 to 15. Markus Wenzel and Hans Meine from Fraunhofer MEVIS instructed a 1-day course on »Deep Learning for Image Understanding«. The fully booked course was intended for students, researchers, and engineers from academia and industry, who seek to obtain practical working knowledge in deep learning. It enabled almost 70 actively involved participants to gain practical experience in Deep Learning. In addition, Fraunhofer MEVIS director Horst Hahn chaired together with Lubomir Hadjiiski from the University of Michigan the »Live Demonstrations Workshop« on February 13.

Joseph von Fraunhofer Prize 2018

Fraunhofer MEVIS scientists Andrea Schenk, Stephan Zidowitz and Alexander Köhn have received the Joseph von Fraunhofer Prize of the year 2018 for their work on algorithms that analyze patients' imaging data and calculate surgical risks in order to make liver cancer surgery safer and easier to plan. In addition to scientific excellence, the jury recognizes the practical effectiveness of the surgical support, the many years of expertise of the MEVIS team in liver surgery and the character of the research project as a role model in society. The Joseph von Fraunhofer Prize was awarded to three teams of researchers at this year's annual conference of the Fraunhofer-Gesellschaft on May 15, 2018 in Berlin.

SBMC 2018 at Jacobs University and Fraunhofer MEVIS

The 7th Conference on Systems Biology of Mammalian Cells (SBMC) was held between July 4 and 6, 2018 under the auspices of the BMBF at Jacobs University and Fraunhofer MEVIS. The conference, chaired by Tobias Preusser and co-organized by Anja Hennemuth, was a joint effort of the competence network Liver Systems Medicine (LiSyM) and Fraunhofer MEVIS. More than 100 international scientists attended the SBMC 2018 and followed 26 talks in six scientific sessions complemented by four hands-on workshop and two poster sessions. In a science night under the motto »Systems Biology Meets Digital Medicine«, the participants of the SBMC 2018 took advantage of the opportunity for a get-together barbecue in a relaxed atmosphere while gaining insights into the work of Fraunhofer MEVIS.

ESMRMB Training Course on MR Image Processing

Fraunhofer MEVIS researchers Anja Hennemuth and Matthias Günther organized an ESMRMB training course taking place at the Technical University Berlin from September 5 to 7, 2018. The course titeled »MR image processing – From image data to information« provided an overview on modern technologies for dealing with MR images. The topics ranged from simple pre-processing methods, over aligning datasets with different contrasts to quantitative analysis and visual exploration of results. A short outlook on using MR images for modelling was given as well. About 30 participants from 14 countries attended the course and learned in 18 lectures und four hands-on sessions criteria for deliberate selection of tools and methods they can use in their studies.

Simultaneous Movie Launch at Ars Electronica, Linz and NTU, Singapore

On September 8 and 9, 2018, Fraunhofer MEVIS presented the new short movie »Digital Medicine, Arts, and STEAM: BEFORE US LIES ETERNERDY« in the Deep Space 8K theatre at the Ars Electronica Festival, Linz in cooperation with Media Art Nexus at Nanyang Technological University (NTU), Singapore. The simultaneous launch marked the beginning of an aspired deeper cooperation in which Fraunhofer MEVIS will provide techniques, tools, scientific expertise and environment for students from NTU Singapore. During the presentation, Fraunhofer MEVIS scientists Bianka Hofmann and Alexander Köhn talked in a live video call with collaborators Ina Conradi and Mark Chavez from NTU about arts' contribution to bring artistry and a sense of awe to remove barriers for getting engaged with severe health topics and also as a transdisciplinary approach of innovation in digital medicine.

University of Bremen and Fraunhofer MEVIS intensify their Partnership in Computer Science Education

In order to prepare computer science students for challenges in the area of digital medicine, Fraunhofer MEVIS and the University of Bremen are now cooperating even more closely in teaching. The winter semester 2018/19 saw the introduction of a new study area called »Medical Computing« in the Faculty of Mathematics and Computer Science. Whether in health care, diagnosis, surgery, or treatment: today, digital medicine plays an important role in everyday clinical life. The aim is for physicians to make the best possible use of the opportunities offered by big data, artificial intelligence, and image-based medicine. The new study focus of »Medical Computing« at the University of Bremen reflects groundbreaking developments in this field. For example, students gain insights into medical image processing and methods that can help physicians analyze increasingly complex situations. In order to create a connection to practice, clinical staff will also come to the university and be integrated into the teaching operations.

