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Medizinische Fakultät

2016
ANNUAL REPORT

iccas

IMPRINT

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Medizinische Fakultät
Innovation Center Computer Assisted Surgery (ICCAS)

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PREFACE

In 2016, two main considerations were on the agenda of ICCAS: the road to sustainability and raising its public profile. The first has been generously supported by the Medical Faculty. The later was accomplished through ICCAS attending international conferences including DGE-BV, CARS, BMT, CURAC, SMIT and MEDICA. We were delighted to host Germany's Minister of Health Hermann Gröhe and Barbara Klepsch, Saxony's State Minister of Social Affairs and Consumer Protection in August. The general public was invited to ICCAS on two open days held in June as well as on 'Dies academicus' in December.

Throughout 2016, research activities at ICCAS focused on the Intelligent Operating Room headed by Professor Thomas Neumuth. This highly advanced and now fully networked smart operating room brings together the successfully completed joint research projects OR.Net- Secure and Dynamic Networking in the Operating Room and MAI- Model-based Automation and Integration. The Junior Research Group Digital Patient and Process Model also funded by the BMBF was extended until the end of 2018. In July, leadership of the group was placed in the capable hands of the newly appointed leader PD Dr.-Ing. habil. Steffen Oeltze-Jafra.

SONORAY, the Meta-ZIK of OncoRay in Dresden and ICCAS (lead), was launched in October. Funded by the BMBF to the tune of €6.2 million, the project explores the combined use of MR-guided focused ultrasound and radiation therapy to improve cancer treatment. The team in Leipzig is headed by Dr. Doudou Xu from Chongqing in China, who is highly experienced in this field. Under her management, a cell laboratory for focused ultrasound has been set up at the SIKT Saxon Incubator for Clinical Translation, where initial experiments have already been conducted. We would like to take this opportunity to thank all those involved at SIKT, especially Prof. Christian Etz.

Finally, Multimodal Intraoperative Imaging headed by Dr. Claire Chalopin was augmented by the project Multiparametric Spectral Patient Imaging funded by the BMWi Federal Ministry for Economic Affairs and Energy.

The ISO 13485 certification of ICCAS in June 2016 was an outstanding achievement paving the way to regulatory approval and clinical use of ICCAS medical device developments.

The DORS Summer School, which was held for the third time, was a resounding success. Generously supported by the Volkswagen Foundation, it attracted more than 35 participants and tutors from 11 countries.

Finally, cooperation was stepped up with our partners at Leipzig University Hospital and with the Heart Center Leipzig. At this point, we would like to thank the many members of our Clinical Advisory Board and all our collaborative partners for supporting us with their valuable medical expertise.

Best wishes,

Prof. mult. Dr. med. Andreas Melzer
Director of ICCAS

INSTITUTIONAL FACTS

FIRST FUNDING PERIOD (2005–2010)

ICCAS's starting vision is the development of computer assisted surgery based on the interdisciplinary application of surgery, computer science and engineering. The institution will act as a platform for research collaboration between science and industry and wants to translate surgical problems into technically and economically feasible products.

2005

ICCAS founded as a research initiative at the Faculty of Medicine of Universität Leipzig, funded by the German Ministry of Education and Research (BMBF)

TWO RESEARCH GROUPS
Scientific Methods (Dr. Oliver Burgert), Surgical PACS & Mechatronics (Dr. Werner Korb)

ICCAS BOARD
Prof. Jürgen Meixensberger, Dr. Christos Trantaktis, Prof. Andreas Dietz, Dr. Gero Strauß, Prof. Friedrich Wilhelm Mohr, Dr. Volkmar Falk, Prof. Heinz U. Lemke

PROJECT MANAGEMENT
Karin Weiße

2007

Scientific Worksflow Analysis GmbH and Phacon GmbH founded as spin-off companies

Professorship of Computer Assisted Surgery: Prof. Dirk Bartz

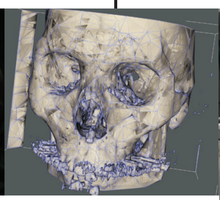
Third research group: Visual Computing (Prof. Dirk Bartz)

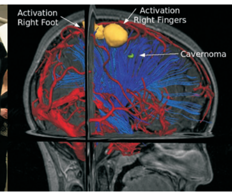
2009

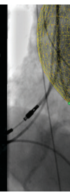
ICCAS colloquium on Computer Assisted Surgery launched

Establishment of the IRDC – ICCAS as a pioneer and cooperation partner







2006

Aspects of CAS included in educational programs of the Faculty of Medicine and the Faculty of Mathematics and Computer Science, University of Leipzig

2008

Germany's Minister of Education and Research visits ICCAS CURAC in Leipzig

FIVE RESEARCH GROUPS
Therapy Imaging and Model Management Systems (Dr. Oliver Burgert), Patient Model (Dr. Rafael Mayoral), Workflow and Knowledge Management (Dr. Thomas Neumuth), Assessment of Surgical Automation Systems (Dr. Werner Korb), Visual Computing (Prof. Dirk Bartz)

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

SECOND FUNDING PERIOD (2011-2016)

ICCAS is continuously developing into Europe's foremost center of computer assisted surgery. Research is focused on pioneering fields such as the development of IT infrastructure and workflow management for the operating room of the future, the creation and effective use of digital patient models in surgery, the standardization efforts of surgical assistance systems, new imaging modalities for surgical applications and new processes for image guided applications in surgery.

2011

ICCAS participates in the DICOM WG24 group

ICCAS's demo OR 2.0 opens

RESEARCH AREAS
Model-Based Automation and Integration (Dr. Thomas Neumuth) and Standards (Prof. Heinz U. Lemke)

Advisory Board founded

2012

ICCAS starts academic courses at the HTWK

RESEARCH AREA
Digital Patient Model (Dr. Kerstin Denecke) starts

2013

TPU including ‚oncoflow' launched at Leipzig University Hospital

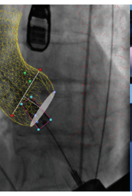
PascAL (Patient Simulation Models for Surgical Training and Teaching) – research project by University of Leipzig and HTWK Leipzig

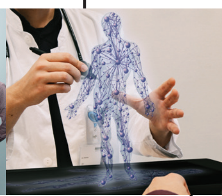
ICCAS plays a key role in the national BMBF research project 'OR.Net – Safe and Dynamic Networks in the Operating Room'

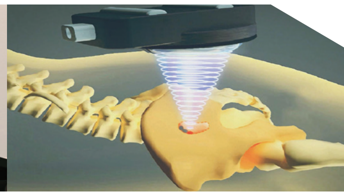
Honorary Professorship of Biomedical Information Systems at the HTWK Leipzig: Thomas Neumuth

Project 'HWS- Structural Defect Classification and Modeling of the Cervical Spine' in cooperation with the Institute of Anatomy (University of Leipzig) 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







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)

2015

Launching of cooperation with several scientific and clinical institutions

Tenth anniversary of ICCAS with second 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

New Advisory Board members: Prof. Ron Kikinis and Prof. Günter Rau

2016

Final presentation of flagship project OR.Net

ICCAS receives ISO 13485 certification

Federal health minister visits ICCAS

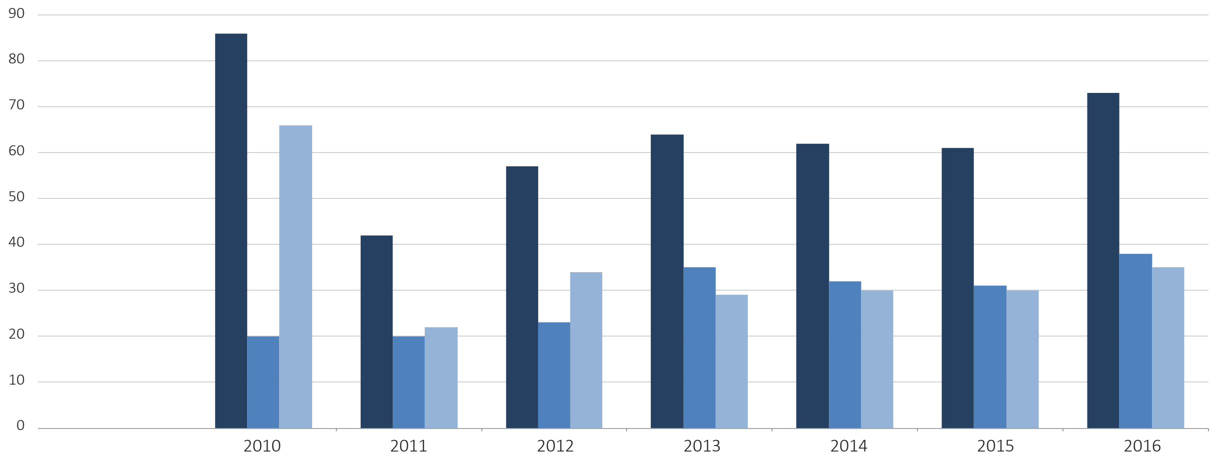
3rd Digital Operating Room Summer School - DORS 2016

Project start of Meta-ZIK SONORAY

FACTS AND FIGURES

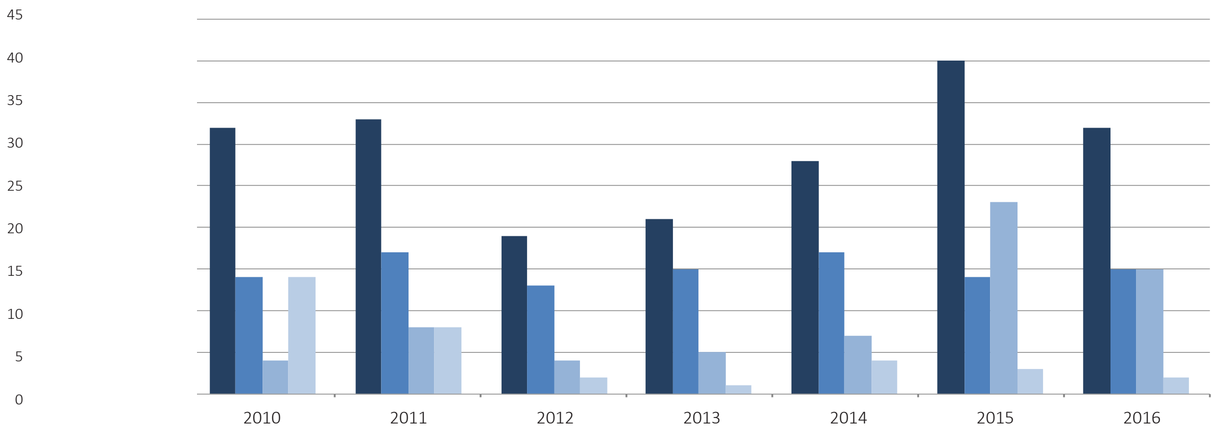
HEADCOUNT

ICCAS began its second phase (2010–16) with a staff of 86. Decreasing substantially in 2011 when fixed-term junior research groups were discontinued as planned, it rose again the following year, stabilizing at over 60 members of staff until 2016.



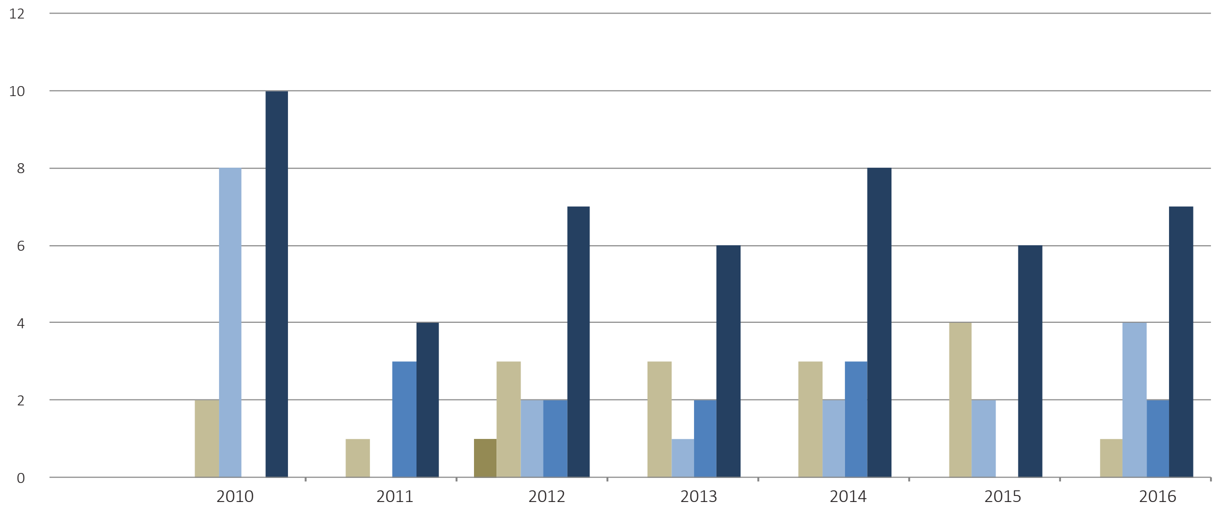
	2010	2011	2012	2013	2014	2015	2016
Total	86	42	57	64	62	61	73
Staff	20	20	23	35	32	31	38
Students	66	22	34	29	30	30	35

PUBLICATIONS



	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total	32	33	19	21	28	40	32
Lead authorship	14	17	13	15	17	14	15
Co-authorship	4	8	4	5	7	23	15
Book chapters	14	8	2	1	4	3	2

GRADUATIONS

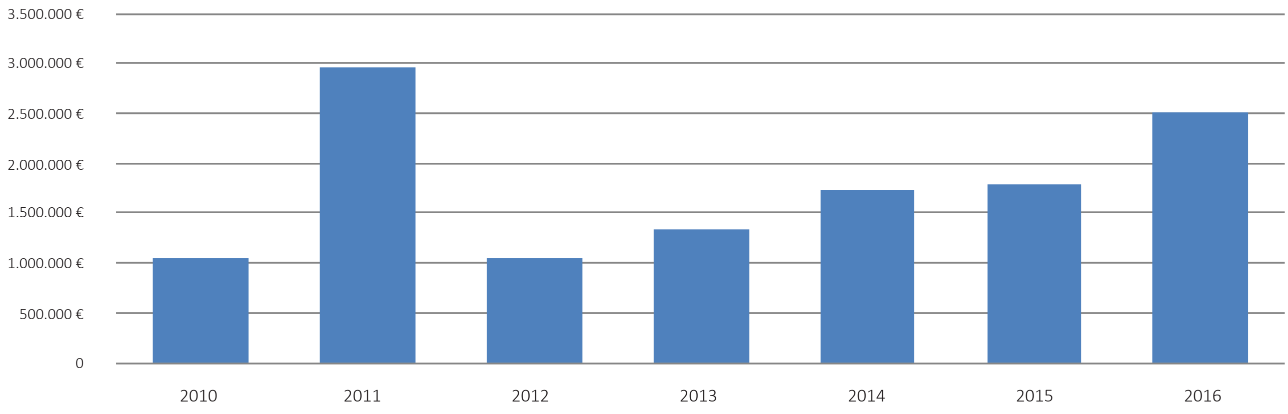


	2010	2011	2012	2013	2014	2015	2016
Habilitation	0	0	1	0	0	0	0
Doctoral thesis	2	1	3	3	3	4	1
Master thesis	8	0	2	1	2	2	4
Bachelor thesis	0	3	2	2	3	0	2
Total	10	4	7	6	8	6	7

ICCAS GRADUATION IN 2016

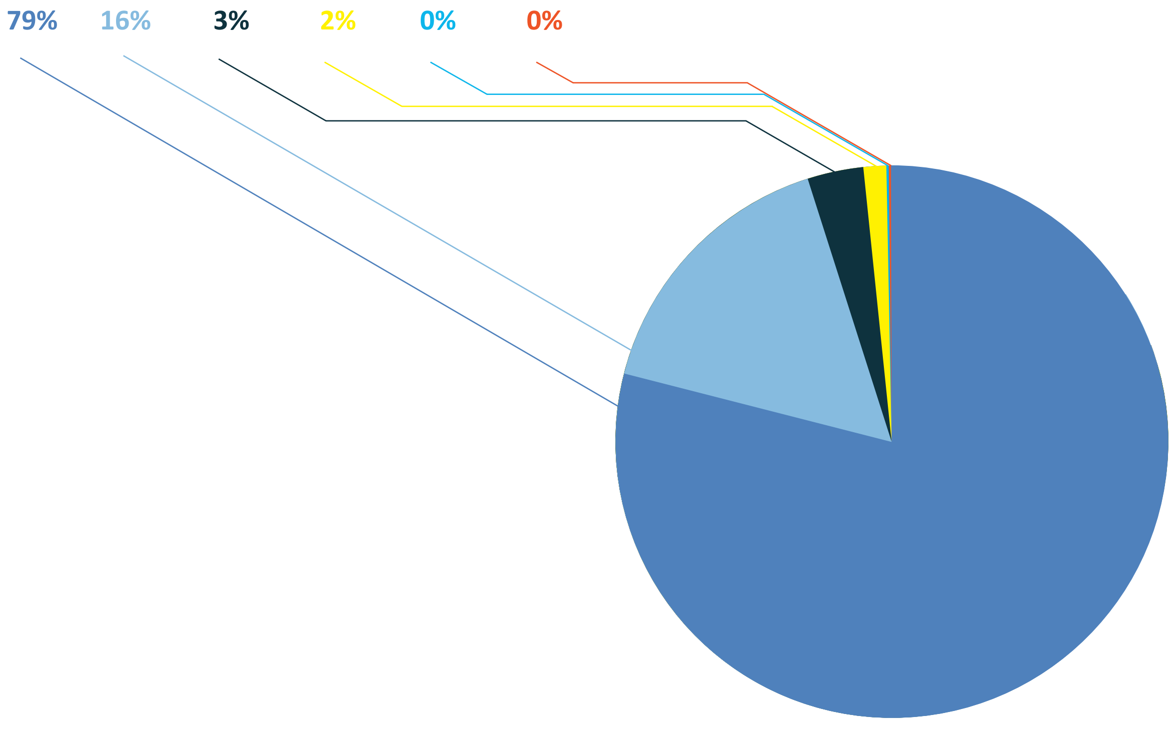
Markus Kaiser (M.Sc., Dipl.-Ing. (FH))
Dissertation title: 'Fusion of Interventional Ultrasound & X-Ray'
Institute: Faculty of Informatics, Otto-von-Guericke-University Magdeburg
Grade: magna cum laude

FUNDING



Year	Third-party funds
2010	1.047.000 €
2011	2.957.000 €
2012	1.055.000 €
2013	1.332.000 €
2014	1.732.000 €
2015	1.793.000 €
2016	2.514.000 €

BMBF	17.872.000 €
SMWK	3.645.000 €
BMWI	734.000 €
DFG	305.000 €
Industry	28.000 €
Others	43.000 €



ICCAS is mainly financed by the BMBF Federal Ministry of Education and Research under its ZIK Centers of Innovation Excellence program. Additional external funding was received for successful applications submitted to the BMWi Federal Ministry for Economic Affairs and Energy for projects related to the ZIM Central Innovation Program for SMEs as well as from the DFG German Research Foundation and at a regional level the Saxon Ministry of Science and Art. Leipzig University's Faculty of Medicine also provides ICCAS with performance-based funding.

External funding spent at ICCAS in the second ZIK funding phase (2010–2016) totaled €12.5 million. In 2010, the institute's future strategy and structure with two main junior research groups were mapped out. One year later, Demo OR 2.0 was opened thanks to a strategic investment of €2.31 million by the BMBF. The second period saw a steady rise in the number of externally funded projects. In 2016, one main junior research group ended. At the same time, three new projects were launched and the BMBF Meta-ZIK excellence SONORAY between OncoRay in Dresden and ICCAS was established with total funding of €6.3 million.

HONORS AND AWARDS

At the 26th International Conference on Electronics, Communications and Computers (CONIELECOMP 2016), **Elisee Ilunga** and his co-supervisor **Dr. Claire Chalopin** received the best paper award for the work about 'Automatic brain tumor tissue detection based on hierarchical centroid shape descriptor in T1-weighted MR images'.

In September 2016, **Dr. Matthäus Stöhr** (ENT-Department, Leipzig University Hospital) and **Mario Cypko** (ICCAS) received the 2nd Poster-award at 'Mitteldeutscher HNO-Kongress' in Halle/Saale on 'TNM classification of laryngeal carcinoma: modeling and validation of a Bayesian Network'.

Dr. Sandra von Sachsen was awarded the PhD thesis prize of the Medical Faculty of Leipzig University on October 25, 2016. She completed her doctorate on 'Employment of numerical simulations for the comparison of stent grafts in vascular medicine. Use potential, requirement specification and man-machine interface'.