»Open House With The Mouse« at Fraunhofer MEVIS

Fraunhofer MEVIS opened the doors and invited kids and their parents to visit the MRI Center at Fraunhofer MEVIS on October 3rd, 2018. MEVIS joined the initiative »Maus Türöffner-Tag« by the WDR »Die Sendung mit der Maus« opening doors all over Germany to discover exciting and interesting facts and sites. Fraunhofer MEVIS researchers showed curious kids and parents how medical imaging with MR works. In practical experiments, they demonstrated how to get images from the inside of melons and lemons without slicing, and explained how MR images of the brain and the beating heart are acquired.

Laying the Cornerstone for the New Institute Building

In the presence of about 100 guests, including Prof. Eva Quante-Brandt (Senator for Science, Bremen), Andreas Meuer (Fraunhofer-Gesellschaft, Munich) and Prof. Heinz-Otto Peitgen (Founder and former Director of Fraunhofer MEVIS), the cornerstone for Fraunhofer MEVIS' new home in Bremen was laid on December 5, 2018. The new institute building, considered to be a »Workshop for Digital Medicine«, will be located on Max-von-Laue-Straße on the campus of the University of Bremen. It will provide 210 workspaces on four floors and 2,600 square meters of usable area. The plans for the new building were developed by the architectural office Haslob Kruse and Partner in Bremen. The ownerbuilder is the Fraunhofer-Gesellschaft in Munich. The construction costs of around 15 million euro will be split in thirds between the Federal Ministry of Education and Research, the Federal State of Bremen, and the European Regional Development Fund (ERDF). Construction should be finalized by December 2020.

Winner of the Joseph von Fraunhofer Prize 2018: Andrea Schenk, Stephan Zidowitz and Alexander Köhn have developed algorithms that analyze patient image data and calculate surgical risks. Liver cancer surgery is thus easier to plan. *© Fraunhofer / Kay Michalak*

AWARDS 2018

Industry Award for Best Immersive Media at Raw Science Film Festival 2017/18

Fraunhofer MEVIS receives the »Industry Award for Best Immersive Media« for the movie »The Beauty of Blood Flow Analysis« submitted by Bianka Hofmann, Alexander Köhn, Mathias Neugebauer, Anja Hennemuth, and David Black to the 4th »Raw Science Film Festival: The Bridge between Science and Media« held between January 5–7, 2018 in Santa Barbara, CA.

MedVis Award 2018

Lennart Tautz wins 2nd place at the Karl-Heinz Höhne MedVis Award 2018 for his work »An image-based method for decision support in diagnosis and therapy of heart insufficiency« at the Annual Meeting of the Working Group Visual Computing in Biology and Medicine in Ulm on April 12.

ISMRM Merit Award 2018

Daniel Christopher Hoinkiss wins magna cum laude award for his oral presentation »Prospective Motion Correction in Multi-Shot RARE Imaging Using Multi-Slice-to-Volume Image Registration« at the Joint Annual Meeting of the ISMRM – ESMRMB in Paris, France on June 16-21.

Joseph von Fraunhofer Prize 2018

Andrea Schenk, Stephan Zidowitz and Alexander Köhn receive the Joseph von Fraunhofer Prize 2018 for their work on software assistance in liver surgery at the annual meeting of the Fraunhofer-Gesellschaft on May 15, 2018 in Berlin.

SCIENTIFIC PUBLICATIONS 2018

Journal Articles

Anazodo UC, Finger E, Kwan BYM, Pavlosky W, Warrington JC, Guenther M, Prato FS, Thiessen JD, St Lawrence KS (2018) Using simultaneous PET/MRI to compare the accuracy of diagnosing frontotemporal dementia by arterial spin labelling MRI and FDG-PET. Neuroimage Clin 17:405–414

Black D, Hahn HK, Kikinis R, Wardell K, Haj-Hosseini N (2018) Auditory display for fluorescence-guided open brain tumor surgery. Int J CARS 13(1):25–35

Black D, Unger M, Fischer N, Kikinis R, Hahn H, Neumuth T, Glaser B (2018) Auditory display as feedback for a novel eye-tracking system for sterile operating room interaction. Int J CARS 13(1):37–45

Chlebus G, Schenk A, Moltz JH, van Ginneken B, Hahn HK, Meine H (2018) Automatic liver tumor segmentation in CT with fully convolutional neural networks and object-based postprocessing. Sci Rep 8:15497

Dettmer S, Suhling H, Klingenberg I, Otten O, Kaireit T, Fuge J, Kuhnigk JM, Gottlieb J, Haverich A, Welte T, Wacker F, Vogel-Claussen J, Shin HO (2018) Lobe-wise assessment of lung volume and density distribution in lung transplant patients and value for early detection of bronchiolitis obliterans syndrome. Eur J Radiol 106:137–144

Eickel K, Porter DA, Söhner A, Maaß M, Lüdemann L, Günther M (2018) Simultaneous multislice acquisition with multi-contrast segmented EPI for separation of signal contributions in dynamic contrast-enhanced imaging. PLoS ONE 13(8):e0202673

Fedorov A, Schwier M, Clunie D, Herz C, Pieper S, Kikinis R, Tempany C, Fennessy F (2018) An annotated test-retest collection of prostate multiparametric MRI. Sci Data 5:180281

Fernandes JF, Alves R, Silva TF da, Nordmeyer S, Hellmeier F, Goubergrits L, Hennemuth A, Berger F, Schubert S, Kuehne T, Kelm M (2018) CMR-Based and Time-Shift Corrected Pressure Gradients Provide Good Agreement to Invasive Measurements in Aortic Coarctation. JACC Cardiovasc Imaging 11(11):1725–1727

Flechsig P, Walker C, Kratochwil C, Konig L, Iagura A, Moltz J, Holland-Letz T, Kauczor H-U, Haberkorn U, Giesel FL (2018) Role of CT Density in PET/CT-Based Assessment of Lymphoma. Mol Imaging Biol 20(4):641–649

Galinovic I, Dicken V, Heitz J, Klein J, Puig J, Guibernau J, Kemmling A, Gellissen S, Villringer K, Neeb L, Gregori J, Weiler F, Pedraza S, Thomalla G, Fiehler J, Gerloff C, Fiebach JB (2018) Homogeneous application of imaging criteria in a multicenter trial supported by investigator training: A report from the WAKE-UP study. Eur J Radiol 104:115–119

García-Vázquez V, von Haxthausen F, Jäckle S, Schumann C, Kuhlemann I, Bouchagiar J, Höfer AC, Matysiak F, Hüttmann G, Goltz JP, Kleemann M, Ernst F, Horn M (2018) Navigation and visualisation with HoloLens in endovascular aortic repair. Innovative Surgical Sciences 3(3):167–177

Gubitz R, Lange T, Gosheger G, Heindel W, Allkemper T, Stehling C, Gerss J, Kanthak C, Schulte TL (2018) Influence of Age, BMI, Gender and Lumbar Level on T1rho Magnetic Resonance Imaging of Lumbar Discs in Healthy Asymptomatic Adults. RöFo Fortschr Röntgenstr 190(2):144–151

Hanken K, Francis Y, Kastrup A, Eling P, Klein J, Hildebrandt H (2018) On the role of the amygdala for experiencing fatigue in patients with multiple sclerosis. Mult Scler Relat Disord 20:67–72

Harloff A, Mirzaee H, Lodemann T, Hagenlocher P, Wehrum T, Stuplich J, Hennemuth A, Hennig J, Grundmann S, Vach W (2018) Determination of aortic stiffness using 4D flow cardiovascular magnetic resonance – a population-based study. J Cardiovasc Magn Reson 20:43

Hänsch A, Schwier M, Gass T, Morgas T, Haas B, Dicken V, Meine H, Klein J, Hahn HK (2018) Evaluation of deep learning methods for parotid gland segmentation from CT images. J Med Imag 6(1):011005

Höfener H, Homeyer A, Weiss N, Molin J, Lundström CF, Hahn HK (2018) Deep learning nuclei detection: A simple approach can deliver state-of-the-art results. Comput Med Imaging Graph 70:43–52