HIGHLIGHTS

FEDERAL HEALTH MINISTER VISITS ICCAS

On August 18, ICCAS was visited by Germany's Federal Health Minister Hermann Gröhe during his summer tour. He was accompanied by Babara Klepsch, Saxony's State Minister of Social Affairs and Consumer Protection.

The two ministers explored the smart capabilities of assistive technology during simulated surgery on the ears and nose of a phantom patient involving microscope, endoscope and milling machine. The new possibilities of surgical support prompted admiration – and also a number of questions. Answers were provided by Professor Andreas Melzer (from a clinical perspective) and Professor Thomas Neumuth (from a technical angle). They emphasized that R&D work at ICCAS was intended to help physicians rather than replace their expertise and activity. Hermann Gröhe explained that networking and interoperability were also key issues for the German government in connection with ensuring that everyone benefits from state-of-the-art medicine. Other guests in attendance during the ministers' visit included Professor Beate Schücking (Rector of Leipzig University), Professor Michael Stumvoll (Dean of the Faculty of Medicine), Professor Oliver Gotthold (Administrative Director of the Faculty of Medicine) and Professor Wolfgang Fleig (Medical Director of Leipzig University Hospital) as well as Professor Andreas Dietz (Director of the Department of Otolaryngology and a member of the ICCAS Board) and Professor Jürgen Meixensberger (Director of the Department of Neurosurgery and chair of the ICCAS Board).

FINAL PRESENTATION OF FLAGSHIP PROJECT OR.NET

Visitors to this year's Connecting Healthcare IT (conhIT) in April were able to see the future operating room at first hand at the impressive OR.Net exhibition booth.

The results of joint research involving over 80 industrial, clinical and scientific partner institutions from all over Germany have been used to set up an operating room where medical devices from different manufacturers can communicate in real time with each other, the surgeon and the hospital's IT infrastructure.
ICCAS played a key part in the conception

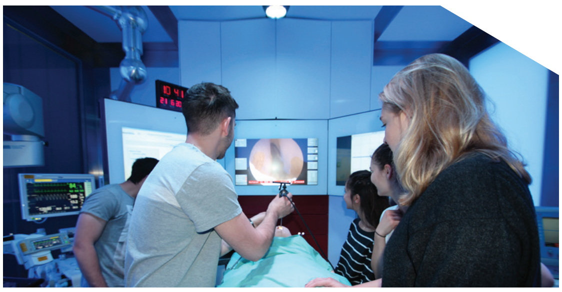
of the system and its architecture as well as in work on standardization processes. The positive effects include not just improved patient safety and stress management but also benefits for hospitals and innovative small and medium-sized enterprises.

ISO CERTIFICATION

On June 23, ICCAS was awarded ISO certification for its research and development of medical device software. This means that businesses can now implement collaborative projects with ICCAS in accordance with ISO 13485, the standard setting out requirements for the design and manufacture of medical devices. For example, software systems developed in cooperation with ICCAS are now automatically deemed to comply with ISO 13485. Furthermore, manufacturing processes now take place under defined guidelines to ensure high product quality. Compliance with scientific and technical standards at ICCAS is especially important because the products developed there are intended to be used directly on humans.

ICCAS'S OPEN DAYS

On June 20 and 21, ICCAS displayed its latest research developments, especially those related to the Future Operating Room.



The highlight was a demonstration of the first vendor-independent, fully networked operating room. The many visitors from various branches of medicine were impressed by the technical progress achieved, which already maps out the future of computer-aided assistance in the operating room. Some of them used the opportunity to try out the highly innovative technology for themselves. Other developments were also displayed, such as the Digital Patient Model (a support system for patient-specific treatment decisions) and the CephaLens (an assistance system for minimally invasive neurosurgery and infrared thermography for use in plastic surgery).

3RD DIGITAL OPERATING ROOM SUMMER SCHOOL – DORS 2016

In September, ICCAS hosted its third Digital Operating Room Summer School.

This year, the 35 participants and tutors came from USA, France, Italy, Germany, Switzerland, the Netherlands, Turkey, Italy, China, Japan and India. The CME-certified course (57 credits from the Saxon Medical Association and 33 European CME credits (EACCME®)) offered a unique insight into the latest developments in computer-assisted interventions. The packed program consisted of fascinating lectures delivered by experts followed by practical exercises (including on patient phantoms) as well as visits to state-of-the-art operating rooms and labs at Leipzig University Hospital and Heart Center Leipzig.

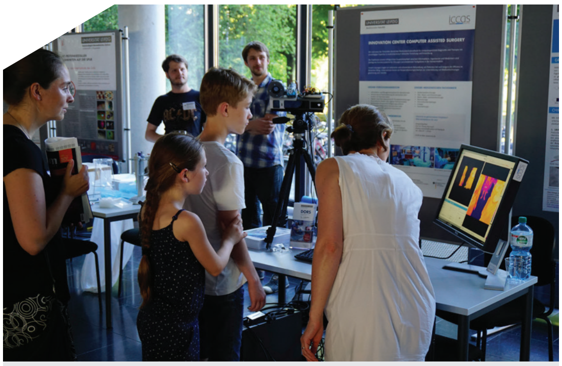
PUBLIC EVENTS

Day of German Unity in Dresden | 03.10.2016

Girls' Day at ICCAS | 28.04.2016

Leipzig Corporate Challenge | 08.06.2016

Female pupils experienced research atmosphere at ICCAS on Girls' Day. The 'QUICCAS' sports team put in a strong performance in the Leipzig Corporate Challenge. During the Leipzig Night of Sciences visitors were invited to visualize their skin temperature. The mobile version of ICCAS's 'Intelligent OR' was a real crowd-puller in Dresden at the Day of German Unity and in Düsseldorf at MEDICA trade show. Many people visited ICCAS on Dies academicus, Leipzig University's 607th anniversary.



Long Night of Sciences at BIO City Leipzig | 24.06.2016

Dies academicus at ICCAS | 02.12.2016

MEDICA 2016 in Düsseldorf | 14.-17.11.2016

GUESTS AT ICCAS'S INTELLIGENT OPERATING ROOM

Medical students from Abilene Christian University, Texas | 26.05.2016, 02.06.2016, 09.06.2016

Visiting professors from Palestine within the scope of 'Erasmus+ program' at HTWK Leipzig | 19.05.2016

Visiting professors from Jordan within the scope of 'Erasmus+ program' at HTWK Leipzig | 25.10.2016

Researchers from 'Sanjay Gandhi Postgraduate Institute of Medical Sciences', Lucknow, India | 28.06.2016

Hospital IT leaders in the scope of the 'Hospital IT Spring Meeting' in Leipzig | 07.04.2016

Participants from the 2nd 'Symposium Medizintechnik', Leipzig | 08.12.2016

EDUCATIONAL EVENTS

3RD DIGITAL OPERATING ROOM SUMMER SCHOOL - DORS 2016

SEPTEMBER 12 - 17, 2016 | ICCAS, LEIPZIG
In September 2016, ICCAS hosted its third Digital Operating Room Summer School.

Hands On 'CAS in Neurosurgery' with Dr. Dirk Lindner

This year, the 35 participants and tutors came from USA, France, Italy, Germany, Switzerland, the Netherlands, Turkey, Italy, China, Japan and India. The CME-certified course (**57 credits by the national authority 'Sächsische Landesärztekammer' and 33 European CME-credits** (EACCME®)) offered a unique insight into the latest developments in computer-assisted interventions. The well filled program consisted of interesting expert lectures, followed by practical exercises partly on patient phantoms and visits to state-of-the-art operating theaters and labs of Leipzig University Hospital and Heart Center Leipzig.

ICCAS COLLOQUIUM AND SEMINAR

International experts reported about state-of-the-art research at ICCAS colloquium (at Leipzig University Hospital) and seminar (at Semmelweisstr. 14).

FEB. 16, 2016 | COLLOQUIUM
Speakers: Neil Stewart and Derek McKenzie (European funding advisors- University of Dundee, Scotland, KITE Innovation Europe Ltd)
Topic: 'EU Horizon 2020 Funding: Strategies for successful proposals'

APRIL 04, 2016 | SEMINAR
Speaker: Dr. Robert Adunka (TRIZ project leader for Siemens AG)
Topic: 'Overview of procedures in development departments of large enterprises: solutions for specific problems.'

JULY, 2016 | SEMINAR
Speaker: Dr. Doudou Xu (Associate Researcher at the Institute for Medical Science and Technology, University of Dundee, Senior Researcher at Chongqing Changlin Science &Technology Ltd., Guest Researcher at School of Pharmacy and Bioengineering, Chongqing University of Technology, China)
Topic: 'Targeted Drug Delivery with Cyclodextrin-based Nanocarriers and Focused Ultrasound Triggering'

NOV. 03, 2016 | SEMINAR
Speaker: Prof. Alejandro Frangi (Director for Computational Imaging & Simulation Technologies in Biomedicine at the University of Sheffield)

Topic: 'Clinical Decision Support in Cerebral Aneurysm Treatment. Image-based cerebro-vascular modeling for advanced diagnosis and interventional planning.'

NOV. 24, 2016 | COLLOQUIUM
Speaker: Prof. Chrit Moonen (Image Science Institute at the University Medical Center Utrecht)
Topic: 'New technologies for non-invasive tumor treatment'
Speaker: Prof. Chris Terhaard (Department of Radiotherapy at the University Medical Center Utrecht)
Topic: 'The role of MRI in radiotherapy for head and neck cancer'

UNIVERSITY COURSES

Young academics are supported with courses in computer-assisted medicine at Leipzig University and Leipzig University of Applied Sciences (HTWK). ICCAS also suggests and supervises dissertations in computer-assisted medicine for BSc, MSc and PhD students, and offers placements to students of computer science and engineering.

LECTURES & COURSES	INSTITUTION
'Surgical Navigation, Mechatronics and Robotics'	Leipzig University
'Computer Assisted Surgery'	Leipzig University
'Medical Planning and Simulation Systems'	Leipzig University
'Introduction to Computer Assisted Surgery'	Leipzig University
'System Innovation in Medicine'	Leipzig University
'Project Management for Engineers'	Leipzig University of Applied Sciences
'Systems Engineering'	Leipzig University of Applied Sciences

SCIENTIFIC AND ECONOMIC EVENTS

CONFERENCES, SYMPOSIA AND WORKSHOPS

ICCAS contributed to a wide variety of national and international conferences, symposia and workshops which play an important role in the development of key innovations for computer assisted medicine.

WORKSHOP AG ONKOLOGIE

Jan. 10, 2016 | Lübeck, Germany

Prof. Andreas Dietz | invited lecture: 'Selektoren für die Therapie des fortgeschrittenen Larynx- , Hypopharynxkarzinoms – Beobachtungen aus der DeLOS-II-Studie'

EUROPEAN ASSOCIATION FOR ENDOSCOPIC SURGERY AND OTHER INTERVENTIONAL TECHNIQUES E.A.E.S. TECHNOLOGY WINTER MEETING

Jan. 22, 2016 | Amsterdam, Netherlands

Prof. Andreas Melzer | program committee; invited lectures: 'Workflow for surgery and intervention', 'Safe patient data management and data mining for the digital patient model'

WORKFLOW WINTER SCHOOL

Jan. 25, 2016 | Innsbruck, Austria

Prof. Thomas Neumuth | invited lecture: 'Surgical workflows at ICCAS'

IDIBELL University Barcelona

Jan. 29, 2016 | Barcelona, Spain

Prof. Andreas Dietz | invited lecture: 'Larynx organ preservation and better patient selection'

SPIE MEDICAL IMAGING CONFERENCE 2016 | 17TH SPIE/IFCARS JOINT WORKSHOP ON INFORMATION MANAGEMENT, SYSTEMS INTEGRATION, STANDARDS AND APPROVAL ISSUES FOR THE DIGITAL OPERATING ROOM

Feb. 27 – March 3rd, 2016| San Diego, CA, USA

Dr. Frank Heckel | lecture: 'Evaluation of image quality of MRI data for brain tumor surgery'
Erik Schreiber |invited lecture: ‚Proposals for IHE integration profiles'

12. DGBMT/FRAUNHOFER/ SMIT SYMPOSIUM 'KRANKENHAUS DER ZUKUNFT' AT THE 46. KONGRESS DER DEUTSCHEN GESELLSCHAFT FÜR ENDOSKOPIE UND BILDGEBENDE VERFAHREN E.V. (DGE-BV)

March 17 – 19, 2016| Mannheim, Rosengarten, Germany

Prof. Andreas Melzer, PD Dr. Thomas Wittenberg | organizing committee members
Richard Bieck | lecture: 'Bild-, Ontologie- und Prozessgestützte Assistenz für die minimal-invasive endoskopische Chirurgie'
Prof. Andreas Dietz | lecture: 'Onco Flow-Ein Beispiel für Computer-assistierte Chirurgie in der Praxis'
Prof. Andreas Melzer | lecture: 'Der digitale OP am Beispiel MRgFUS (TransFusimo), chairman in session: 'DGBMT I'
Prof. Thomas Neumuth | lecture: 'Prozessketten im OP'

KH-IT FRÜHJAHRSTAGUNG

April 07, 2016 | Leipzig

Max Rockstroh and Dr. Armin Will (UKSH Lübeck) | lecture: 'Das Vernetzte Krankenhaus der Zukunft. Perspektiven aus Sicht von Betreibern (und Anwendern)', presentation of ICCAS's ‚Intelligent Operating Room'

SYMPOSIUM MULDENTALKLINIKEN

April 16, 2016 | Grimma, Germany

Prof. Thomas Neumuth | invited lecture: 'Herausforderungen der Chirurgie aus Sicht des Informatikers'

1ST ONTOSPM WORKSHOP

April 28 – 29, 2016 | Rennes, France

Juliane Neumann | invited lecture: 'Ontologies for surgery at ICCAS: Experiences from 2005 to 2015'

87. JAHRESVERSAMMLUNG DER DEUTSCHEN GESELLSCHAFT FÜR HALS-NASEN-OHREN-HEILKUNDE, KOPF- UND HALS-CHIRURGIE E.V.

April 04 – May 07, 2016 | Düsseldorf, Germany

Prof. Andreas Melzer | chairman in session: 'Chirurgische Assistenzverfahren'
Prof. Andreas Dietz | chairman in session: 'Geschäftssitzung der AG Onkologie der DGH-NOKHC'

4TH EHEALTH SUMMIT AUSTRIA

May 24 – 25, 2016 | Vienna, Austria

Jan Gaebel | lecture: 'Accessing patient information for probabilistic patient models using existing standards'
Mario Cypko | invited lecture: 'Clinical decision support in practice: The way from a Bayesian Network to a Clinical Decision Support System for tumor boards'

AMERICAN SOCIETY OF CLINICAL ONCOLOGY ANNUAL MEETING (ASCO 2016)

June 03 – 07, 2016 | Chicago, Il, USA

Prof. Andreas Dietz | invited lecture: 'What's new in head and neck cancer: Key findings in 2015-2016 from ECCO/ESMO'

24TH INTERNATIONAL CONGRESS OF EUROPEAN ASSOCIATION FOR ENDOSCOPIC SURGERY (E.A.E.S.)

June 15 – 18, 2016 | Amsterdam, Netherlands

Prof. Andreas Melzer | contribution from the research area 'Non-invasive Image-guided Interventions'

30TH INTERNATIONAL CONGRESS AND EXHIBITION OF COMPUTER ASSISTED RADIOLOGY AND SURGERY (CARS 2016)

June 21 – 25, 2016 | Heidelberg, Germany

Klemens Birnbaum | lecture and poster: 'Metric Learning for TNM-classifications of patients
with head and neck tumors'
Mario Cypko | lecture: 'Concepts for IHE integration profiles for communication with probabilistic graphical models'
Jan Gaebel | lectures: 'Integrating intelligent agents in form of Arden Syntax for computing instances based fuzziness in patient specific Bayesian Networks',

Yihan Deng | 'Towards summarized treatment guidelines and studies in personalized treatment planning for complex multifactorial diseases'
Prof. Andreas Melzer | lecture: 'Synergism of ultrasound and magnetic resonance imaging in interventional radiology', chair in session: 'Magnetic Resonance Imaging'
Juliane Neumann | 'Ontology-based surgical process modeling by using SNOMED CT concepts and concept model attributes'
Dr. Matthäus Stöhr (UKL) in collaboration with DPM | lecture: 'Development of the digital patient model 'Laryngeal Cancer' to support the decision-making process'

Workshop 'Surgical data science'
Klemens Birnbaum | 'Evaluation of structured learning algorithms for the prediction of clinical workflows'

Young Investigator Networking (YINS) session of the International Society for Computer Aided Surgery (ISCAS)
Mario Cypko | organization

HAMLYN SYMPOSIUM ON MEDICAL ROBOTICS 2016

June 25 – 28, 2016 | London, England

Prof. Andreas Melzer | Program committee; presentation of 'Image guided robotics for positioning of FUS'

9TH INTERNATIONAL CONFERENCE ON HEAD AND NECK CANCER

July 06 – 20, 2016 | Seattle, WA, USA

Prof. Andreas Dietz | Instructional course 'Larynx cancer treatment', Chair for free paper sessions

5TH INTERNATIONAL SYMPOSIUM ON FOCUSED ULTRASOUND

Aug. 28 – Sep. 01, 2016 | Bethesda, MD, USA

Prof. Andreas Melzer | presentation of 'Robotic positioning of FUS in MRI' and 'MR guided FUS for targeted drug delivery'

HEALTH – EXPLORING COMPLEXITY (HEC 2016)

Aug. 28 – Sep. 02, 2106 | Munich, Germany

Marianne Maktabi | lecture: 'Online medical device use prediction: Assessment of accuracy'
Yihan Deng | lecture: 'Patient centered event representation for the treatment of multifactorial diseases: Current progress and challenges'

MENSCH UND COMPUTER 2016

Sep. 07, 2016 | Aachen, Germany

Prof. Thomas Neumuth | invited lecture: 'BIOPASS- Bild-, Ontologie- und Prozess-gestützte Assistenz für die minimal-invasive endoskopische Chirurgie'

7TH EUROPEAN CONGRESS ON HEAD AND NECK ONCOLOGY (ECHNO 2016)

Sep. 07 – 09,2016 | Budapest, Hungary

Prof. Andreas Dietz | invited lecture: 'Immuno Checkpoint Inhibition in HNSCC'

18TH INTERNATIONAL CONFERENCE ON E-HEALTH NETWORKING, APPLICATION AND SERVICES (IEEE HEALTHCOM)

Sep. 14 – 17, 2016 | Munich, Germany

Erik Schreiber | lecture: 'A concept for consistent and prioritized presentation of surgical information'

1ST JOINT WORKSHOP ON OR-INTEGRATION - HYPERSCOT MEETS OR.NET.