Homeyer A, Hammad S, Schwen LO, Dahmen U, Höfener H, Gao Y, Dooley S, Schenk A (2018) Focused scores enable reliable discrimination of small differences in steatosis. Diagn Pathol 13(76):1–9

Humpire-Mamani GE, Setio AAA, van Ginneken B, Jacobs C (2018) Efficient organ localization using multi-label convolutional neural networks in thorax-abdomen CT scans. Phys Med Biol 63(8):085003

Kaufhold L, Harloff A, Schumann C, Krafft AJ, Hennig J, Hennemuth A (2018) Image-based assessment of uncertainty in quantification of carotid lumen. JMI 5(3):1–9

König L, Rühaak J, Derksen A, Lellmann J (2018) A matrix-free approach to parallel and memory-efficient deformable image registration. SIAM J Sci Comput 40(3):B858–B888

Kiessling F (2018) Molecular ultrasound imaging of JAM-A depicts early arterial inflammation (Editorial). Aging 10(9):2222–2223

Kitajima T, Kaido T, Tajima T, Uemura T, Fujimoto Y, Schenk A, Uemoto S (2018) Younger Age is an Independent Factor for Graft Weight Overestimation: Analysis of the Clinical Impact on Recipient Outcomes in 340 Japanese Living Liver Donors. World J Surg 42(1):218–224

Klein O, Strohschein K, Nebrich G, Fuchs M, Thiele H, Giavalisco P, Duda GN, Winkler T, Kobarg JH, Trede D, Geissler S (2018) Unraveling local tissue changes within severely injured skeletal muscles in response to MSC-based intervention using MALDI Imaging mass spectrometry. Sci Rep 8:12677

Klein O, Hanke T, Nebrich G, Yan J, Schubert B, Giavalisco P, Noack F, Thiele H, Mohamed SA (2018) Imaging Mass Spectrometry for Characterization of Atrial Fibrillation Subtypes. Prot Clin Appl 12(6):1700155

Lang G, Vicari M, Siller A, Kubosch EJ, Hennig J, Südkamp NP, Izadpanah K, Kubosch D (2018) Preoperative Assessment of Neural Elements in Lumbar Spinal Stenosis by Upright Magnetic Resonance Imaging: An Implication for Routine Practice? Cureus 10(4):e2440

Lasso A, Nam HH, Dinh PV, Pinter C, Fillion-Robin J-C, Pieper S, Jhaveri S, Vimort J-B, Martin K, Asselin M, McGowan FX, Kikinis R, Fichtinger G, Jolley MA (2018) Interaction with Volume-Rendered Three-Dimensional

Echocardiographic Images in Virtual Reality. J Am Soc Echocardiogr 31(10):1158–1160

Lessmann N, van Ginneken B, Zreik M, de Jong PA, de Vos BD, Viergever MA, Isgum I (2018) Automatic Calcium Scoring in Low-Dose Chest CT Using Deep Neural Networks With Dilated Convolutions. IEEE Trans Med Imaging 37(2):615–625

Liu Y, Duan Y, Huang J, Ren Z, Liu Z, Dong H, Weiler F, Hahn HK, Shi F-D, Butzkueven H, Barkhof F, Li K (2018) Different patterns of longitudinal brain and spinal cord changes and their associations with disability progression in NMO and MS. Eur Radiol 28(1):96–103

Oei MTH, Meijer FJA, Mordang J-J, Smit EJ, Idema AJS, Goraj BM, Laue HOA, Prokop M, Manniesing R (2018) Observer variability of reference tissue selection for relativecerebral blood volume measurements in glioma patients. Eur Radiol 28(9):3902–3911

Oldhafer KJ, Peterhans M, Kantas A, Schenk A, Makridis G, Pelzl S, Wagner KC, Weber S, Stavrou GA, Donati M (2018) Navigierte Leberchirurgie: Aktueller Stand und Bedeutung in der Zukunft. Chirurg 89(10):769–776

Rosenhain S, Magnuska ZA, Yamoah GG, Rawashdeh W'el A, Kiessling F, Gremse F (2018) A preclinical micro-computed tomography database including 3D whole body organ segmentations. Sci Data 5:180294

Schreuder A, Schaefer-Prokop CM, Scholten ET, Jacobs C, Prokop M, van Ginneken B (2018) Lung cancer risk to personalise annual and biennial follow-up computed tomography screening. Thorax 73(7):626–633