Sep. 16 – 17, 2016 | Leipzig, Germany

Lectures and presentations on the current state of the SCOT-project and OR.Net-project and discussion on further cooperation opportunities

7TH WORKSHOP ON ONTOLOGIES AND DATA IN LIFE SCIENCES (ODLS 2016)

Sep. 29 – 30, 2016 | Halle/Saale, Germany

Juliane Neumann | lecture: 'Risk Identification Ontology (RIO): An ontology for specification and identification of perioperative risks'

33RD ANNUAL SCIENTIFIC MEETING OF THE EUROPEAN SOCIETY FOR MAGNETIC RESONANCE IN MEDICINE AND BIOLOGY (ESMRMB)

Sep. 29 – Oct. 1, 2016 | Vienna, Austria

Prof. Andreas Melzer | co author: 'Modeling and Simulation of FUS for Moving Organs'

15TH ANNUAL CONFERENCE OF THE GERMAN SOCIETY FOR COMPUTER AND ROBOTIC ASSISTED SURGERY E.V. (CURAC)

Sep. 29 – Oct. 1, 2016 | Bern, Switzerland

Dr. Frank Heckel | lecture: 'Influence of image quality on semi-automatic 3D reconstructions of the lateral skull base for cochlear implantation'
Jan Gaebel | lecture: 'Medical logic modules for monitoring the diagnostic delay in the treatment of laryngeal cancer'
Prof. Thomas Neumuth | session chair: 'Human Machine Interfaces'

CONFERENCE OF THE SWISS, AUSTRIAN AND GERMAN SOCIETIES OF BIOMEDICAL ENGINEERING (BMT 2016)

Oct. 04 – 06, 2016 |Basel, Switzerland

Prof. Andreas Melzer | leadership of the expert committees: 'Medical Technology in MRT' and 'Ultrasound'
ICCAS focus session 'Computer-Assisted Procedures'
Dr. Frank Heckel | lecture: 'A service for monitoring the quality of intraoperative cone beam CT images'
Michael Unger | lecture: 'Automatic depth scanning system for 3D infrared thermography'

28TH CONFERENCE OF THE INTERNATIONAL SOCIETY FOR MEDICAL INNOVATION AND TECHNOLOGY (SMIT 2016)

Oct. 05 – 08, 2016 | Delft, Netherlands

Special session 'Intelligent Operating Room'
Richard Bieck | lecture: 'Situation-based extraction of medical device activity for adaptive or task management'
Stefan Franke | lecture: 'Context-aware medical assistance systems in integrated surgical environments'
Juliane Neumann | lecture: 'Ontology-based instrument classification for workflow-driven surgical assistance in the intelligent operating room'
Erik Schreiber | lecture: 'Intraoperative process model generation using XMS and ISO/IEE 11073'

11TH INTERVENTIONAL MRI SYMPOSIUM

Oct. 07 – 08, 2016 | Baltimore, MD, USA

Prof. Andreas Melzer | keynote lecture on 'MR-guided focused ultrasound'; presentation of 'New MRI interventional Coil DuoFlex' and 'MRI safe Guide Wires'

19TH INTERNATIONAL CONFERENCE ON MEDICAL IMAGE COMPUTING AND COMPUTER ASSISTED INTERVENTION (MICCAI 2016)

Oct. 17 – 21, 2016 |Athens, Greece

M2CAI Workshop
Stefan Franke | presentation: 'Towards the intelligent OR- Implementation of distributed, context-aware automation in an integrated surgical working'
Juliane Neumann | lecture: BPMNSIX – A BPMN 2.0 Surgical Intervention Extension'

15TH WORLD CONGRESS OF ENDOSCOPIC SURGERY (WCES 2016)

Nov. 09 – 12, 2016 | Shanghai-Suzhou, China

Prof. Andreas Melzer | invited lecture: 'Non-invasive surgery by image guided focused ultrasound'

102ND SCIENTIFIC ASSEMBLY AND ANNUAL MEETING OF THE RADIOLOGICAL SOCIETY OF NORTH AMERICA (RSNA 2016)

Nov. 27 – Dec. 01, 2016 | Chicago, IL, USA

Prof. Andreas Melzer | presentation of 'New MRI interventional Coil DuoFlex' and 'MRI safe Guide Wires'

SYMPOSIUM MEDIZINTECHNIK

Dec. 08, 2016 | Leipzig, Germany

Max Rockstroh | lecture: 'Verbundprojekt OR.NET – sichere und dynamische Vernetzung in Operationssaal und Klinik'

EXHIBITIONS

In 2016, ICCAS showcased itself at prominent trade fairs and exhibitions throughout Germany.

LEIPZIG INTERVENTIONAL COURSE (LINC 2016)

Jan. 26 – 29, 2016| Leipzig, Germany

Presentation of the exhibits ‘CephaLens’ and ‘Digital Patient Model’

BUNDESKONGRESS CHIRURGIE

Feb. 26 – 28, 2016| Nuremberg, Germany

Presentation of the exhibits ‘CephaLens’ and ‘Digital Patient Model’

CONHIT 2016

April 19 – 21, 2016 | Berlin, Germany

Exhibit stand with final results of the project ‘Secure and dynamic networking in the operating room - OR.Net’

133. KONGRESS DER DEUTSCHEN GESELLSCHAFT FÜR CHIRURGIE

April 26 – 29, 2016 | Berlin, Germany

Presentation of the exhibits ‘CephaLens’ and ‘Digital Patient Model’, user survey on the ‘Digital Patient Model’

97. DEUTSCHER RÖNTGEN KONGRESS

May 04 – 07, 2016 | Leipzig, Germany

Presentation of the exhibit ‘CephaLens’ and of results from the research area ‘Noninvasive Image-guided Interventions’

MEDICA 2016 – THE WORLD FORUM FOR MEDICINE

Nov. 14 – 17, 2016 | Düsseldorf, Germany

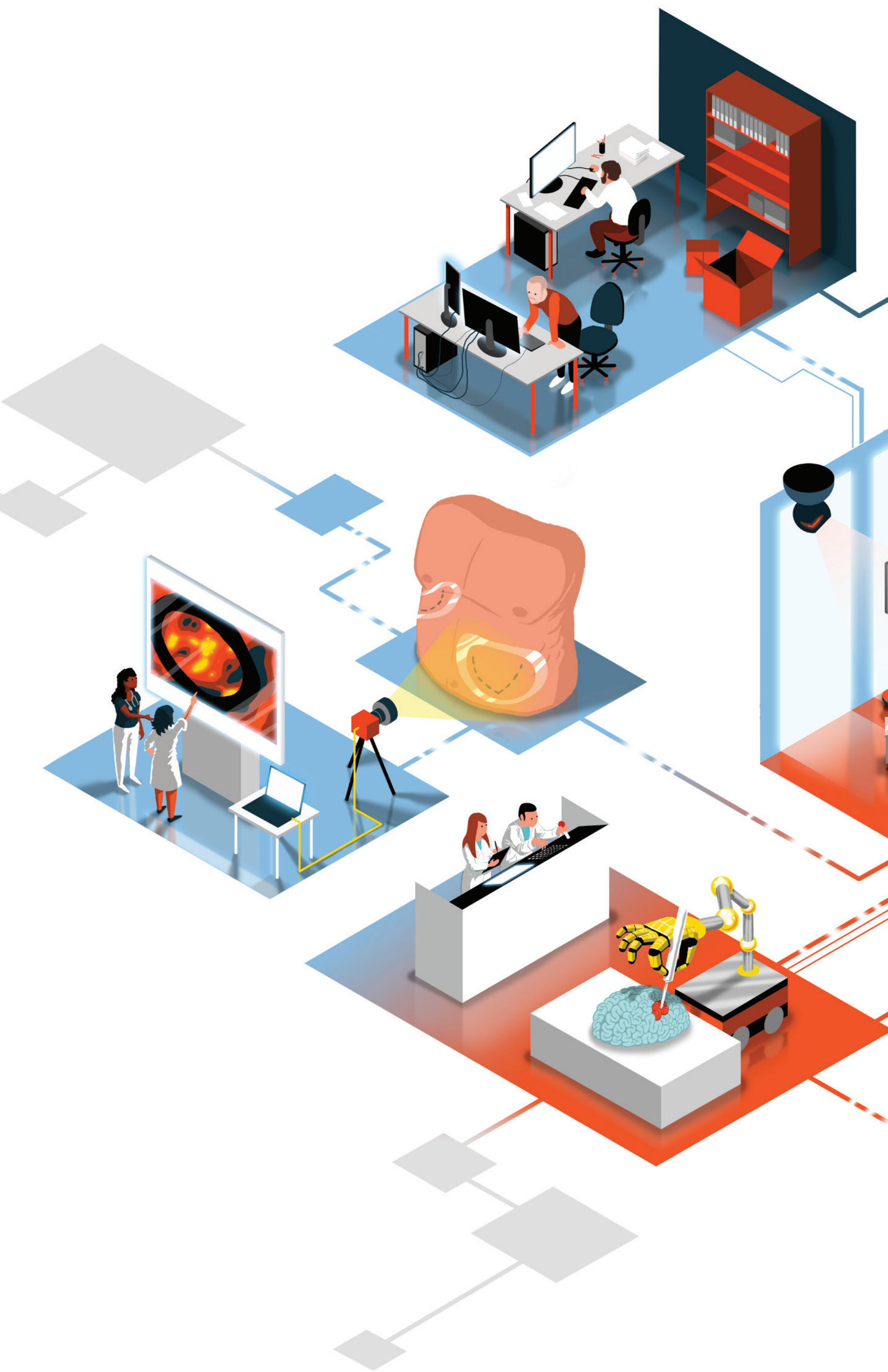
Presentation of the ‘Intelligent Operating Room’

COMPAMED 2016

Nov. 14 – 17, 2016 | Düsseldorf, Germany

Prof. Andreas Melzer | invited lecture: ‚MR-taugliche Führungsdrähte und Thrombektomiesysteme‘

RESEARCH AREAS AND RELATED PROJECT PROFILES

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MODEL-BASED AUTOMATION AND INTEGRATION

'Excellent patient care by integration'

INTRODUCTION

For the MAI research area of ICCAS the year 2016 was a year of change. Two major challenges, the BMBF-funded projects 'Systems technology for the surgical cockpit' and 'OR.NET – Secure and dynamic networking in the operating room' were finished successfully. As outstanding result, ICCAS presented the world's first integrated operating room with vendor independent device networking and integrated workflow management support.

Beyond the research activities, the MAI group was an international pacemaker in developing new approaches for model-based therapies, medical device networks and surgical workflow management. The group was involved in organizing numerous international workshops and conference events all over the world, such as the Workflow Winter School in Innsbruck, the Surgical Data Science Workshop in Heidelberg, the M2CAI-Workshop at MICCAI in Athens, and the Digital Operating Room Summer School (DORS) in Leipzig.

SCIENTIFIC STAFF

Marianne Maktabi, Florian G. Hermes, Juliane Neumann, Stefan Franke, Thomas Neumuth (group leader), Richard Bieck, Lisa-Marie Kunz, Gero Kraus, Marlen Ristola, Klemens Birnbaum, Reinhard Fuchs (f.l.t.r.)

SELECTED PUBLICATIONS

Rockstroh M, Wittig M, Franke S, Meixensberger J, Neumuth T. Video-based detection of device interaction in the operating room. Biomed Tech. 2016; 61(5): 567-76.

Franke S, Neumuth T. Rule-based medical device adaptation for the digital operating room. Conf Proc IEEE Eng Med Biol Soc. 2015; 1733-6.

Glaser B, Schellenberg T, Koch L, Hofer M, Modemann S, Dubach P, Neumuth T. Design and evaluation of an interactive training system for scrub nurses. Int J Comput Assist Radiol Surg. 2016; 11(8): 1527-36.

CONTEXT-AWARE TECHNICAL ASSISTANCE IN INTEGRATED SURGICAL WORKING ENVIRONMENTS

INTRODUCTION

In integrated ORs, devices provide standardized communication interfaces. However, they still show very limited cooperative behavior, especially with the surgical team. To implement an intelligent behavior, devices need to be aware of its actual application context. We implemented a context-aware assistance, which combines device interoperability, surgical workflow tracking, and behavioral rule sets to establish a surgical working environment that autonomously cooperates with the surgical team.

MATERIAL AND METHODS

In the ICCAS Demonstrator OR, in which the context-aware assistance was implemented, device communication is based on IEEE 11073 standards developed in the OR.Net project. A pipeline for context-awareness was realized. First, the surgical process had to be modelled in multiple perspectives to establish a comprehensive network of process models. The intraoperative processing is then triggered by workflow recognition data, especially device states, tracking and instrument usage. Next, a rule-based approach allowed deriving the actual work step. Based upon that, the model network is continuously evaluated to generate hierarchically structured contextual information. Finally, medical devices may process the contextual information to adapt themselves based on behavioral rules.

RESULTS

A set of assistance functionalities was implemented for Functional Endoscopic Sinus Surgery (FESS), which included the automated switching of the primary display, the adaptation of ambient light conditions, as well as the parameterization of the medical devices. Automated screenshots were generated to assist the documentation. Additionally, situation-dependent configuration profiles were proposed to ease complex configuration tasks. A validation study was conducted with twenty-four FESS procedures on phantoms. The setup is depicted in figure 1.

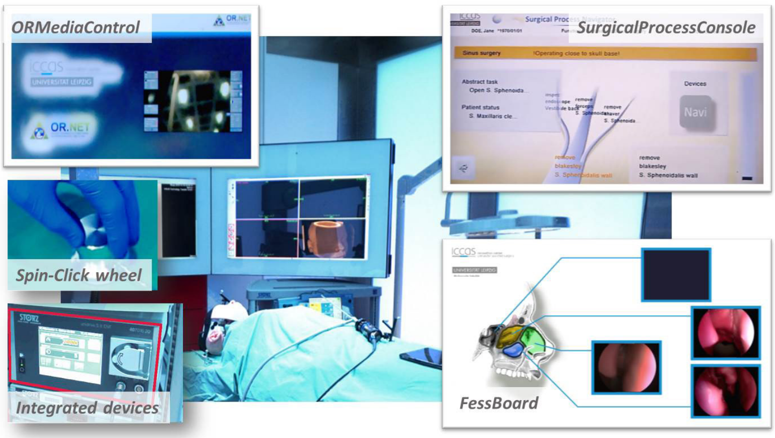

Fig. 1- The demonstration setup at ICCAS with display switching component (ORMediaControl), integrated spin-click-wheel for user interaction, integrated surgical pump and shaver, centralized control console (SurgicalProcessConsole) and documentation tool (FessBoard).

DISCUSSION AND CONCLUSION

The implemented assistance for ENT surgery is designed to optimally support the OR team by (semi-) automatic adaptations and context-aware information provision. The setup demonstrates the feasibility of the approach for context-aware assistance in integrated surgical environments.

PROJECT TEAM

Dipl.-Inf. Stefan Franke

Dipl.-Inf. Max Rockstroh

Prof. Dr. Thomas Neumuth

SELECTED PUBLICATIONS

Franke S, Rockstroh M, Schreiber E, Neumann J, Neumuth T. Context-aware medical assistance systems in integrated surgical environments. Proc of the 28th Conference of the international Society for Medical Innovation and Technology (SMIT). Delft, Netherlands; 2016.

Franke S, Rockstroh M, Schreiber E, Neumann J, Neumuth T. Towards the intelligent OR- Implementation of distributed, context-aware automation in an integrated surgical working environment. 19th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI), M2CAI. Athens, Greek; 2016.

Franke S, Meixensberger J, Neumuth T. Multi-perspective workflow modeling for online surgical situation models. J Biomed Inform. 2015; 54: 158-66.

Franke S, Neumuth T. Rule-based medical device adaptation for the digital operating room. Proc. of 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society. Milano, Italy. IEEE. 2015; 1733—1736.

Franke S, Neumuth T. Towards structuring contextual information for workflow-driven surgical assistance functionalities. 49th Annual conference of the German Society for Biomedical Engineering (DGBMT); Lübeck; 2015.

FUNDING

German Federal Ministry of Education and Research (BMBF)

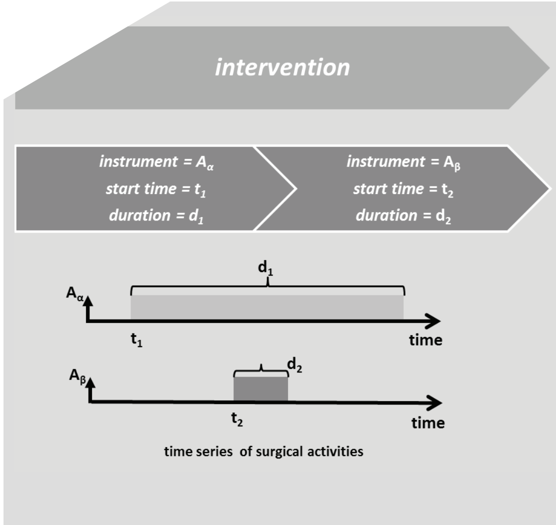

Fig. 1- Applied surgical activity information to generate time sequences.

ONLINE TIME AND RESOURCE MANAGEMENT BASED ON SURGICAL WORKFLOW TIME SERIES ANALYSIS

INTRODUCTION

Hospitals' economy can be improved by automating the resource and time management of the most cost-intensive unit in the hospital: the operating room (OR). The crucial parts required for the excellent organization of hospital staff and technical equipment (such as devices in the OR) are an accurate online forecast of both the surgeon's resource usage and the remaining intervention time.

MATERIAL AND METHODS

We present a novel online approach relying on signal analysis and the application of signal processing. Firstly, we transformed surgical recordings into rectangular time series (Fig. 1). The surgical recordings are presented as surgical activity sequences. We used information of the surgical activity describing either the instrument used or the use of the surgeon's right hand and the time information to transform to rectangular time series. To compare the several time sequences of the workflows we calculated the power spectral density and the spectrogram of surgical sequences (e.g. used instrument) of interest.

RESULTS

We predicted the remaining intervention time online with an error of 21 min 45 s ± 9 min 59 s for lumbar discectomy. We considered only the use of the surgeon's right hand during an intervention. Furthermore, the quality of forecasting of technical equipment usage in the next 20 min was calculated from a combination of spectral analysis and the application of a linear time variant system (sensitivity: 74%: specificity: 75%) focusing on the use of surgeon's instrument in question.

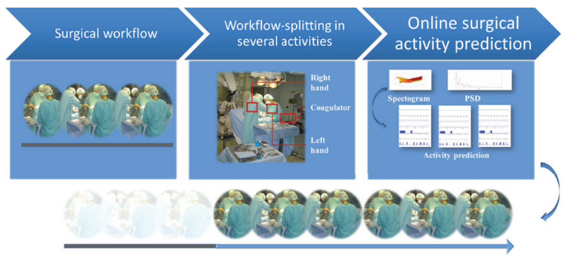

Fig. 2- Pipeline of applied methods to predict device usage and remaining intervention time.

DISCUSSION AND CONCLUSION

The outstanding benefit of these methods is that the automated recording of surgical workflows has minimal impact during interventions since the whole set of surgical perspectives need not be recorded. Besides, technical resource usage can be predicted over multiple defined time spans. The resulting predictions can help various stakeholders, e.g. OR staff and hospital technicians.

PROJECT TEAM

Dipl-Ing. Marianne Maktabi

Prof. Dr. Thomas Neumuth

SELECTED PUBLICATIONS

Maktabi M, Neumuth T. Online time and resource management based on surgical workflow time series analysis. International journal of computer assisted radiology and surgery, 2016.

Maktabi M, Neumuth T. Device Use Prediction: Assessment of Accuracy. Studies in health technology and informatics. 2016; 228: 557–61..

FUNDING

German Federal Ministry of Education and Research (BMBF)

OR.NET – SECURE AND DYNAMIC NETWORKING IN THE OPERATING ROOM

INTRODUCTION

The German flagship project focuses on networking medical devices and IT systems in the operating room and clinic. About 50 partners and 50 associated partners are involved, including manufacturers of integrated operating rooms, medical devices and medical IT systems as well as research institutes and clinical partners. The project is divided into six subprojects each tackling different aspects of secure, dynamic networking in a medical environment.

MATERIAL AND METHODS

In addition to defining the required communication architecture, programming interfaces, and implementing the interfaces to medical devices in Subproject 2, the project also addresses issues of regulatory approval and risk management (Subproject 3), the standardization of data models and interfaces (Subproject 4), and the implementability in hospitals (Subproject 5). The holistic project was completed by demonstrators presenting the features as well as a technical and clinical evaluation (Subproject 6, managed by ICCAS). Overall, five demonstrators focusing on different technical aspects and clinical applications were established. The ICCAS demonstrator deals with all the technical and clinical aspects of the project involving clinical use cases of head and neck surgery. Additionally, we explored the use of workflow management technologies in order to support the intraoperative process. Workflow management tracks the current situation based on the data provided by medical equipment and information systems via the open surgical communication protocol (OSCP) developed in Subproject 2 and provides workflow-driven adaptation features. During different evaluation studies, our clinical partners had the opportunity to perform simulated interventions on a patient phantom and to use the developed technologies in a realistic scenario. In a second evaluation, we conducted a questionnaire study with various clinic operators.

Fig. 1- Current state of the integrated operating theater at ICCAS including communication technologies based on the OR.NET project during the evaluation study with Dr. Mathias Hofer.

DISCUSSION AND CONCLUSION

The feedback from the clinicians and operators was very positive, regarding both the implementation of the OR integration as well as the assistance functionalities. Some of the identified problems (i.e. high latency) could be solved during the course of the studies in cooperation with the project partners. The OR.NET project is a significant contribution to vendor-independent OR integration based on open standards. The ICCAS demonstrator illustrates the opportunities for implementing novel assistance features for the digital operating room.