Schreuder A, van Ginneken B, Scholten ET, Jacobs C, Prokop M, Sverzellati N, Desai SR, Devaraj A, Schaefer-Prokop CM (2018) Classification of CT Pulmonary Opacities as Perifissural Nodules: Reader Variability. Radiology 288(3):867–875

Schwen LO, Rueschenbaum S (2018) Ten quick tips for getting the most scientific value out of numerical data. Plos Comp Biol 14(10):e1006141

Schwen LO, Andersson A, Korski K, Weiss N, Haase S, Gaire F, Hahn HK, Homeyer A, Grimm O (2018) Data-Driven Discovery of Immune Contexture Biomarkers. Front Oncol 8(627):1–15

Strehlow J, Spahr N, Rühaak J, Laue H, Abolmaali N, Preusser T, Schenk A (2018) Landmark-based evaluation of a deformable motion correction for DCE-MRI of the liver. Int J CARS 13(4):597–606

Tautz L, Neugebauer M, Hüllebrand M, Vellguth K, Degener F, Sündermann S, Wamala I, Goubergrits L, Kuehne T, Falk V, Hennemuth A (2018) Extraction of open-state mitral valve geometry from CT volumes. Int J CARS 13(11):1741–1754

Thomalla G, Simonsen CZ, Boutitie F, Andersen G, Berthezene Y, Cheng B, Cheripelli B, Cho T-H, Fazekas F, Fiehler J, Ford I, Galinovic I, Gellissen S, Golsari A, Gregori J, Günther M, Guibernau J, Häusler KG, Hennerici M, Kemmling A, Marstrand J, Modrau B, Neeb L, Perez de la Ossa N, Puig J, Ringleb P, Roy P, Scheel E, Schonewille W, Serena J, Sunaert S, Villringer K, Wouters A, Thijs V, Ebinger M, Endres M, Fiebach JB, Lemmens R, Muir KW, Nighoghossian N, Pedraza S, Gerloff C (2018) MRI-Guided Thrombolysis for Stroke with Unknown Time of Onset. N Engl J Med 379(7):611–622

van den Heuvel TLA, de Bruijn D, de Korte CL, Ginneken B van, Reyes-Aldasoro CC (2018) Automated measurement of fetal head circumference using 2D ultrasound images. PLoS ONE 13(8):e0200412

van den Heuvel TLA, de Bruijn D, Moens-van de Moesdijk D, Beverdam A, van Ginneken B, de Korte CL (2018) Comparison Study of Low-Cost Ultrasound Devices for Estimation of Gestational Age in Resource-Limited Countries. Ultrasound Med Biol 44(11):2250–2260

Wehrum T, Günther F, Kams M, Wendel S, Strecker C, Mirzaee H, Harloff A (2018) Quantification of aortic stiffness in stroke patients using 4D flow MRI in comparison with transesophageal echocardiography. Int J Cardiovasc Imaging 34(10):1629–1636

Wehrum T, Guenther F, Fuchs A, Schuchardt F, Hennemuth A, Harloff A (2018) Measurement of cardiac valve and aortic blood flow velocities in stroke patients: a comparison of 4D flow MRI and echocardiography. Int J Cardiovasc Imaging 34(6):939–946

Wehrum T, Lodemann T, Hagenlocher P, Stuplich J, Ngo BTT, Grundmann S, Hennemuth A, Hennig J, Harloff A (2018) Age-related changes of right atrial morphology and inflow pattern assessed using 4D flow cardiovascular magnetic resonance: results of a population-based study. J Cardiovasc Magn Reson 20(1):38

Wolf ME, Okazaki S, Eisele P, Rossmanith C, Gregori J, Griebe M, Günther M, Gass A, Hennerici MG, Szabo K, Kern R (2018) Arterial Spin Labeling Cerebral Perfusion Magnetic Resonance Imaging in Migraine Aura: An Observational Study. J Stroke Cerebrovasc Dis 27(5):1262–1266

Ziemer T, Schultheis H, Black D, Kikinis R (2018) Psychoacoustical Interactive Sonification for Short Range Navigation. Acta Acust United Acust 104(6):1075–1093