PROJECT TEAM

Dipl.-Inf. Max Rockstroh

Dipl.-Inf. Stefan Franke

M.Sc. Erik Schreiber

B. Sc. Gero Kraus

B. Sc. Christoph Georgi

PROJECT PARTNERS

Karl Storz GmbH & Co. KG

Richard Wolf GmbH

SurgiTAIX AG

Inomed Medizintechnik GmbH, Research and Development

Localite GmbH

KLS Martin

Group Möller-Wedel GmbH ImageNET (R&D)

Ziehm Imaging GmbH

Söring GmbH

UTK – UniTransferKlinik GmbH

Synagon GmbH

MedPlan Engineering GmbH

MT2IT GmbH & Co. KG

Software und IT-Lösungen für Vernetzung:

MEDNOVO Medical Software Solutions GmbH

how to organize

VISUS Technology Transfer GmbH/ R & D

Fraunhofer-Institut MEVIS

Fraunhofer-Institut FOKUS

Technische Universität München, Lehrstuhl für Mikrotechnik und Medizingerätetechnik

ITM – Institut für Telematik, Universität zu Lübeck

ISP-Institut für Softwaretechnik und Programmiersprachen, Universität zu Lübeck

ICCAS – Innovation Center Comupter Assisted Surgery, Universität Leipzig

MedIT – Lehrstuhl für Medizinische Informationstechnik, RWTH Aachen

mediTEC – Lehrstuhl für Medizintechnik, RWTH Aachen

OFFIS – Institut für Informatik e.V. / FuE-Bereich Gesundheit

Institut für Angewandte Mikroelektronik und Datentechnik, Universität Rostock

Institut für Medizinische Informatik, Universität zu Lübeck

Universitätsklinikum RWTH Aachen, Integrierte Teleanästhesiologie

Technische Universität München, Lehrstuhl für Automatisierung und Informationssysteme

Technische Universität München, Institut für Informatik, Robotics and Embedded Systems

Technische Universität München, MITI, Minimal-invasive Interdisziplinäre Therapeutische Intervention

Universität Augsburg, FMPR, Forschungsstelle für Medizinprodukterecht

Uniklinik Tübingen, Universitätsklinik für Urologie, Frauenklinik und Radiologie

Klinikum Rostock Anästhesie, Klinik für Anästhesiologie und Intensivmedizin

Uniklinik Schleswig-Holstein, Klinik für Chirurgie

Universitätsklinikum Heidelberg

Klinik für Chirurgie

Klinik für Radiologie

Klinik Mund- ,Kiefer- und Gesichtschirurgie

Uniklinikum der RWTH Aachen

FUNDING

German Federal Ministry of Education and Research (BMBF)

INFORMATION QUALITY ASSURANCE IN THE NETWORKED OPERATING ROOM

INTRODUCTION

Intraoperative imaging such as cone beam computed tomography (CBCT) guides the surgeon during an intervention, so he or she is able to create a preoperative plan aiming for the best possible outcome. In recent years, operating rooms have transformed from a collection of independent medical devices into interconnected digital (integrated) operating rooms, where devices are able to communicate, exchange data, or control each other. Despite this trend, image data processing is commonly done by dedicated workstations, like navigation systems. We propose a concept for dynamic service components for image data processing on the example of automatic image quality assessment (AQUA) of intraoperative CBCT images. The service has been implemented using the Open Surgical Communication Protocol (OSCP) and DICOM.

MATERIAL AND METHODS

We tested four image quality characteristics: the resolution, the signal-to-noise ratio, a generic quality index, and the amount of metal artifacts. The results were combined into an overall rating using a voting mechanism. The rating was visualized by an intuitive traffic sign pictogram (see figure 1). The communication between the devices is shown in figure 2. The analysis is initiated as soon as the image data becomes available to the AQUA service. Finally, the results of the analysis are sent to other devices using OSCP so they can be shown on a central or mobile display for example.

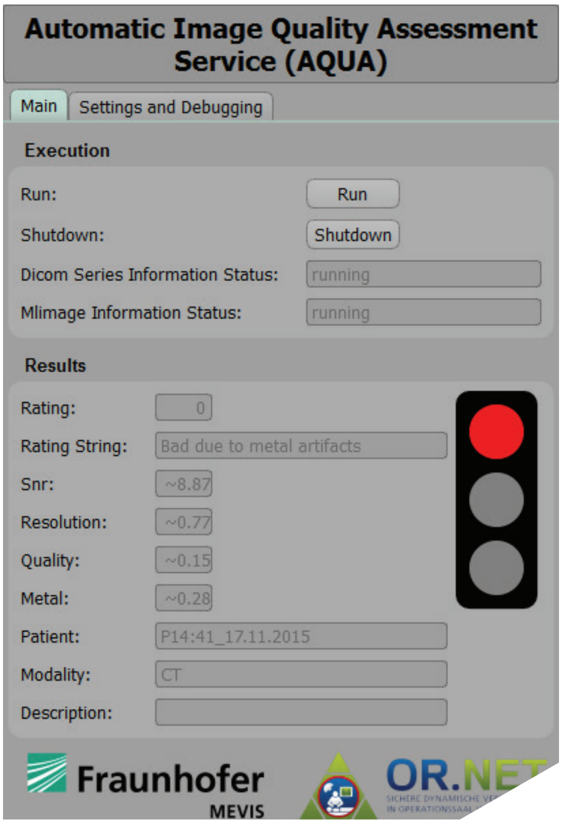

Fig. 1- Graphical user interface of the AQUA component.

RESULTS

We have validated our prototypical implementation as part of a demonstrator operating room. For image quality assessment, three exemplary 3D images of a head phantom were provided: a high-quality image, a reconstruction with suboptimal signal-to-noise ratio, and an image with metal artifacts. The AQUA service was able to distinguish between these images and it correctly returned the reason for bad image quality. The overall time required by the processing pipeline was about one minute.

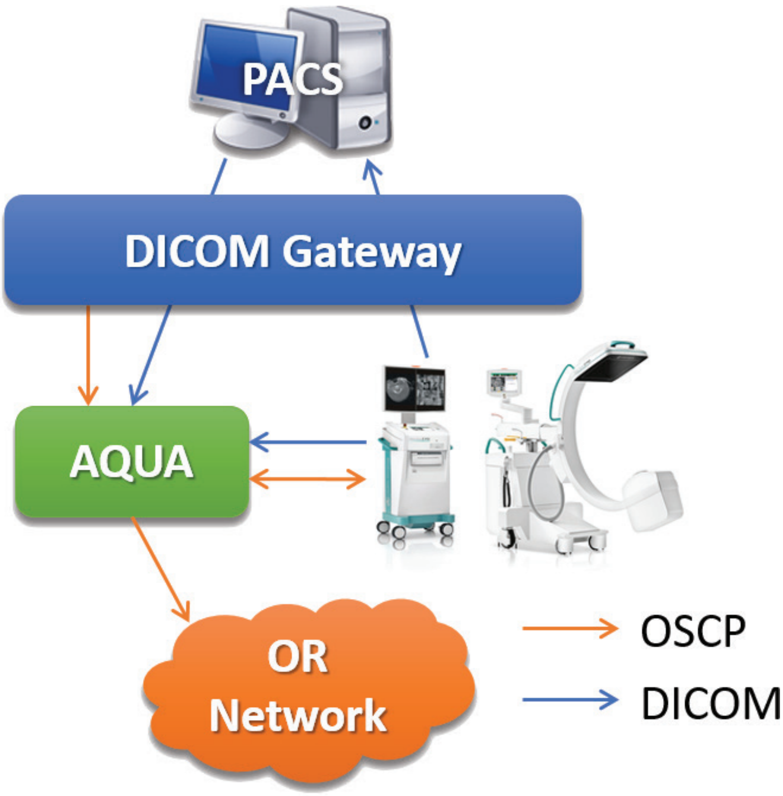

Fig. 2- Communication of the devices in the CBCT setting.

DISCUSSION AND CONCLUSION

We presented a concept for implementing a dynamic service component for image processing in an integrated OR using standardized and open protocols. Image processing services can run on any device that can be dynamically added and removed from the network. The AQUA service provides a monitoring component that is able to permanently review the quality of intraoperatively acquired images. One central application is found in navigated interventions, where high accuracy is required but limited by image quality. Another use-case is surgery documentation, where low-quality images could automatically be tagged or excluded.

PROJECT TEAM

Dr. Frank Heckel

Dipl.-Inf. Max Rockstroh

PROJECT PARTNERS

Hanna Rotermund, Ziehm Imaging GmbH

Stephan Zidowitz, Fraunhofer Institute for Medical Image Computing MEVIS

Dr. Mathias Hofer, Leipzig University Hospital, Department of ENT

SELECTED PUBLICATIONS

Heckel F, Schlamelcher J, Rotermund H, Rockstroh M, Zidowitz S, Neumuth T. A service for monitoring the quality of intraoperative cone beam CT images. Current Directions in Biomedical Engineering. 2016; 2(1): 373-377.

Heckel F, Zidowitz S, Neumuth T, Tittmann M, Pirlich M, Hofer M. Influence of Image Quality on Semi-Automatic 3D Reconstructions of the Lateral Skull Base for Cochlear Implantation. Proceedings of Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC). 2016.

Heckel F, Arlt F, Geisler B, Zidowitz S, Neumuth T. Evaluation of Image Quality of MRI Data for Brain Tumor Surgery Proceedings of SPIE Medical Imaging: Image Perception, Observer Performance, and Technology Assessment. 2016.

FUNDING

German Federal Ministry of Education and Research (BMBF)

BIOPASS – IMAGE-, ONTOLOGY- AND PROCESS-BASED ASSISTANCE FOR MINIMALLY INVASIVE ENDOSCOPIC SURGERY

INTRODUCTION

Navigation systems based on optical tracking are an essential component in minimally-invasive surgery. However, these assisting systems require additional hardware in the operating room and can only poorly adapt to the surgical skills and the anatomical knowledge. In the BIOPASS project, a novel localization approach for a markerless navigation system is developed that potentially reduces the navigation hardware while assisting the surgeon's cognition with self-learning and adaptive assistance functions. Critical aspects for the development of such an intelligent system are the surgeon's ambiguous perception of adaptive system behavior and information presentation. As a consequence, the primary goals of the BIOPASS project are the definition of clearer human-machine-interaction (HMI) requirements for adaptive systems in the OR and the development of a corresponding presentation model of surgery-related situational information needed by the surgeon. As a result, current work steps comprise studies for knowledge representation of situational information in a functional endoscopic sinus surgery (FESS) and intraoperative information presentation in a preliminary mock-up demonstrator.

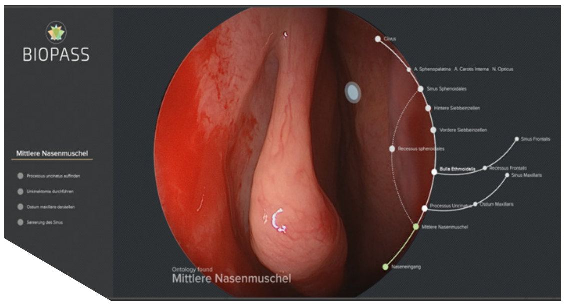

Fig. 1 - Concept design for the navigation system interface with different aspects of the analyzed surgical situation information.

MATERIAL AND METHODS

An online survey with ENT surgeons was conducted to identify key aspects of the HMI for an intelligent navigation system. Standard questions were used to group surgeons according to their experience, context-related questions involved information for corresponding FESS procedure phases as well as the preferred form of presentation (audible or visible) and respective complexity. Additionally, relevant context-sensitive questions to be answered by a responsive navigation system had to be selected.

In a second study, a mock-up demonstrator was implemented to simulate the ideal navigation process performed with an intelligent navigation system. We expect that early functionality and interaction assessment is a necessary starting point for the development of evaluation strategies for adaptive medical systems. A Localite Navigator (Localite GmbH, St. Augustin) tracks the endoscope position in specifically manufactured FESS phantoms of type ‘Müller’ (PHACON GmbH, Leipzig). Text-based information, naming the apparent visible anatomical landmarks, was displayed in the endoscopic view. Additionally, audible feedback in form of a short signal followed by the apparent anatomical landmark was added.

RESULTS

Over 80 % of surveyed surgeons (between 1 and 28 (9.14) years of experience) stated that more intelligent behavior of navigation systems would be vital. All respondents would ask an intelligent system about the current endoscope position. 70 % would ask about which work steps are still missing. 57 % of the respondent would expect audible & visible presentations as a mixture of anatomical models and complex sounds. 70 % of the respondents believed that a new navigation system needs to be easy-to-use and predictable. Over 55 % stated that the audio response was helpful but unpleasant, while displayed visual information was helpful and pleasant. Over 60 % of the respondent wanted to know the source of the presented information.

DISCUSSION AND CONCLUSION

Since there is little information on the evaluation of intelligent adaptive assistance systems in the operating room, the studies provided first insights on the stakeholder situation, challenges and potential concept pitfalls. The combination of audible and visible feedback was supported but needs sophisticated adjustment. Audio responses should be limited to singular distinct statements either for error or risk indication. More specifically, relevant information should be presented closer to the focus point of the surgeon.

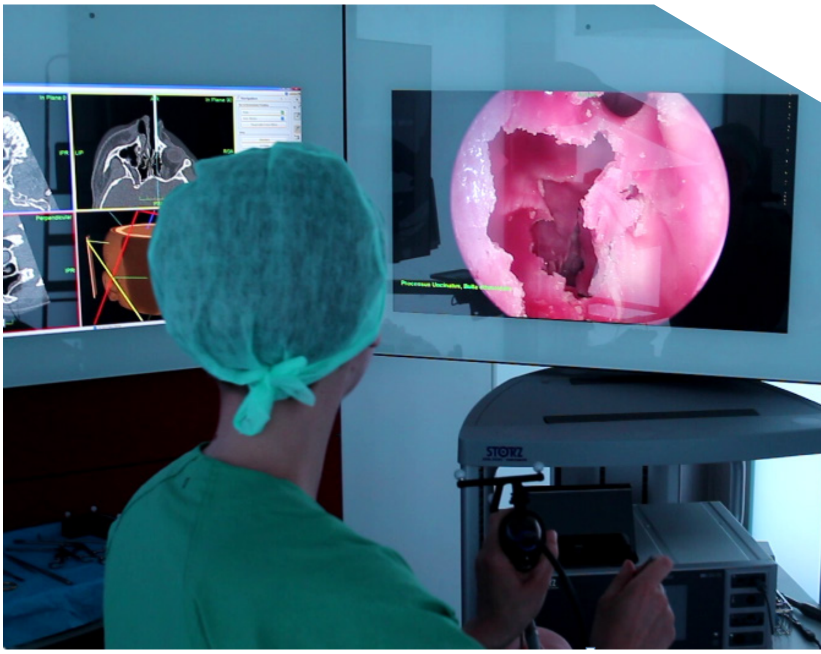

Fig. 2 - First demonstrator setup and evaluation with experts of the ENT department of the Leipzig University Hospital.

We introduced a project with a novel localization approach for the markerless surgical navigation in minimally-invasive endoscopic ENT surgery. The system under development uses the concept of situation awareness to learn new surgical situations from endoscopic images and surgical procedure information. The performance of such an intelligent system highly depends on the surgeon’s needs. With the introduction of early interaction and information presentation studies, the aim is to generate an internal representation of the user’s cognition process in the navigation system.

PROJECT TEAM

M.Sc. Richard Bieck

Prof. Dr. Thomas Neumuth

PROJECT PARTNERS

Katharina Heuermann, Department for ENT, Leipzig UNiversity Hospital

Prof. Dr. Heinrich Herre, Leipzig University, Institute for Medical Informatics, Statistics and Epidemiology (IMISE)

Dr. Stefan Zachow, Zuse Institute for Information Technology

Prof. Dr. Hubertus Feussner and Dr. Sebastian Koller, Munich Technical University & Klinikum rechts der Isar Munich, Minimally-invasive Interdisciplinary Therapy Interventions (MITI) & Minimally-invasive Interdisciplinary Therapy Interventions (MITI) Institute and Visceral Interventions Department

STORZ GmbH & Co. KG (associated Partner)

SELECTED PUBLICATIONS

Bieck R, Heuermann K, Schmidt M, Schmitgen A, Arnold S, Dietz A, Neumuth T. Towards an Information Presentation Model of a Situation-Aware Navigation System in Functional Endoscopic Sinus Surgery. 15th CURAC Annual Conference. Bern, Switzerland. 2016.

FUNDING

German Federal Ministry of Education and Research (BMBF)

EYE TRACKING INTERACTION IN A STERILE ENVIRONMENT WITH AUDITORY DISPLAY AS SECONDARY FEEDBACK

INTRODUCTION

With the increasing number of computer systems available in today's operating rooms, both clinicians and assistants are exposed to a growing array of interaction possibilities in both pre-interventional and intraoperative phases.

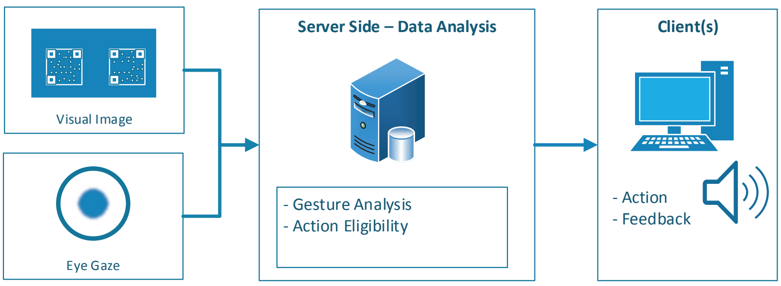

Fig. 1-The prototypical system consisting of eye tracking glasses, a server to process the data and clients running software to evaluate typical use cases.

To prevent an increasing risk of bacterial contamination, new touchless interaction techniques are necessary. Although gesture-based interaction technologies such as the Microsoft Kinect or Leap Motion are feasible, they disrupt user workflow. Eye tracking has been used to improve laparoscopic surgery training and to position the camera during laparoscopic surgery. Although eye tracking interaction shows great potential for employment in sterile environments, they, along with other touchless interaction concepts, only provide primary visual feedback, abandoning the secondary feedback usually provided by haptic interaction with a button, knob, or other physical interaction device.

This work investigates the benefits of both eye tracking as an input concept for sterile operating room interaction and the effect of the addition of auditory display as a secondary feedback mechanism.

MATERIAL AND METHODS

We developed a system consisting of eye tracking glasses, a server, a client, an auditory display system, and custom software. The prototypical system setup is depicted in Fig. 1.

The SMI eye tracking glasses are connected to the server via USB. The glasses consist of a visual camera to capture the view of the user and two infrared cameras to monitor the pupils to calculate the point of regard. A client computer, connected via ethernet to the server, runs software written to evaluate typical use cases. The auditory display system provides so-called earcons and parameter-mapping synthesis mechanisms as a secondary feedback for the user.

Three different use cases were evaluated in an intraoperative scenario in the Demonstrator - OR of ICCAS.

RESULTS

The system has an overall mean precision of 0.98. The precision is higher when providing auditory feedback. The times needed to complete a task are significantly lower when providing auditory feedback.

DISCUSSION AND CONCLUSION

Eye tracking can be used as a sterile interaction technique. Adding an auditory display as a secondary feedback improves the usability and acceptance of the system.

PROJECT TEAM

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PROJECT PARTNERS

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FUNDING

German Federal Ministry of Education and Research (BMBF)

STRUCTURED ANALYSIS OF SCRUB NURSE INSTRUMENT TABLE SETUP SIMILARITIES

INTRODUCTION

Standardization of surgical processes is a topic which has gained recognition as a means to not only streamline the surgical intervention itself, but also to contribute to safety in the operating room by providing a basic framework for day-to-day routine. While the standardization of the surgical intervention is mainly targeted from the surgeon's point of view, many details in the collaboration of the surgical team have only been sparsely analyzed so far. This applies to the role of the scrub nurse, and in particular to the involved instrument table. Currently, there are very few publications available about the strategic setup of the surgical instrument table and the analysis of the usage of surgical instrument trays.

MATERIAL AND METHODS

The presented project aims to close one of the gaps in current literature by performing a structured analysis and comparison of setups of surgical instrument tables. A similarity index is developed to determine the differences of the setups between different groups of scrub nurses from multiple clinics in Germany and Switzerland. The study makes use of the previously developed Nosco Trainer, an interactive training system for surgical scrub nurses (Fig. 1). This system allows not only for the simulation of the course of a surgical intervention, but also for the accurate detection of the state of a simulated surgical instrument table, which is displayed using an interactive touchscreen system.

Fig. 1- The Nosco Trainer – An interactive training environment for scrub nurses.

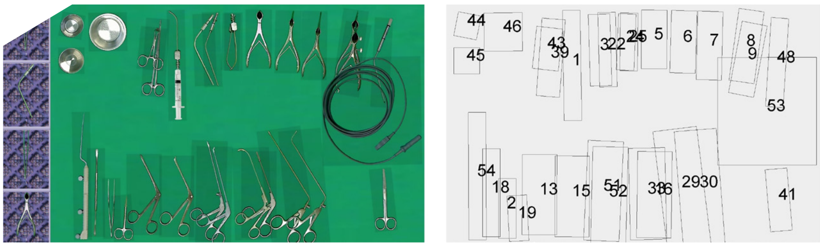

Fig. 2- Screenshot of an example instrument table with the associated schematic information gathered by the interactive table of the Nosco Trainer.

RESULTS

A metric was developed to compare surgical instrument tables based on collected position data of individual instruments. Figure 2 shows an exemplary setup state of the instrument table along with the schematic representation used for the similarity metric. Preliminary results indicate common aspects for scrub nurses working in the same operating room.

DISCUSSION AND CONCLUSION

The structured analysis of the surgical instrument table is a step towards standardization of surgical interventions based on data analysis. The results can be used to improve the intra-operative interaction of surgeon and scrub nurse. Furthermore, the composition of surgical trays can be optimized. Insights can also be gained for the further development of scrub nurse training scenarios.

PROJECT TEAM

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PROJECT PARTNERS

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FUNDING

German Federal Ministry of Education and Research (BMBF)

ONCOCONTROL – WEB-BASED AND MULTIDISCIPLINARY CLINICAL DECISION SUPPORT SYSTEM FOR COMPUTER ASSISTED TUMOR DIAGNOSIS AND TREATMENT PROCESSES

INTRODUCTION

The multidisciplinary treatment of patients in head-and-neck tumor therapy is a challenging task for the clinicians involved due to the huge amount of information available. This information stems from diagnostic methods such as patient history, blood count and biopsy results as well as medical imaging techniques like computed tomography (CT), magnetic resonance imaging (MRI) and positron emission tomography (PET). In order to support the clinicians, these complex information entities must be processed in a meaningful way. The project oncocontrol is the realization of a web-based system which is intended to support the head and neck oncology, for the exploration, analysis and management of patient data.

MATERIAL AND METHODS

Oncocontrol is based on Ruby on Rails, a sophisticated web application framework and a MySQL database. Furthermore, we have also implemented an interface to the local hospital information system for the continuous transfer of patient data between both systems.

RESULTS

The developed clinical information system oncocontrol allows the physician to get all information about existing patients in a consistent and structured way as well as to retrieve clinical documents such as medical reports or surgery reports. Furthermore, oncocontrol allows the clinicians to create and make use of existing information for clinical trials, quality management or conducting clinical certifications. Building on the established central database innovative and knowledge-based methods will assist the clinicians, for example, for the TNM classification or document generation in the diagnosis, treatment strategy, documentation, as well as presentation and patient education. Thus the clinical practice and the communication between professionals is facilitated. The use of automated procedures potentially paves the way for standardized procedures and comparable analysis results.

DISCUSSION AND CONCLUSION

The central idea in developing oncocontrol was the improvement of the oncological therapy decision-making processes in the field of complex head and neck tumors. This improves existing work and treatment processes and furthermore, supports the decision-making process in the tumor board through the use of endoscopy images and 3D tumor reconstructions alongside the current unused slice images from CT and MRI.

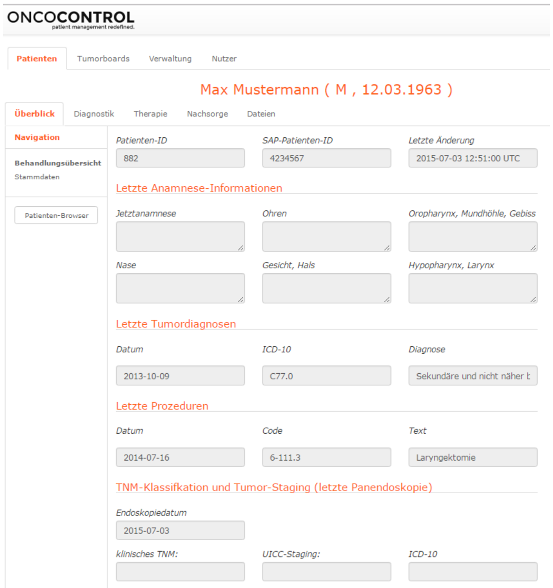

Fig. 1- The oncocontrol system – Relevant information regarding the therapy of the patient is shown in a structured overview

Additionally, a new and innovative form of presentation, the 'treatment summary', supports the clinicians after opening the patient file with a compressed representation of all relevant information in the current treatment step and provides a quick overview of the patient status.

PROJECT TEAM

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PROJECT PARTNERS

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SELECTED PUBLICATIONS

Birnbaum K, Boehm A, Neumuth T. Evaluation of Structured Learning Algorithms for the Prediction of Clinical Workflows. Surgical Data Science Proceedings; Heidelberg; 2016.

Birnbaum K, Zebralla V, Boehm A, Dietz A, Neumuth T. Metric learning for TNM classifications of patients with head and neck tumors. Proc of the Int Joint Conf CARS; Heidelberg; 2016.

FUNDING

German Federal Ministry for Economic Affairs and Energy (BMWi): ZIM

ONTOMEDRISK – ONTOLOGY-BASED PERIOPERATIVE RISK MINIMIZATION

INTRODUCTION

Medical personnel are often under great stress, raising the likelihood of errors and adverse events. The aim of the OntoMedRisk-project is to develop an agent-based software solution to minimize the occurrence of such events. Therefore, an ontology was developed, which identifies risks across medical processes and supports the avoidance of errors in perioperative settings.

Risk	*Infection_Risk_001*
Risk Specification Rule	(c1 OR c2 OR c3) AND (c4 OR c5) AND c6
Message	Risk of **Dura Mater Bacteria Infection (Meningitis)**. Please check antibiotic administration and vaccination status (pneumococcus, meningococcus and haemophilus influenzae type b).

Condition Nr.	KPI	Operator	Values
c1	Age_in_months	IN	[0; 5)
c2	Skull_bone_thickness	IN	[0; 2]
c3	Ear_structure	==	"abnormal"
c4	Vaccination_status	==	"no"
c5	Vaccination_status	==	"unknown"
c6	Antibiotic_prevention	==	false

Adverse Situation	Probability	Treatment Phase
Dura_Mater_Bacteria_Infection	[0.05; 0.09]	Indication

Fig. 1- Risk specification example.

MATERIAL AND METHODS

The software system uses a risk identification ontology (RIO) for the specification and the identification of risk situations. The ontology is built upon an ontological model of the notion of risk and is embedded into the General Formal Ontology (GFO). Based on this notion, medical staff can specify relevant clinical risks. The risk specification is then used within the system to identify and to analyze the according risk in a treatment situation. In Fig.1 an example risk specification is presented.

RESULTS

RIO and an ontology-based software module, called Ontology-based Risk Detector (OntoRiDe), were developed, which allows the identification of the ontologically specified risks. This tool receives the key performance indicators (KPI) of the current potential risk situation as input parameters, and carries out the risk specification rule contained in the ontology. If the current KPIs satisfy one of the rules then the considered situation is a risk situation. The results of this analysis are transmitted to the medical personnel in form of context sensitive hints and alerts. Fig. 2 shows the basic principle and components of the system. An extensive risk assessment has been performed for an ENT use case. The insertion of cochlear implants was chosen to demonstrate the features and benefits of the risk identification system. About 20 risks relating to cochlear implantation have already been specified, and on this basis, the functionality of RIO and OntoRiDe were successfully tested.

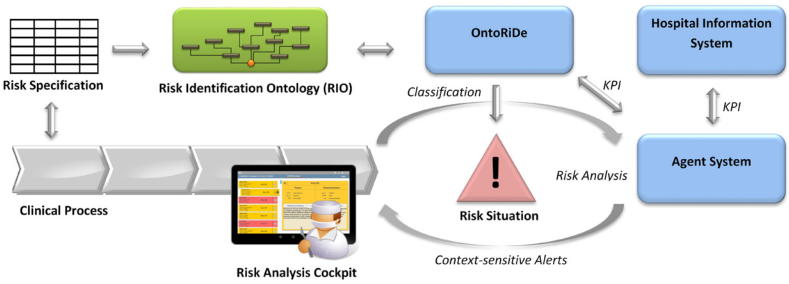

Fig. 2- Ontology-based identification of perioperative risk situations.

DISCUSSION AND CONCLUSION

With the help of RIO, perioperative risks can be specified, whereas OntoRiDe can be used to identify risks in a current treatment situation. An agent-based system continuously gathers process risk-relevant data from various sources and provides it for the risk identification analysis. This allows the recognition of risk situations and supports the avoidance of possible adverse situations. Future work includes the implementation of a cockpit component, which implements a role-based visualization of risk information and context-sensitive hints for the medical experts.

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SELECTED PUBLICATIONS

Uciteli A, Neumann J, Tahar K, Saleh K, Stucke S, Faulbrück-Röhr S, Kaeding A, Specht M, Schmidt T, Neumuth T, Besting A, Portheine F, Herre H. Risk Identification Ontology (RIO): An ontology for specification and identification of perioperative risks. 7th Workshop on Ontologies and Data in Life Sciences (ODLS 2016); Halle (Saale); 2016.

FUNDING

German Federal Ministry of Education and Research (BMBF) / Initiative: KMU-Innovative

SURGICAL INTERVENTION ONTOLOGY (SIO) – UTILIZING SNOMED CT FOR ONTOLOGY-BASED SURGICAL PROCESS MODELING

INTRODUCTION

Workflow management is a prerequisite for computer-aided surgical assistance, situation-awareness and autonomous adaptation of medical devices in intelligent operating rooms. The integration of ontologies in surgical workflow management allows the enhancement of assistance functionalities by formal knowledge representation and decision support. For this purpose, surgical processes should be described through an ontological approach, encompassing the surgical action, which is performed by an actor on an anatomical structure using a surgical instrument. In this project a new approach for ontology-based surgical process modeling by using standardized medical ontologies is developed. For this purpose, the widely used and clinically validated ontology, SNOMED CT, is utilized. Based on SNOMED CT concepts and concept model attributes, a generic approach for semantic surgical process modeling is developed.

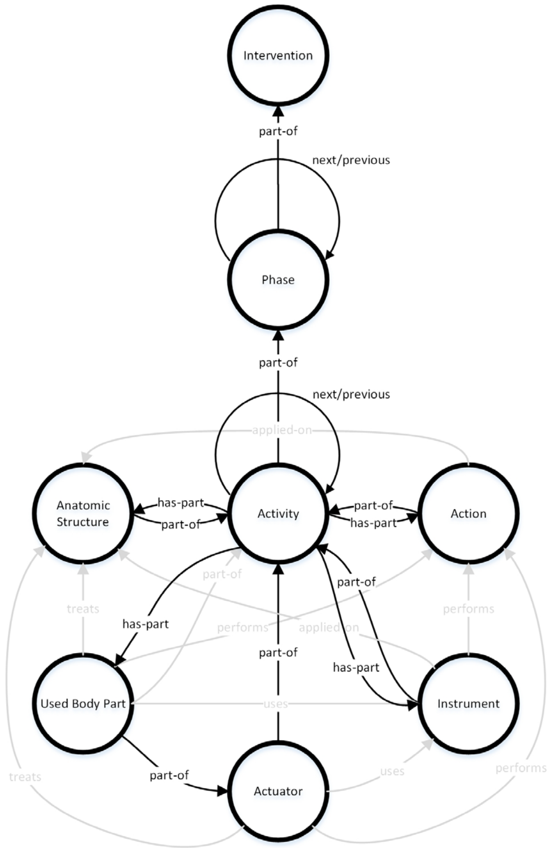

Fig. 1- Generic concept of the Surgical Intervention Ontology (SIO) with surgical process elements and semantic relations.

MATERIAL AND METHODS

For the development of a generic concept for surgical process models, workflow records of different surgical disciplines have been analyzed. The workflows were recorded at the University Hospital Leipzig, using a formal approach for description and a surgical workflow editor for the acquisition of work steps. The relevant process elements and their relationships were extracted from the recorded workflows and transferred into SNOMED CT concepts and concept model attributes. In addition, generic translation rules for mapping surgical process elements and their relations to SNOMED CT have been specified.

RESULTS

The resulting representation of surgical process elements with their semantic relations are depicted in Fig. 1. Based on this generic concept for ontology-based surgical process modeling, the Surgical Intervention Ontology (SIO) has been developed. The ontology is built upon an ontological model of the defined concepts, concept model attributes and the specified translation rules to SNOMED CT. SIO is embedded into the General Formal Ontology (GFO) top-level ontology and is currently implemented for a neurosurgical use case.

DISCUSSION AND CONCLUSION

Based on the generic concept and the SIO, a standardized and reusable representation of surgical processes and process knowledge with a consistent terminology could be achieved. Future applications of the ontology may be recognition of surgical activities and phases as well as, in the context of workflow and situation awareness, surgical knowledge representation and workflow management support in modern integrated operating rooms.

PROJECT TEAM

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SELECTED PUBLICATIONS

Neumann J, Schreiber E, Neumuth T. Ontology-based surgical process modeling by using SNOMED CT concepts and concept model attributes. 30th International Conference on Computer Assisted Radiology and Surgery (CARS); Heidelberg; 2016; 11: 66–8.

Neumann J, Franke S, Glaser G, Schreiber E, Bieck R, Neumuth T. Ontology-based instrument classification for workflow-driven surgical assistance in the intelligent operating room. 28th Conference of the international Society for Medical Innovation and Technology (SMIT); Delft, Netherlands; 2016.

FUNDING

German Federal Ministry of Education and Research (BMBF)

CONSISTENT AND PRIORITIZED PRESENTATION OF SURGICAL INFORMATION

INTRODUCTION

New assistance functionalities emerge rapidly in the operating room (OR). The amount of available information grows with each solution, but also raises the amount of information that needs to be displayed. To avoid information overload for the user, a priorization step in respect to the current situation of the intervention is mandatory, so that only relevant information is displayed. Furthermore, a standardized pattern needs to be developed to provide a consistent presentation of surgical information across surgical setups, surgery rooms and intervention types.

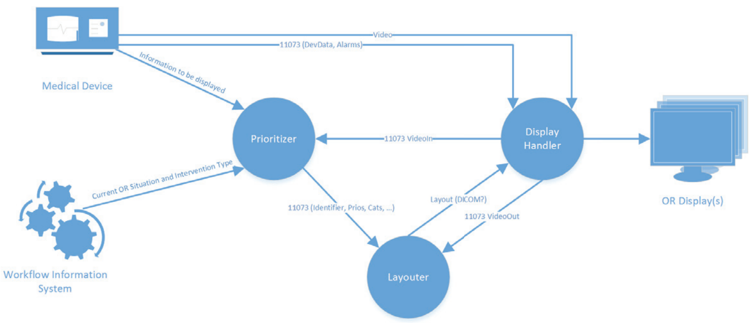

Fig. 1- Schematic depiction of components and data flow for consistent, prioritized presentation of information in the OR.

MATERIAL AND METHODS

In order to provide these functionalities, several requirements have to be met. Besides online access to all required input data and intraoperative workflow information, a highly performant time and resource efficient method to prioritize information is mandatory. Furthermore, a method to register available displays as well as a method to automatically orchestrate information on a given set of screens is required. Therefore, a template is required that allows the allocation of information to screen position. Hereby, information of the same type (e.g. vital parameters) can be clustered. Frequently accessed information (e.g. the endoscopic video) should be located in the center of the surgeons FOV, while indifferent information should be displayed in the periphery or should be hidden until required.

RESULTS

The architecture proposal consists of three components, namely the Prioritizer, the Layouter and the Display Handler. These components are interposed between the OR network and a Workflow Information System on the one side and a variable set of OR displays on the other side (see figure 1). The Workflow Information System includes a backend service that is capable of providing all required information about the current situation in the operating room to prioritize information. The Prioritizer is connected to a knowledge base containing customizable rules that affect the priorities of information. The Display Handler is responsible for providing information about the available displays in the OR as well as for displaying the prioritized and arranged information, while the Layouter is used to orchestrate the prioritized information before passing them to the Display Handler.

DISCUSSION AND CONCLUSION

The proposed method is well suited to prioritize and to position surgical information on an OR monitor setup intraoperatively. It may contribute to an efficient surgical workflow by automatically toggling information entities depending on their relevance to the current surgical situation.

PROJECT TEAM

M. Sc. Erik Schreiber

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SELECTED PUBLICATIONS

Schreiber E, Franke S, Bieck R, Neumuth T. A Concept for Consistent and Prioritized Presentation of Surgical Information. IEEE 18th International Conference on e-Health Networking, Applications and Services (Healthcom); Munich; 2016.

FUNDING

German Federal Ministry of Education and Research (BMBF)

SCORPIO - DEVELOPMENT OF A ROBOT-BASED SYSTEM FOR COLLABORATIVE WORKFLOW ASSISTANCE IN INTERVENTIONAL RADIOLOGY

INTRODUCTION

In the field of minimal-invasive diagnostics image guided interventions require precise localization of regions of interest as well as precise placement of instruments. In the case of needle insertion procedures the entry point accuracy is highly dependent on the surgeon's skill and experience. Hence, intraoperative CT imaging is needed to revalidate the correct needle trajectory and position. In recent years robot-assisted applications helped to improve accuracy and therefore, offer a promising alternative to intraoperative CT imaging. However, with increasing complexity and the highly interactive nature of radiology interventions new interaction and guidance principles need to be developed. The aim of the project Scorpio is to overcome these limitations and focuses on the usage of new collaborative robotic systems.

MATERIAL AND METHODS

Two KUKA LBR iiwa 7 R800 lightweight robots were used in the Scorpio system to assists the surgeon. One is used for registration and tracking, utilizing a combined tracking system (NDI, Microsoft Kinect); the other is responsible for positioning a needle holder at the targeted position.

Currently, registration of the robot in camera space as well as registration of the patient in camera/CT space is done through a landmark-based approach. A transition to a markerless method using the depth image of the attached Microsoft Kinect is planned.

An application on a tracked tablet is used to explore the patient data, set the desired needle position and command the robot. For robot path planning, the Robot Operating System (ROS) is used.

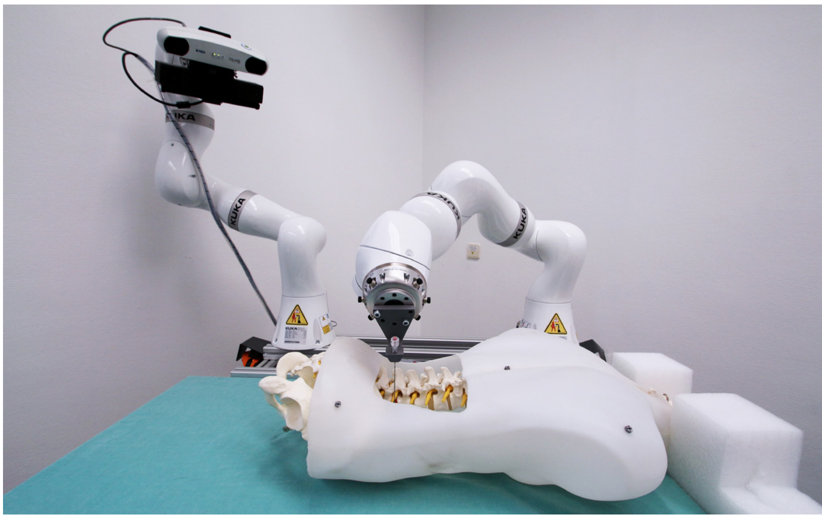

Fig. 1- Scorpio demo setup. Combined tracking system on the left, needle placement system on the right.

Fig. 2- Needle placement robot holding needle in position at target structure.

RESULTS

First studies were performed to investigate accuracy and precision of the position. Needle positions can be approached collision free and according to the preplanned target entry with an interactive tablet navigation system.

DISCUSSION AND CONCLUSION

The initial studies suggested that a combined setup of two collaborative robots potentially supports the interactive character of radiologic interventions. Work still needs to be done on optimizing path planning and interaction paradigms. Subsequent work includes a simplified interface using the OSC-protocol for extensive plug-and-play funtionality.

PROJECT TEAM

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FUNDING

Saxon State Ministry for Higher Education, Research and the Fine Arts (from grants for dedicated projects at medical facultuties)

DIGITAL PATIENT AND PROCESS MODEL

'Support of patient-specific therapy decision making along the clinical pathway for better outcomes and more patient safety'

INTRODUCTION

For complex diseases, the increasing number of available examinations and feasible therapies allow for more patient-specific therapy decisions with a higher probability of better outcomes and for therapy processes tailored to the individual patient. However, the large amount of patient data and the multitude of available therapy options can quickly become too extensive to be fully considered in a clinician's decision making. The Digital Patient and Process Modelling Group at ICCAS is addressing this problem by developing therapy decision support systems, patient-specific therapy process models, methods for extracting and structuring patient data, and standardized information models.

In 2016, our research focused on continuing the development of a decision model for laryngeal cancer treatment and on developing new methods for collaborative therapy decision modelling, decision model validation, integrating fuzziness in decision models, monitoring the diagnostic delay in treatment, accessing patient information for probabilistic patient models using existing standards, and extracting and representing events in clinical guidelines and electronic patient records. Furthermore, previous work on analytic user interfaces for decision model investigation was continued.

The findings have been presented and discussed at dedicated conferences and workshops such as CARS, HEC, BMT, and CURAC. Projects in this area are currently funded by the German Federal Ministry of Education and Research (BMBF).

Since July 2016, the Digital Patient and Process Modelling Group is led by PD Dr.-Ing. habil. Steffen Oeltze-Jafra.