Zimmermann J, Demedts D, Mirzaee H, Ewert P, Stern H, Meierhofer C, Menze B, Hennemuth A (2018) Wall shear stress estimation in the aorta: Impact of wall motion, spatiotemporal resolution, and phase noise. J Magn Reson Imaging 48(3):718–728

Articles in Conference Proceedings

Black D, Schmidt E, Strehlow J, Pätz T, Rascher-Friesenhausen R (2018) Comparison of Auditory Display Methods for Real-time Catheter Navigation. Proceedings of CURAC. pp 125–131

Brehmer K, Wacker B, Modersitzki J (2018) A Novel Similarity Measure for Image Sequences. In: Klein S, Staring M, Durrleman S, Sommer S (eds) Biomedical Image Registration. WBIR 2018. LNCS 10883, pp 47–56

Breutigam N-J, Günther M, Porter D (2018) Simultaneous Multi-Contrast Imaging in Combination with in-plane Parallel Imaging. Proceedings of the Joint Annual Meeting of the ISMRM and the ESMRMB. 2704

Chlebus G, Meine H, Abolmaali N, Schenk A (2018) Automatic Liver and Tumor Segmentation in Late-Phase MRI Using Fully Convolutional Neural Networks. Proceedings of CURAC. pp 195–200

Eickel K, Günther M (2018) A Neural Network for Referenceless Reconstruction in Simultaneous Multi-Slice Imaging. Proceedings of the Joint Annual Meeting of the ISMRM and the ESMRMB. 2782

Günther M (2018) Arterial Spin Labeled Input Function (ASLIF): signal acquisition during pseudo-continuous arterial spin labeling. Proceedings of the Joint Annual Meeting of the ISMRM and the ESMRMB. 0305

Haensch A, Dicken V, Gass T, Morgas T, Klein J, Meine H, Hahn HK (2018) Deep learning based segmentation of organs of the female pelvis in CBCT scans for adaptive radiotherapy using CT and CBCT data. International Journal of Computer Assisted Radiology and Surgery. pp 179–180

Hänsch A, Schwier M, Gass T, Morgasz T, Haas B, Klein J, Hahn HK (2018) Comparison of different deep learning approaches for parotid gland segmentation from CT images. Proceedings of SPIE Medical Imaging: Computer-Aided Diagnosis. 1057519:pp 1–6

Hoinkiss DC, Erhard P, Guenther M, Breutigam NJ, von Samson-Himmelstjerna F, Porter DA (2018) Prospective Motion Correction in Multiband fMRI Using Multislice-to-Volume Image Registration. Proceedings of the Joint Annual Meeting of the ISMRM and the ESMRMB. 1170

Jayender J, Xavier B, King F, Hosny A, Black D, Pieper S, Tavakkoli A (2018) A Novel Mixed Reality Navigation System for Laparoscopy Surgery. Medical Image Computing and Computer Assisted Intervention – MICCAI 2018. pp 72–80

Jäckle S, Heldmann S (2018) Rigid Lens – Locally Rigid Approximations of Deformable Registration for Change Assessment in Thorax-Abdomen CT Follow-Up Scans. Image Analysis for Moving Organ, Breast, and Thoracic Images. pp 272–283

Kaufhold L, Goebel H, Mirzaee H, Strecker C, Harloff A, Hennemuth A (2018) Background Correction and Stitching of Histological Plaque Images. In: Maier A. DT Handels H. Maier-Hein K. Palm C. Tolxdorff T. (ed) Bildverarbeitung für die Medizin 2018. Springer Vieweg, Berlin, Heidelberg, pp 109–114

Kaufhold L, Harloff A, Schumann C, Krafft A, Hennig J, Hennemuth A (2018) Image-based assessment of uncertainty in quantification of carotid lumen. Proceedings of SPIE Medical Imaging: Image Processing. 105742J:pp 1–11

Kaufhold L, Krafft A, Strecker C, Huellebrand M, Ludwig U, Harloff A, Hennemuth A (2018) Automatic carotid vessel wall assessment based on a combined analysis of TOF-MR angiography and MSD T2-weighted MRI sequences. Proceedings of the Joint Annual Meeting of the ISMRM and the ESMRMB. 1885

Lilge S, Black D, Nabavi A, Burgner-Kahrs J (2018) Comparisonof Haptic and Auditory Feedback Methods for the Teleoperationof Concentric Tube Continuum Robots. Proceedings of CURAC 2018. pp 74–79

Lippert F, Cheng B, Golsari A, Weiler F, Gregori J, Thomalla G, Klein J (2018) Exploring DeepMedic for the purpose of segmenting white matter hyperintensity lesions. Proceedings of SPIE Medical Imaging: Computer-Aided Diagnosis. 105752F:pp 1–7

Medved M, Vicari M, Karczmar GS (2018) Effect of compressed sensing acceleration on High Spectral and Spatial resolution (HiSS) breast MRI image quality. Proceedings of the Joint Annual Meeting of the ISMRM and the ESMRMB. 2815

Oechtering T, Schlueter J, Sieren M, Scharfschwerdt M, Auer C, Huellebrand M, Sievers H-H, Barkhausen J, Frydrychowicz A (2018) 4D-Flow-MRI analysis of aortic flow patterns after replacement of the ascending aorta with a physiologically pre-shaped, 90° bent prosthesis. Proceedings of the Joint Annual Meeting of the ISMRM and the ESMRMB. 0006

Spahr N, Thoduka S, Abolmaali N, Schenk A (2018) Investigation of local liver strain derived from deformation fields used for radioembolization planning of the liver. International Journal of Computer Assisted Radiology and Surgery. 177

Tautz L, Neugebauer M, Wamala I, Sündermann S, Falk V, Hennemuth A (2018) Automatic Detection of Commissures in Mitral Valve Geometry. Proceedings of CURAC 2018. pp 16–21

von Dresky C, Ballhausen H, Becker M, Serowy S, Skalej M, Rieder C (2018) Towards the optimization of generator modulation and applicator positions for radiofrequency ablation of spine metastases. Proceedings of CURAC. pp 208–213

Weiler F, Klein J, Gregori J, Spiess L, Hildebrandt H, Heldmann S (2018) Fully automatic quantification of mean-upper cervical cord area: Agreement with multiple human raters. International Journal of Computer Assisted Radiology and Surgery. pp 150–151

Weiss N, Kost H, Homeyer A (2018) Towards Interactive Breast Tumor Classification Using Transfer Learning. In: Campilho A, Karray F, ter Haar Romeny B (eds) Proceeding of International Conference Image Analysis and Recognition. LNCS 10882, pp 727–736

Zimmermann J, Demedts D, Markl M, Meierhofer C, Stern H, Hennemuth A (2018) Exploring vessel inward normal computation for 4D flow based wall shear stress estimation in complex vessel geometries. Proceedings of the Joint Annual Meeting of the ISMRM and the ESMRMB. 3435

Book Chapters

Hahn H, Schreiber A (2018) E-Health: Potenziale der Digitalen Transformation in der Medizin. In: Neugebauer R (ed) Digitalisierung. Springer Vieweg, Berlin, Heidelberg, pp 321–345

Stavrou G, Schenk A, Oldhafer KJ (2018) 3D-Bildgebung und virtuelle Operationsplanung. In: Bechstein WO, Schnitzbauer AA (eds) Expertise Leber – Gallenwege. Thieme, pp 51–59

Dissertations

Hoinkiss, DC (2018) Acquisition and Processing Techniques for Image-Based Prospective Motion Correction in Magnetic Resonance Imaging, Universität Bremen

König, L (2018) Matrix-free approaches for deformable image registration with large-scale and real-time applications in medical imaging, Universität zu Lübeck

Polzin, T (2018) Large Deformation Diffeomorphic Metric Mappings – Theory, Numerics, and Applications, Universität zu Lübeck

Rothlübbers, S (2018) Motion Tracking for Medical Applications using Hierarchical Filter Models, Universität Bremen

Strehlow, J (2018) Motion Compensation for Minimally Invasive Liver Interventions, Jacobs University Bremen

Master Theses

Galuschka, P (2018) Verwendung der mittleren Krümmung als Regularisierer in der Bildregistrierung - Herleitung, Analyse und Erweiterung auf 3D, Universität zu Lübeck

Huber, J (2018) Korrektur von Bewegungsartefakten in Perfusionsbildern mit der 3D GRASE PROPELLER MR-Sequenz, Carl von Ossietzky Universität Oldenburg