SCIENTIFIC STAFF

Chris Unger, Stefan Franke, Erik Schreiber, Mario Cypko, Lara Heuft,
Steffen Oeltze-Jafra (group leader), Alexander Oeser, Gero Kraus, Hans-Georg Wu, Jan Gaebel
(f.l.t.r.)

SELECTED PUBLICATIONS

Gaebel J, Cypko MA, Stoehr M. Integrating intelligent agents in form of Arden Syntax for Computing Instances Based Fuzziness in Patient Specific Bayesian Networks. Int J Comput Assist Radiol Surg. 2016; 11 (Suppl 1).

Cypko MA, Lemke HU. Concepts for IHE Integration Profiles for Communication with Probabilistic Graphical Models. Int J Comput Assist Radiol Surg. 2016; 11 (Suppl 1).

Stoehr M, Dietz A, Cypko MA. Development of the Digital Patient Model 'Laryngeal Cancer' to Support the Decision-Making Process. Int J Comput Assist Radiol Surg. 2016; 11 (Suppl 1).

Deng Y, Gaebel J, Denecke K. Patient Centered Event Representation for the Treatment of Multifactorial Diseases: Current Progress and Challenges. Stud Health Technol Inform. 2016; 228: 110–4.

GUIDED EXPERT MODELING FOR CLINICAL BAYESIAN NETWORK DECISION GRAPHS

INTRODUCTION

We present a novel method for graph modeling of Bayesian networks (BN) in the clinical domain. Creating BN models is separated in modeling 1) the graph structure, and 2) the probabilistic parameters. Complex treatment decisions are modeled by domain experts (clinicians) manually, because sufficient data for machine learning algorithms is not available. Autonomous expert modeling is difficult, because modeling requires BN background knowledge and experience with modeling tools. Therefore, modeling in teams with a knowledge engineer (computer scientist) is necessary. This complicates the knowledge acquisition and influences the resulting models. In 2014, we presented a concept for guided autonomous expert modeling and validation, more specific, a system that transforms BN equations into a natural language questionnaire. In 2015, we successfully implemented the first web application for probabilistic modeling.

MATERIAL AND METHODS

Based on our web application for probabilistic modeling and 3 years of graph modeling experience, a set of recurring modeling questions were collected. From this set, we designed a generic questionnaire with modeling descriptions for a standardized modeling procedure. We evaluated our method separately with a clinician and a medical student. Both were asked to model the same exemplary decision of acute middle ear infection. The clinician was experienced in BN modeling, the medical student had only minimal experience. After modeling, the participants were asked to review each other's model. The study was recorded on video and the test models were compared. applied by our highly specialized ENT tumor board at Leipzig University Hospital.

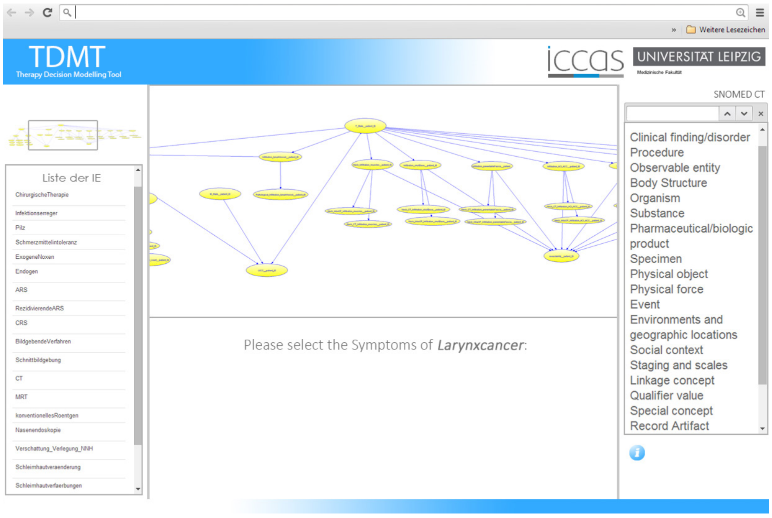

Fig. 1- Conceptual visualization of the graph modeling tool. This includes a questionnaire window (bottom center), a graph visualization (top center), a list of standardized clinical terms to create nodes, e.g., using SNOMED_CT (right), a list of modeled nodes (bottom left), and a graph overview (top left).

RESULTS

In general, both participants followed the modeling instructions of the questionnaire, resulting in the generation of comparable models within a similar timespan of one hour. In detail, the medical student followed the instruction, step by step, while the experienced clinician wished to skip descriptions and repetitive questions. Initially, skipping was allowed but resulted in mistakes. From the participants, we received similar decision models; the same model structure, with a few differences in selected variables. These variables are related to desired model details. The participants were able to 'read' and understand the other's model and variable selection.

CONCLUSION

We conclude that this method enables autonomous expert modeling. Resulting models comply with BN model formalities. The questionnaire would benefit from a usability study. Finally, with an appropriate web-based modeling framework, collaborative modeling between domain experts would be possible, would expedite the model development of other diagnoses and therapies, and would allow for discussing domain-specific decisions.

PROJECT TEAM

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SELECTED PUBLICATIONS

Stoehr M, Dietz A, Cypko MA Development of the digital patient model 'Laryngeal Cancer' to support the decision-making process. Int J Comput Assist Radiol Surg 2016; 11 (1).

FUNDING

German Federal Ministry of Education and Research (BMBF)

ENHANCING CLINICAL DATA FOR THE APPLICATION IN PATIENT SPECIFIC BAYESIAN NETWORKS

INTRODUCTION

The aim of personalized medicine is to find the best fitting therapy for the individual patient. Model based clinical decision support systems (CDSS) can assist clinicians in finding the most suitable therapy. The Bayesian network currently being developed at ICCAS is instantiating a Patient-Specific Bayesian network when supplied with routinely recorded patient information. The problem of such Bayesian networks is that they cannot differentiate and assess the information, which is necessary to create a correct depiction of the patient and precise inference. Hence, instances need to be weighted individually depending on the specific argument values.

MATERIAL AND METHODS

We created a set of intelligent agents that interpret patient specific data from the clinical data bases before the information is passed to the engine which calculates the patient-specific Bayesian networks. The agents are implemented in Arden Syntax and are allocated as a web service. We applied the principal of Fuzziness to be able to depict uncertainty within the clinical data. When implementing single medical correlations, the use of fuzzy sets can integrate the right amount of accuracy to the actual medical fact and evaluate the accuracy. The approach of adding intelligent agents to a clinical decision support system is applicable to the therapy imaging and model management system (TIMMS) architecture. Arden Syntax modules will also be used to send messages to the clinical user to inform about specific reevaluations of patient data and ensure the understanding and reasoning of the system.

RESULTS

The system's architecture is shown in Figure 1. The Arden Syntax agents enhance the information entities by assessing teir value regarding the respective medical knowledge (e.g. a radiological finding should not be older than 30 days when staging a cancer patient).

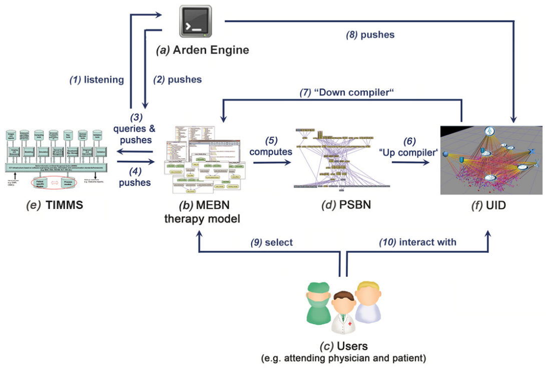

Fig. 1- Concept of CDSS using MEBN extended to intelligent agents based on Arden Syntax.

DISCUSSION AND CONCLUSION

The problems that arise with information entities from routinely recorded patient data can be solved with the use of intelligent agents in the form of Arden Syntax. MLMs can integrate well into existing systems and could expand decision support systems by the needed features.

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SELECTED PUBLICATIONS

Gaebel J, Stoehr M, Cypko MA. Integrating Intelligent Agents in form of Arden Syntax for Computing Instance Based Fuzziness into Patient-Specific Bayesian Networks. Proc of the Int Joint Conf CARS; Heidelberg, Germany; 2016.

Deng Y, Stoehr M, Cypko M. Towards Summarized Treatment Guidelines and Studies in Personalized Treatment Planning for Complex Multifactorial Diseases. Proc of the Int Joint Conf CARS; Heidelberg, Germany; 2016.

Deng Y, Gaebel J, Denecke K. Patient Centered Event Representation for the Treatment of Multifactorial Diseases: Current Progress and Challenges. Stud Health Technol Inform. 2016; 228: 110–4.

FUNDING

German Federal Ministry of Education and Research (BMBF)

MONITORING AND ASSESSING THE DIAGNOSTIC DELAY FOR PATIENTS WITH LARYNGEAL CANCER

INTRODUCTION

The clinical tumor stage is the most important prognostic factor for the treatment of laryngeal cancer. It is evaluated by different diagnostic procedures and correlates with the patients' prognosis. In a specialized clinic the patient has to undergo a tumor staging process for precise diagnosing. The diagnostic delay is the time between first doctor consultation and histologic verification of the cancer. It averages at approximately 12 weeks. The average tumor volume doubling time for squamous cell cancers is also about 12 weeks. So it is highly desirable to monitor and reduce the diagnostic delay time.

MATERIAL AND METHODS

We analyzed 51 cases of patients (both inpatients and outpatients) with laryngeal cancer from 2013 and 2014. We averaged the days between the first CT scan and the interdisciplinary tumor board meeting as a first measure of the time passing during the diagnostic process. The median of this delay is 37 days. Since diagnostic delay is correlated with a poor survival rate, we developed a system for monitoring the duration of the diagnostic process. We implemented the decision whether a finding is out of date in Arden Syntax Medical Logic Modules (MLM). When encountering a finding that is outdated, the chance of misdiagnosis is increased and physicians need to be informed about this case.

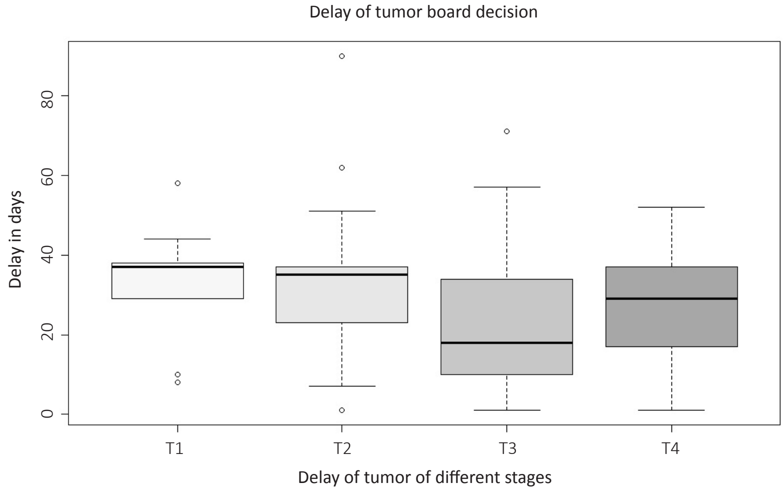

Fig. 1- Median delay of tumor board after initial neck CT.

Fig. 1- Notifying the physician about outdated information.

RESULTS

For the integration of this approach into the clinical context, we applied the ArdenSuite from Medexter Healthcare GmbH as a host system for the modules and the call management. With the ArdenSuite server, MLMs can be made available for HTTP calls via REST. The server also manages the periodic triggering of MLMs. The system periodically checks the available patient information and the time since certain procedures were performed. If outdated information is identified the attending physician is notified via email and on-screen messages.

DISCUSSION AND CONCLUSION

MLMs for monitoring diagnostic delays can be easily integrated into existing information systems. Adaptations and maintenance is rather simple. Yet, the ideal way to notify the clinical user about critical circumstances needs to be examined further. The respective consequences need to be explicitly agreed upon.

PROJECT TEAM

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SELECTED PUBLICATIONS

Gaebel J, Heuft L, Stoehr M. Medical logic modules for monitoring the diagnostic delay in the treatment of laryngeal cancer. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC); Bern, Switzerland; 2016; 249–54.

FUNDING

German Federal Ministry of Education and Research (BMBF)

VALIDATION WORKFLOW FOR BAYESIAN NETWORK DECISION MODELS IN HEAD AND NECK ONCOLOGY

INTRODUCTION

Oncological treatment is being increasingly complex and therefore decision making in multidisciplinary teams is becoming the key activity in the clinical pathways. The increased complexity is related to the number and variability of possible treatment decisions that may be relevant to a patient. A Therapy Decision Support System (TDSS) based on Bayesian networks (BN) can support multidisciplinary teams in making patient-specific therapy decisions. However, the quality of the BN-based advice depends on the quality of the model. Therefore, it is vital to validate the model before it is applied in practice.

MATERIAL AND METHODS

For a sub-network of laryngeal cancer, representing the tumor, lymph node, and metastasis (TNM) staging with 303 variables, we evaluated 66 patient records (see Figure 1). To validate the model on this data set a validation workflow was applied in combination of quantitative and qualitative analyses (see Figure 2). The validation workflow consists of three iterative steps: (1) quantitative validation, (2) qualitative validation, and (3) modification. Quantitative validation required three established methods: accuracy, ROC, and the confusion matrix. Qualitative validation included testing the model behavior on patient records, followed by studying a single node or a sub-network in more detail. Model and data modification was performed manually by the expert and required new quantitative and qualitative validation.

RESULTS

We performed the validation workflow on the TNM model in collaboration between a domain expert and a knowledge engineer. In the subsequent analyses, we observed four sources of imprecise predictions: incorrect data,

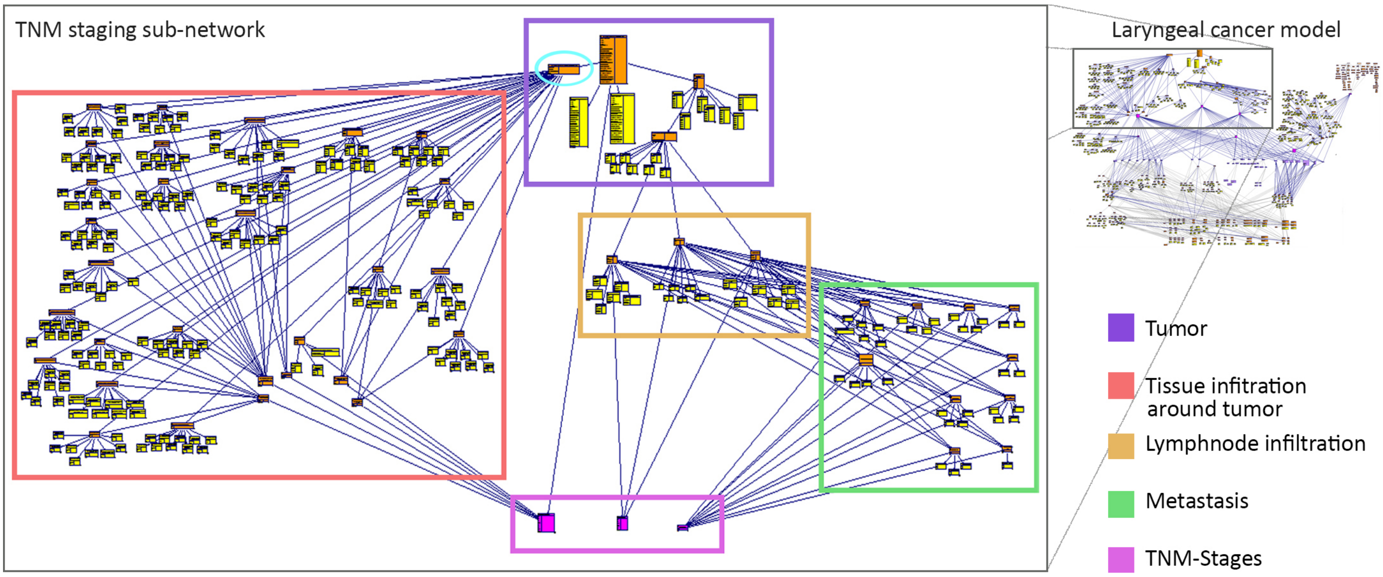

Fig. 1 - The TNM staging sub-network of the treatment decision model of laryngeal cancer.

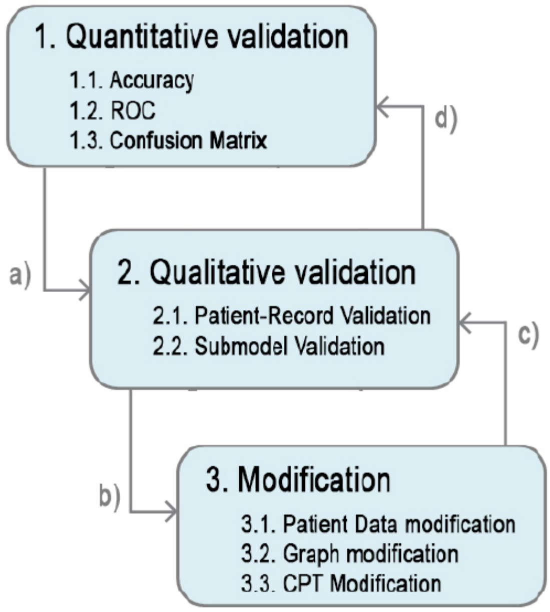

Fig. 2 - Validation and Modification Workflow for clinical Bayesian networks.

DISCUSSION AND CONCLUSION

The presented validation effort is related to the model complexity. For simpler models the validation workflow is the same, but may require fewer validation methods. The validation success is related to the model's well-founded knowledge base. The remaining model may disclose additional sources of imprecise predictions.

PROJECT TEAM

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FUNDING

German Federal Ministry of Education and Research (BMBF)

ISAAC – INTEGRATED SYSTEM FOR ADVANCED ANALYSIS OF COMPLEX CANCER CASES

Fig. 1- ISAAC hardware arrangement with curved displays for a broader viewing angle and touchscreen input.

INTRODUCTION

Complex clinical cases, such as laryngeal cancer are accompanied by a variety of data gathered from clinical tests and observations. The inconsistent state of the contained information causes a demanding preparation process for the individual physician before a collaborative treatment decision can be made inside the tumor board. The goal of the Integrated System for Advanced Analysis of Complex Cancer Cases (ISAAC) is to streamline the phase of tumor board preparation and to ensure a unified representation of contemporary and relevant data within a clear and intuitive interface to support the decisionmaking process.

MATERIAL AND METHODS

The process of medical decisionmaking involves the availability of reliable diagnostic information. Since the different diagnostic disciplines (laboratory, medical imaging, etc.) are relying on specialized software tools for data management, the consolidation process prior to the tumor board meeting requires a lot of time. ISAAC is addressing these issues by collecting the needed information and displaying them in a uniform way (Fig. 2). Furthermore, the system will automatically search for recent studies in relevant databases (PubMed, NCCN) to provide an additional source of evidence.

RESULTS

The system consists of a three-screen setup that comprises the display of patient information, diagnostic and pathological results, and an assortment of the most relevant medical studies as well as a visualization of the patient-specific decision model. A tablet display in front of the physician is used for handling the system input. Events that cause the model to update are automatically triggered by an underlying workflow engine. In this way, newly available data sets are automatically considered in the calculation of the patient-specific model, while outdated information can be re-evaluated or even excluded.

Fig. 2- Draft layout for the user interface of the case data component.

DISCUSSION AND CONCLUSION

Although ISAAC is currently intended to streamline tumor board preparation, it will soon be extended to accompany the overall therapy of laryngeal cancer. Using the workflow engine, the system is intended to adapt to clinical pathways and to support decisionmaking throughout the entire treatment process.