Karimkeshteh, S (2018) Pressure and Geometry in a Population Study of the Aorta, Ruhr-Universität Bochum

Kuckertz, S (2018) Schwach überwachtes Lernen nichtlinearer medizinischer Bildregistrierung mit neuronalen Faltungsnetzwerken, Universität zu Lübeck

Lange, A (2018) Mehrgitterverfahren zur FEM-basierten elastischen Registrierung histologischer Serienschnitte, Universität zu Lübeck

Lux-Hoffmann, KD (2018) Deep Learning für die Bildregistrierung, Universität zu Lübeck

Neiden, M (2018) Analyse hochdimensionaler MALDI-Daten mittels Convolutional Neural Networks, Universität zu Lübeck

Peters, TV (2018) Mastering the game of Dots and Boxes with deep neural networks and tree search, Universität Bremen

Seemann, F (2018) Numerical and theoretical investigations of metamaterials built of split ring resonators and spiral resonators, Universität Bremen

Thomas, S (2018) Schwach überwachtes Deep Learning für Tumor-Segmentierung in CT-Aufnahmen, Universität Bremen

Bachelor Theses

Dieker, J (2018) Interaktive Visualisierung von MRT-Bildqualitätsparameter einer medizinischen Längsschnittstudie, Hochschule Bremerhaven

Entelmann, W (2018) Robuste Perfusionsmessung mittels Arterial Spin Labeling, Hochschule Bremerhaven

Redenius, S (2018) Neuartige Medizinprodukte-Software: Regulatorische Anforderungen an MedicalApps und KI-Lösungen, Hochschule Bremerhaven

Riemann, J (2018) Qualitätsmanagement in der medizinischen Softwareentwicklung am Beispiel von CaFuR, Hochschule Bremerhaven

Schmidt, E (2018) Auditive Darstellung zur zweidimensionalen Katheternavigation, Hochschule Bremerhaven

Tchoutou, J (2018) Klassifizierung von Bewegungsdaten eines Beschleunigungssensors über maschinelles Lernen, Hochschule Bremerhaven

Thavayogarajah, M (2018) Entwicklung eines Usability-Fragebogens für die medizinische Software CaFuR, Hochschule Bremerhaven

Patents by Fraunhofer MEVIS

Breutigam N-J, von Samson-Himmelstjerna F, Günther M (2018, granted) Verfahren zur automatischen Adaption von Labeling Parametern bei der zeitaufgelösten Perfusionsmessung mit Hilfe einer umsortierten Boluskodierung und einem dynamischen Feedback Algorithmus. Deutsche Patentanmeldung 10 2016 206 724.9, Prioritätsdatum 20.04.2016, Erteilung 23.08.2018

Eickel K, Wenzel M (2018, granted) Referenzlose Mehrkanalbildgebung in der Magnetresonanztomographie. Deutsche Patentanmeldung 10 2016 113 138.5, Prioritätsdatum 15.07.2016, Erteilung 15.02.2018

Günther M (2018, filed) Magnetic resonance imaging system. Deutsche Patentanmeldung 102018110826.5, Prioritätsdatum 04.05.2018

Pätz T, Strehlow J, Hahn H (2018, filed) Tracking und Navigation mittels lokaler Dehnungsinformationen. Deutsche Patentanmeldung 102018108643.1, Prioritätsdatum 11.04.2018

Tretbar S, Degel C, Günther M (2018, granted) Aufklebbarer, MR-kompatibler, (Radiotherapie-kompatibler) Ultraschallkopf. Deutsche Patentanmeldung 10 2012 005 895.0, Prioritätsdatum 23.03.2012, Erteilung WE, FR, GB, IT 18.04.2018

IMPRESSUM

Text
Thomas Forstmann
Prof. Matthias Günther
Prof. Horst Hahn
Dr. Guido Prause

Graphic Design
Christoph Brachmann
Olaf Klinghammer
Dr. Mathias Neugebauer

Editing & Layout
Olaf Klinghammer
Dr. Guido Prause

Translation
David Black

Image Credits
© Fraunhofer MEVIS
(unless stated otherwise)

Publisher
Fraunhofer MEVIS
Am Fallturm 1
28359 Bremen
Germany
+49 421 218 59112
info@mevis.fraunhofer.de
www.mevis.fraunhofer.de