PROJECT TEAM

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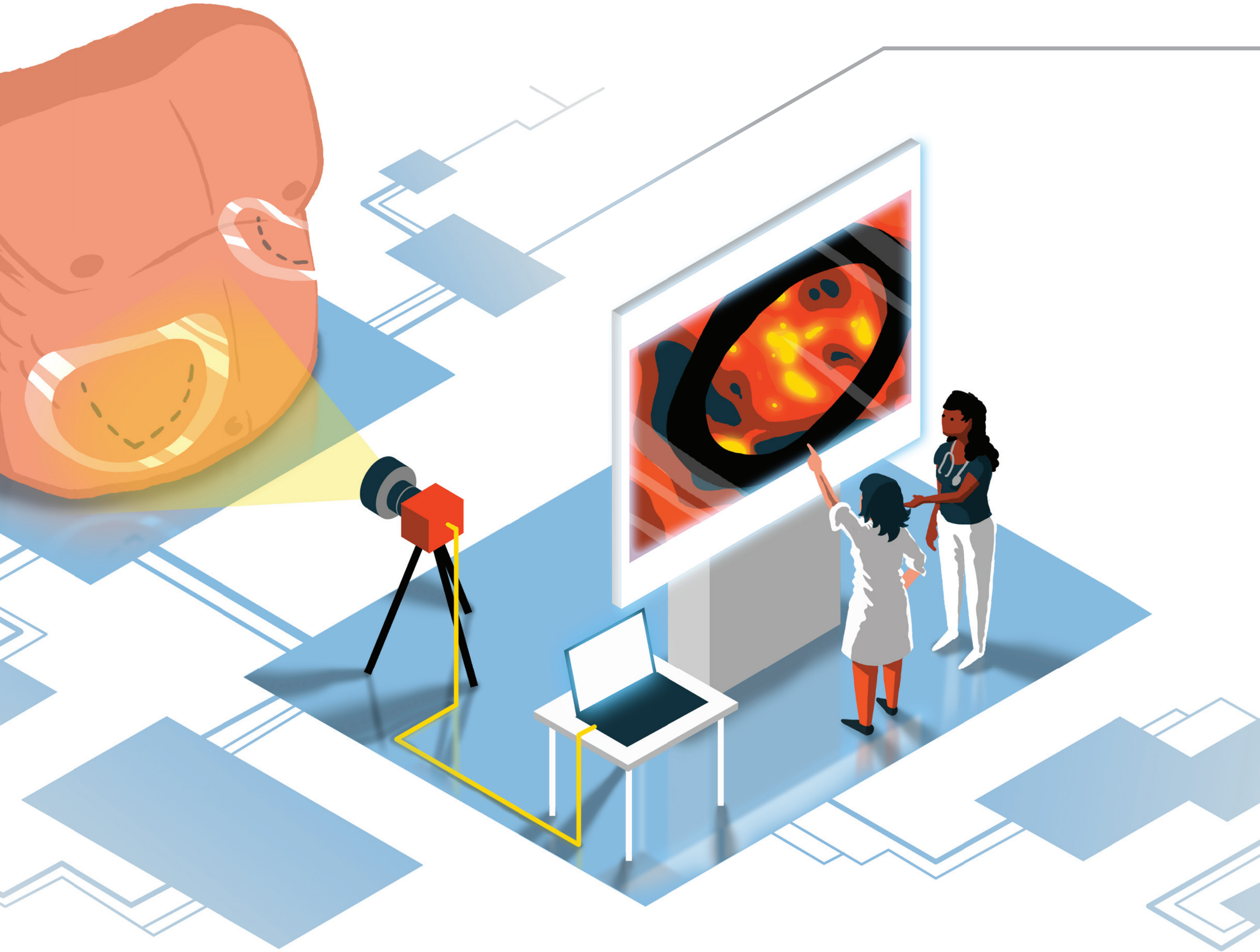
FUNDING

German Federal Ministry of Education and Research (BMBF)

Saxon State Ministry for Higher Education, Research and the Fine Arts (from grants for dedicated projects at medical facultuties)



MULTIMODAL INTRAOPERATIVE IMAGING

'A smart assistant system, improving the operation outcome with non-invasive imaging'

INTRODUCTION

Intraoperative imaging is a valuable tool to support surgeons by decision makings and to improve operation outcomes. Therefore, the objectives of the Multimodal Intraoperative Imaging group are the development of innovative non-invasive imaging methods and assistance systems to facilitate the interpretation of intraoperative images.

In 2016, research topics still focused on intraoperative ultrasound (iUS) imaging and infrared thermography. A further step in the automatic identification of regions including possible brain tumor residuals in iUS images was reached. A system to automatically detect the skin arteries in static thermal images was developed. Moreover, the spectrum of examination methods is enlarging. A new project with the department of Rhythmology at the Heart Center Leipzig started with the implementation of planning software to generate patient specific heart model based on MR data. A new collaboration with Prof. Robitzki (Center for Biotechnology and Biomedicine, Leipzig University) aims at establishing her an impedance spectroscopy system at the Leipzig University Hospital.
Finally, hyperspectral imaging is currently being evaluated with the beginning of a new national project.

SCIENTIFIC STAFF

Marianne Maktabi, Michael Unger, Claire Chalopin (group leader), Elisee Mbuyamba Ilunga, Jesús Guillermo Cabal Aragón, Philip Westphal (f.l.t.r.)

SELECTED PUBLICATIONS

Ilunga Mbuyamba E, Avina-Cervantes JG, Lindner D, Cruz-Aceves I, Arlt F, Chalopin C. Vascular structure tracking in intraoperative 3D contrast-enhanced ultrasound data. Sensors. 2016; 16 (497).

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Ilunga Mbuyamba E, Cruz-Duarte JM, Aviña-Cervantes JG, Correa-Cely CR, Lindner D, Chalopin C. Active contours driven by Cuckoo search strategy for brain tumour images segmentation. Expert Systems With Applications, 2016; 56: 59-68.

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INFRARED THERMOGRAPHY SYSTEM FOR AUTOMATIC DETECTION OF SKIN PERFORATORS

INTRODUCTION

Reconstructive surgery involves transferring a skin transplant from a suitable body part to the damaged area to be repaired. Standard transplants, also called free flaps, consist of human tissue including skin, subcutaneous tissue and the blood vessels supplying the tissue, the perforators. A bad selection of the skin area can lead to necrosis after transplantation. Today, several imaging methods are available for determining the suitability of a skin area for being used as a flap. Standard methods suffer from a low resolution, require the use of contrast agents or ionizing radiation. Infrared thermography showed to be a noninvasive alternative imaging method. The objective of the project is the development of an infrared thermal imaging system dedicated to the automatic detection of the perforators.

MATERIAL AND METHODS

The system includes an infrared camera (PI450, Optris GmbH) mounted on a tripod and connected to a laptop (Fig. 1). The camera acquires static thermal images of the skin which are online processed by software developed at ICCAS. Motions of the participant are corrected based on extrinsic landmarks. Then, the perforator centers are automatically detected in the images as points with local temperature maximum. Corresponding vascularized skin areas are drawn using adaptive thresholding methods (Fig. 2). The sensitivity of the algorithms can be adjusted by tuning two parameters.

RESULTS

Seven skin regions, typically used for transplants, of 20 participants were statically acquired in a pilot study conducted by our clinical partners. The algorithms were tested on the thermal images using different parameter values. The surgeon selected the parameters providing the optimal detection of perforators.

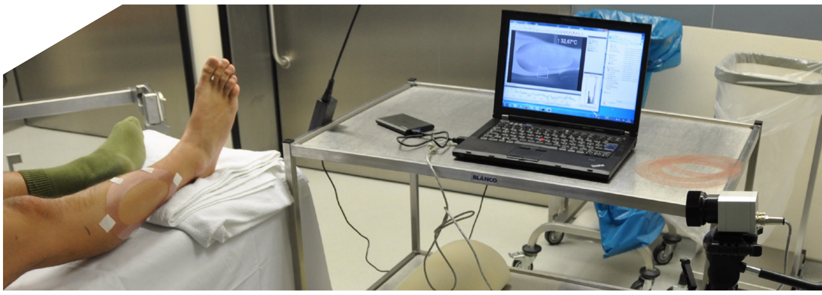

Fig. 1- Experimental setup in the OR.

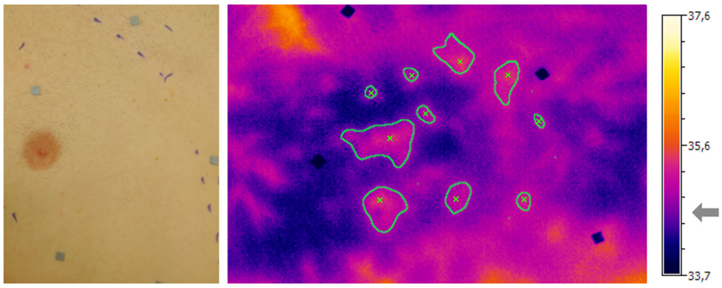

Fig. 2- Detected perforator centers (cross) and the corresponding regions (contour) of the pectoralis flap.

DISCUSSION AND CONCLUSION

The study showed that perforators can be automatically detected in infrared thermography using image processing methods. Further quantitative evaluation will be performed. Moreover, the first results demonstrated that detection sensitivity of the algorithms correlates with tissue location. The optimal parameter values will be included into the imaging system to automatically adapt the acquisition to the examined skin area.

PROJECT TEAM

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Dr. Thomas Heinke, Optris GmbH

FUNDING

German Federal Ministry for Economic Affairs and Energy (BMWi): ZIM

AUTOMATIC DEPTH SCANNING SYSTEM FOR 3D INFRARED THERMOGRAPHY

INTRODUCTION

Infrared thermography can be used as a pre-, intra- and post-operative imaging technique during medical treatment of patients. Modern infrared thermal cameras are capable of acquiring images with a high sensitivity of 10 mK and beyond. They provide a planar image of an examined 3D object in which temperature values are only accurately measured within a plane perpendicular to the camera axis and are defined by the focus of the lens. Out of focus planes are blurred and temperature values are inaccurate.

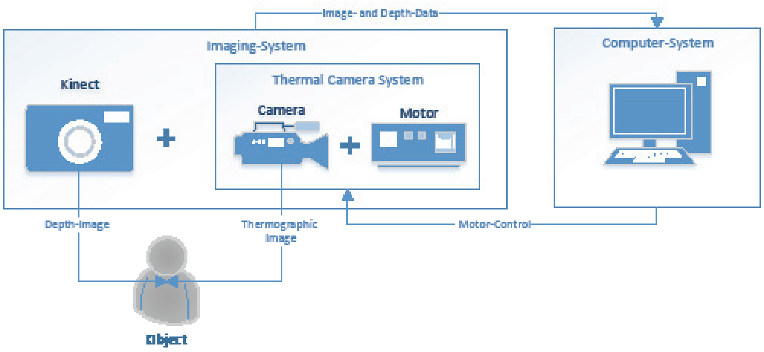

Fig. 1- The 3D thermographic imaging system consists of a thermal camera and a depth camera. A focus motor, controlled by a computer program, enables the automatic acquisition of thermal images at different focal lengths.

MATERIAL AND METHODS

A new 3D infrared thermography system was built by combining a thermal camera (Optris PI450) with a depth camera (Microsoft Kinect V2) providing depth and visual information. The focus of the thermal camera is controlled by an external focus motor. A firmware was developed providing basic functions for referencing the focus as well as getting and setting the focus position.
The idea of the all-in focus system is to automatically acquire multiple thermal images at varying focal planes using the motorized focus. An initial calibration process enabled the computation of the transformation between the thermal and depth images. The acquired temperature values in the corresponding thermal images were then mapped to the 3D surface points acquired with the depth camera. The system was evaluated using LED strips mounted on three boards and positioned at distances of 500 mm, 1000 mm and 1500 mm. The temperature values measured in the reconstructed 3D scene and in three thermal images, each of them focused on a board, were compared.

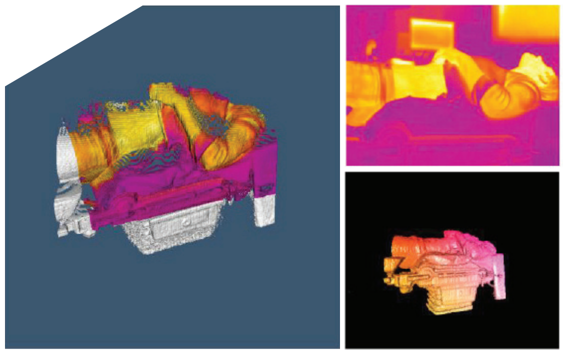

Fig. 2 - A 3D scene with projected thermal map (left) is reconstructed by combining an all-in-focus image (upper right) and the depth data of the scene (lower right).

RESULTS

With the use of depth scanning, the temperature deviation due to blurring was reduced. The best improvement was achieved at lower distances, reducing the temperature error from 16.8 K to 2.5 K. At higher distances, the negative effects of the small field of depth had less impact, reducing the temperature error from 5.5 K to 1.3 K.

DISCUSSION AND CONCLUSION

We showed that reconstructing an all-in-focus thermal image improves the image quality and therefore the accuracy of the temperature measurement. Remaining errors may be reduced by improving the calibration of the system. Further evaluation of the imaging system is needed to assess the impact on the image quality in medical applications.

PROJECT TEAM

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FUNDING

German Federal Ministry for Economic Affairs and Energy (BMWi): ZIM

SPIN – MULTIPARAMETRIC SPECTRAL PATIENT IMAGING – ASSESSMENT OF PATIENT STATUS BASED ON CONTACT-FREE AND NON-INVASIVE MEASUREMENT OF CUTANEOUS PERFUSION AND SURFACE MOISTURE BY USING HYPERSPECTRAL IMAGING

INTRODUCTION

The assessment of the peripheral artery occlusion situation and the correct and clear estimation of patient status contribute significantly to the patient safety during surgery. In the project SPIN a camera-based system is developed to detect patient status information by including multiparametric information.

MATERIAL AND METHODS

We facilitate a non-invasive hyperspectral imaging system (TI-CAM, Diaspective Vision GmbH) working in visible and near infrared spectral range to measure the patient status. The camera system is designed for optimal mobility in the clinical domain. A high spatial and spectral resolution ensures optimal investigation of regions of interest. The camera system is combined with an intraoperative workstation to process the received imaging data and characterize the different patient status of several medical use cases. The tissue haemoglobin index, oxygen saturation, near infrared perfusion, and tissue water index are calculated to achieve clinical usable categorization of several patient status.

Fig. 1- Setup to evaluate the hyperspectral imaging system in laboratory environment.

RESULTS

This system will be tested in different clinical applications to measure cutaneous perfusion and surface moisture. Hence, aspects to be investigated are:
Quality of the identification and classification of patient status; Effectiveness of methods for automatic, clinical relevant analysis of parameters; Feasibility of algorithms for patient status recognition.

DISCUSSION AND CONCLUSION

The reliability of this non-invasive and contact-free monitoring system for cutaneous perfusion and surface moisture will be researched in upcoming development steps. We expect a positive impact on avoiding patient status deterioration as well as early risk recognition capabilities. Furthermore, the camera system might characterize the peripheral artery occlusion fast and objective to enhance physician's daily routine.

PROJECT TEAM

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FUNDING

German Federal Ministry for Economic Affairs and Energy (BMWi): ZIM

DETECTION OF RESIDUAL BRAIN TUMORS IN 3D INTRAOPERATIVE ULTRASOUND IMAGES

INTRODUCTION

In brain tumor surgery, maximizing the amount ofremoved tumor tissue has a positive impact on progression-free survival of patients. At the Leipzig University Hospital, both 3D intraoperative contrast-enhanced and B-mode ultrasound data (3D iCEUS and 3D iB-mode US) were acquired after initial tumor resection to support neurosurgeons in the identification of possible tumor residuals. Both modalities show complementary information. By combining them, brain structure discrimination and suspect tissue classification can be improved. However, the mental fusion of images is a complex intraoperative task for neurosurgeons. Therefore, an assistance system to support the analysis of intraoperative ultrasound data is needed.

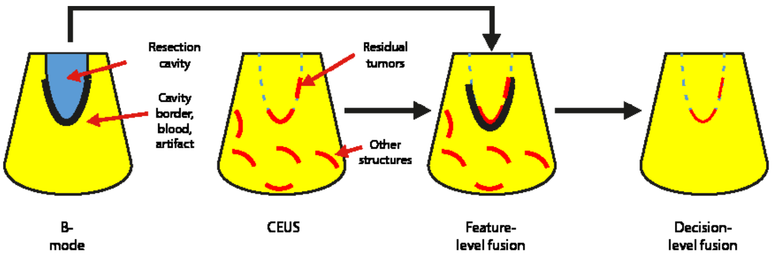

Fig. 1- Schematic overview of the image fusion approach proposed for residual brain tumor identification. The border of resection cavity and highlighted structures are extracted from B-mode and CEUS respectively, and combined in the feature-level fusion step.

MATERIAL AND METHODS

Two assumptions were considered in the approach: (1) tumor residuals are located beyond the resection cavity and (2) tumor tissue is highlighted in CEUS modality (Fig. 1). Firstly, hyperechogenic areas are automatically identified in the images. They are the borders of the resection cavity, vessels, bone structures and artifacts in the 3D iB-mode images, and residuals of tumor and vessels in the 3D iCEUS images respectively. Secondly, a fusion process enables the identification of the extracted structures which fulfill both assumptions.
The method was tested on intraoperative data sets of 23 patients with glioblastoma, for which a gross total tumor resection was planned. Areas extracted by the algorithm were compared to manual segmentation. Tumor tissue was visible in 19 cases.

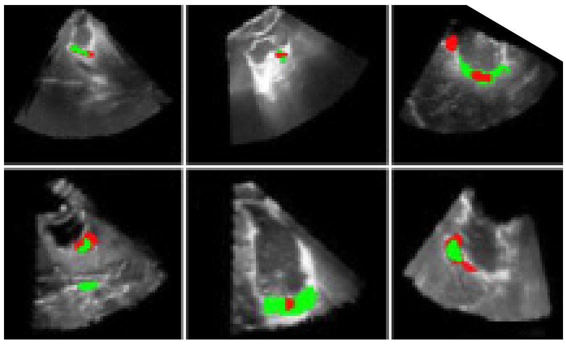

Fig. 2- Examples of automatically extracted regions (in green) superimposed to the manual segmentation (in red).

RESULTS

The approach succeeded in localizing the tumor remnants in 17 out of 19 patients. No tumor tissue was correctly detected in two out of four patients without tumor remnants. However, additional suspect regions were found in 10 cases. Figure 2 shows regions extracted by the algorithm (in green) superimposed to the manual segmentation (in red).

DISCUSSION AND CONCLUSION

The experiments showed that the method is able to successfully indicate local regions with possible tumor residuals. The quantitative evaluation and the development of a suitable visualization method are the next work steps.

PROJECT TEAM

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FUNDING

Mexican National Council on Science and Technology (CONACYT) of Mexico

DEVELOPMENT OF PLANNING SOFTWARE TO VISUALIZE HEALTHY AND INJURED CARDIAC TISSUE BASED ON MRI DATA

INTRODUCTION

Planning of interventions to treat abnormal heart rhythms requires a 3D patient specific model of the heart. Currently available commercial or free software dedicated to the generation of such models have important limitations for routinely use. Automatic algorithms are not robust enough while manual methods are time-consuming. Therefore, the project attempts to develop an optimal software tool. The heart model is generated from preoperative MRI data-sets acquired with contrast agent and allows visualisation of damaged cardiac tissue.

MATERIAL AND METHODS

An important requirement in the development of the software tool was the use of manual to semi-automatic functions. Once the image dataset of the patient has been loaded, the user selects a region of interest. Thresholding functions allow selecting the areas of high intensities which correspond to anatomical structures filled with contrast agent, namely cardiac cavities and blood vessels (Fig. 1). Thereafter, the target-structure, for example the left ventricle, is coarsely selected by interactively outlining the gross shape. An active contour function adjusts automatically the initial contour to the image content (Fig. 2 left). The result can still be manually improved using easy and fast interaction tools. Finally, possible scar tissue located in the cavity muscle is automatically detected and visualized on the 3D heart model (Fig. 2 right).

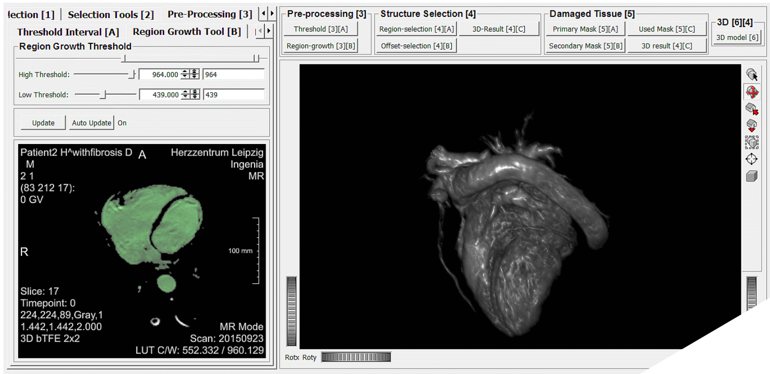

Fig. 1- 3D heart model generated based on MRI data and including the heart cavities and the vascular structures.

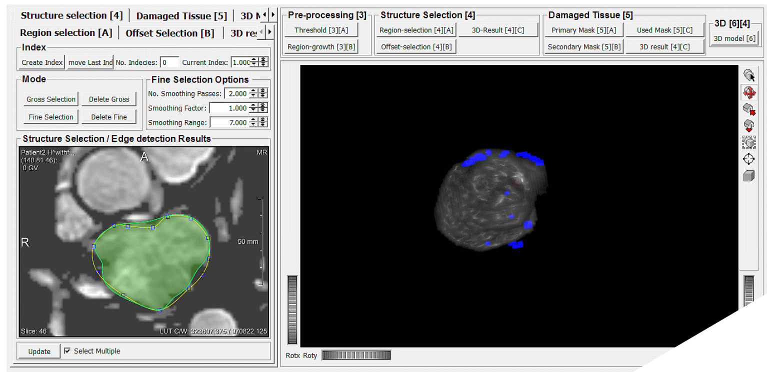

Fig. 2- The left ventricle is automatically segmented using active contour models (yellow contour, left). Injured tissue located in the muscle is automatically detected and represented overlapped on the 3D heart model (blue areas, right).

RESULTS

The development of this software tool was performed in close collaboration with physicians to ensure that the functionalities and the layout fit clinical requirements. Currently, it is possible to generate a 3D heart model including injured tissue in a couple of minutes. The software tool was implemented using MeVisLab.

DISCUSSION AND CONCLUSION

While the tool is in its final stages of development, the results require further testing of additional dataset before any validity can be established.

PROJECT TEAM

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FUNDING

Erasmus Grant

DETECTION AND ASSESSMENT OF UNCAVITATED CARIOUS ENAMEL LESIONS BY OPTICAL COHERENCE TOMOGRAPHY

INTRODUCTION

The noninvasive optical coherence tomography is a suitable method to display the surface and structures below the surface of teeth. Results from our previous studies showed that detection of carious lesions is a potential field of application of this method (ORCA 2013- 2015). The aim of the investigation was the TMR-based evaluation of performance of spectral domain optical coherence tomography (SD-OCT) and X-ray microtomography (µCT) for detection and assessment of uncavitated carious enamel lesions.

MATERIAL AND METHODS

28 extracted human teeth with 47 approximal carious lesions and sound surfaces were used. Approximal surfaces were sectioned visually by means of ICDAS-II codes 0 to 2.
One region of interest (ROI) was marked by 2 drill-holes each according to maximum lateral lesion extent. Imaging these lesions was performed with SD-OCT developing a 2D- and 3D-Scan.
Using X-ray microtomography imaging (microCT) 150 – 250 µm tooth sections were scanned through the ROI. As reference method we used transverse microradiography (TMR), scanning electron microscopy (5 kV), wide-field confocal laser microscopy (WFC).

These imaging methods facilitate lesion depth measurements (µm). According to lesion extent OCT and µCT signals were categorized (Fig. 2).

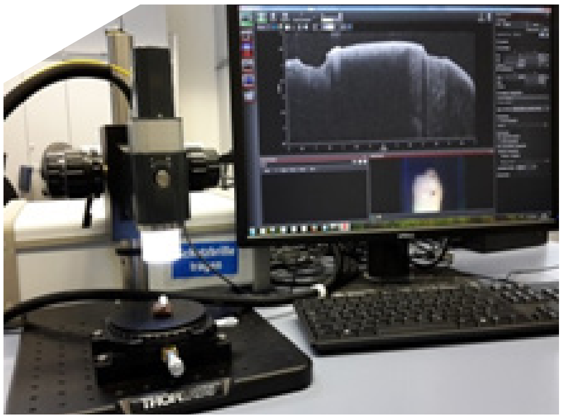

Fig. 1: Spectral domain OCT: Telesto II, λc = 1310 nm; Thorlabs GmbH, G.

Category	Description
0	no signal (sound)
1	signal limited to first quarter of enamel
2	signal extended up to second quarter of enamel
3	signal extension up to third quarter
4	signal located within fourth quarter of enamel

Fig.2: Categorization of lesion extent.

RESULTS

Comparing TMR- µCT, TMR – OCT and µCT - OCT in category 0 agreements were perfect to moderate (100 %/67 %/54 %). In category 1 fair to substantial agreements of 33 %/60 %/67 % were found. Category 1 was detected 2.5 and 2.7 times more often with TMR and OCT than with µCT.
Categories 2 + 3 + 4 resulted in moderate to almost perfect agreements (57 %/52 %/87 %).In categories 0 – 4 moderate to substantial Cohen's kappa agreements (□) of 0.47/0.48/0.69 were detected. Concerning the lesion depth/ correlation TMR- µCT, TMR- OCT and µCT- OCT were compared. The correlations were moderate to strong (0.515/0.614/0.597; pi ≤ 0.001) with the significant differences TMR vs. µCT and µCT vs. OCT (pi < 0.005).

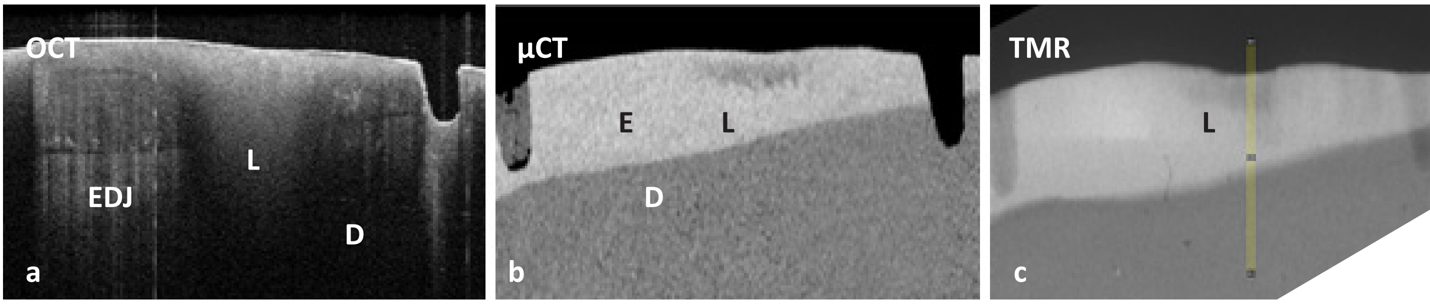

Fig. 2 a- c: A carious lesion (L) of ICDAS-II code 2 (category 2). Enamel (E), dentin (D), enamel-dentin-junction (EDJ).

DISCUSSION

OCT is a non-invasive method, which has proven potential in dental diagnosis, especially for detection and assessment of carious lesions. OCT applies near-infrared light for cross-sectional object imaging scanning to produce two-dimensional cross sections and tomograms. Another method for 3D assessment of materials is the micro-computed tomography technique (µCT). However, µCT is invasive, as X-rays are applied.
All used methods detected the extension of carious lesions in enamel. The demineralization within the ROI is partially different imaged by the various imaging modi. The high correspondence of WFC and TMR as reference methods and µCT or OCT indicated the reliability of the OCT. In case of category 1 OCT and TMR seem to be more suitable to verify enamel defects than µCT. The reference method TMR sometimes demonstrated the overvaluation of the lesion extent with OCT. It is to investigate, if the use of a suitable immersion-medium could improve image quality.

CONCLUSION

OCT seems to be more suitable to assess carious enamel lesions, limited to the first quarter of the enamel than µCT.

PROJECT TEAM

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SELECTED PUBLICATIONS

Park KJ, Schneider H, Haak R. Assessment of interfacial defects at composite restorations by swept source optical coherence tomography. J Biomed Opt. 2013; 18(7): 076018.

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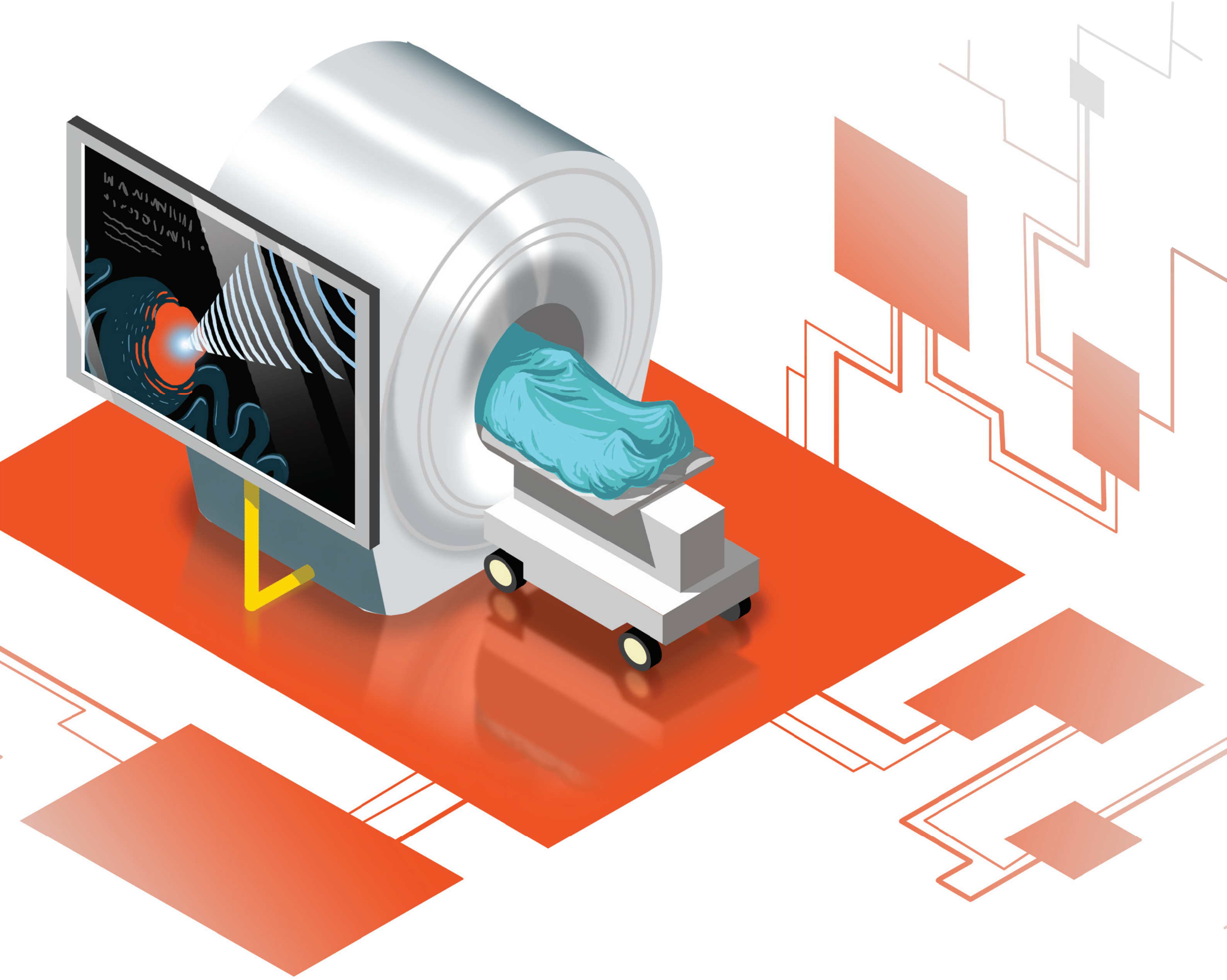
Schneider H, Rüger C, Gutsche CH, Meisner T, Haak R. Mesoscopic Assessment of Caries Infiltration of Non-cavitated Carious Lesions by Optical Coherence Tomography. Organisation for Caries Research. ORCA; Caries Res. 2014; 49: 1-67.

Schneider H, Meißner T, Rüger C, Gutsche CH, Haak R. Detection and Assessment of Carious Lesions by Optical Coherence Tomography vs. X-Ray Microtomography. ORCA; Caries Res. 2015; 49: 297–369.

Schneider H, Gottwald R, Meißner T, Krause F, Becker K, Attin T, Haak R. Assessment of Uncavitated Carious Enamel Lesions by Optical Coherence Tomography and X-Ray Microtomography. ORCA; Caries Res. 2016; 50(2): 180-270.

FUNDING

German Federal Ministry for Economic Affairs and Energy (BMWi): ZIM



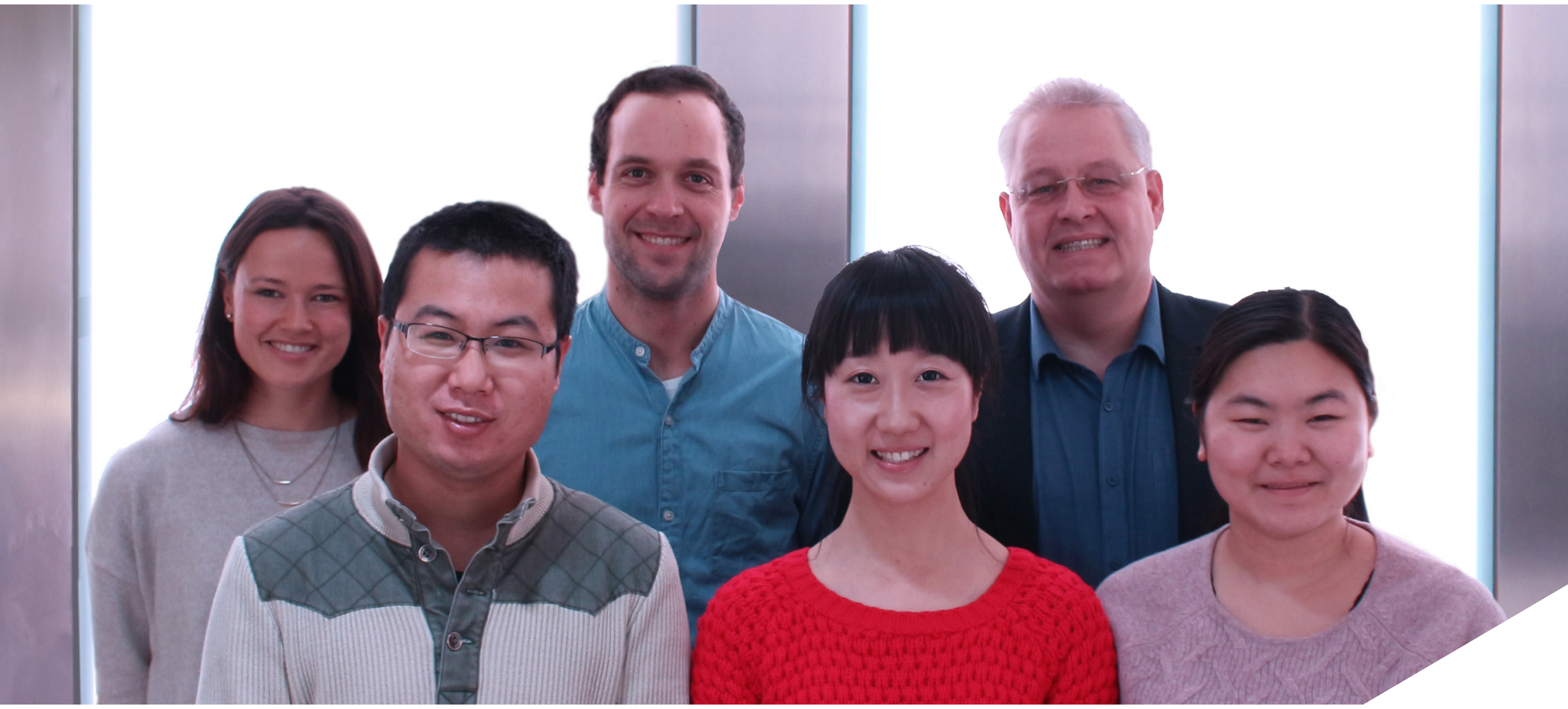
NON-INVASIVE IMAGE-GUIDED INTERVENTIONS

'To support investigation of preoperative diagnosis and real-time guidance for non-invasive image-guided surgery'

INTRODUCTION

In recent years, the application of focused ultrasound under MRI guidance has evolved. It is now approved by FDA to treat uterine myoma and bone and brain metastases. MRgFUS of the brain has received the CE mark and FDA approval for the treatment of thalamic induced pain, essential tremor and Parkinson's disease. Moreover, significant research is underway into its use in the treatment of benignant malignant bone disease as well as liver metastases and liver cancer (‚HCC' - see www.Trans-Fusimo.eu). A new area of research at ICCAS involves the development of novel application procedures in order to establish this new treatment modality as an option for the treatment of cancer, neuromodulation (LIFUP in collaboration with MPI-NCS,Leipzig and Fraunhofer IBMT, St. Ingbert). Through ICCAS funding a clinical focused ultrasound system has been acquired in 2016 and installed at the Department of Radiology so that new applications can be developed and validated in preclinical and clinical trials.

Activities in 2016 also included the establishment of focused ultrasound research for targeted drug delivery at SIKT and radiation therapy on in vitro cell cultures (SonoRay) in collaboration with OncoRay, Dresden. Robotic assisted PET MRI-guided interventions, tumor ablation and focused ultrasound have been progressed by testing and acquisition of a dedicated interventional coil and the MR compatible robotic system INNOMOTION.



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Schwenke M, Strehlow J, Haase S, Jenne J, Tanner C, Langø T, Loeve A, Karakitsios I, Xiao X, Levy Y, Sat G, Bezzi M, Braunewell S, Guenther M, Melzer A, Preusser T. An integrated model-based software for FUS in moving abdominal organs. Int J Hyperthermia. 2015; 31(3).

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SONORAY - TUMOR THERAPY COMBINED BY MR-GUIDED FOCUSED ULTRASOUND AND RADIATION THERAPY

INTRODUCTION

Radiation therapy is one of the main modalities of treatment for cancer patients in addition to conventional surgery and chemotherapy. Focused ultrasound (FUS) plays an increasing role in medical applications because of its thermal and mechanical effects on tissue, cells and bio-molecules, expanding its traditional applications from imaging and diagnostics to therapeutics. While hyperthermia and ablation with HIFU (Ter Haar 2001) are better established therapeutic methods, there is very significant research interest in ultrasound combined therapeutic approaches. Increased radiation sensitivity of tumor cells by high-intensity focused ultrasound exposure has already been demonstrated experimentally. Despite the potential of these studies, previous experiments were carried out only in vitro and on selected tumor cells. There is therefore a great need to carry out further systematic in vitro and, based on this, in vivo experiments in a suitable model to validate the effects of FUS.

AIMS

SONORAY project aims to combine therapeutic focused ultrasound and radiation therapy (RT) to treat malignant solid tumors and tumor metastases. The hypothesis underlying this approach is that the combination of two cancer cell destroying energies (i) the energy of high-intensity acoustic waves and (ii) ionizing radiation should be more effective in cancer treatment than the effect of employing one of the above two energy forms alone. The central scope of the project is to develop tumor cell biology fundamentals, the computer-aided model formation and to evaluate the success potential of a future clinical use of a FUS-RT combination therapy.

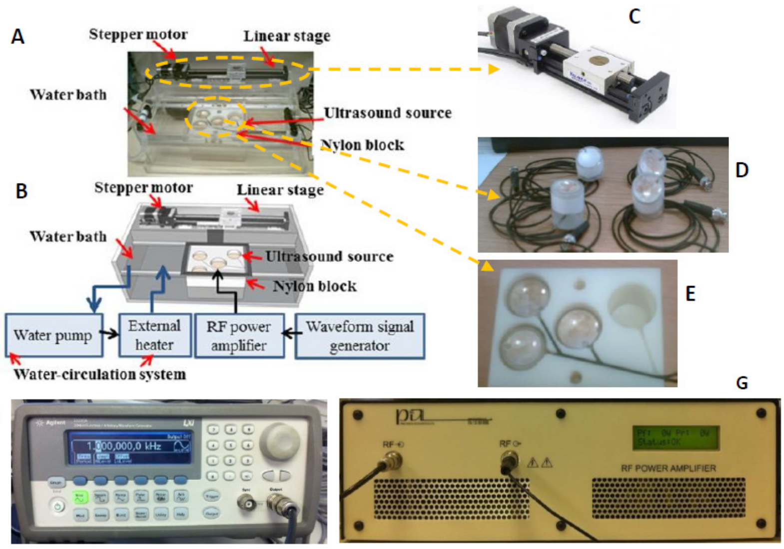

Fig. 1- Photograph (A) and schematic drawing (B) of the sonicator; stepper motor (C) to move the plate holder; piezoceramic bowl transducers within nylon housing (D); Perspex transducer cases (E); signal generator (F); and RF power amplifier (G).

OUTLOOK

Within the framework of this project, the basic principle of the FUS-RT effect on tumor cells (in vitro) and the tumor tissue (ex vivo and in vivo) is going to be analyzed preclinically based on previous experience (by Xu, Melzer et al). The principal task is to first quantify both thermal and mechanical acoustic effects of FUS on tumor cells and convert them into a biologically equivalent radiation dose in vitro stage. For this, biophysical simulations and modeling of FUS effects have to be developed. A further object is to develop a site-resolved multimodal therapy planning which can quantify the effect of the biologically effective doses generated by FUS and RT, also depending on the time regime of their application. This is, in combination with the in vivo experiments, the basis for determining optimal sequences of FUS-RT combination therapy, wherein the tumor entity, the dosage and the time regimes (order, temporal distance, fractionation scheme) occur as parameters.

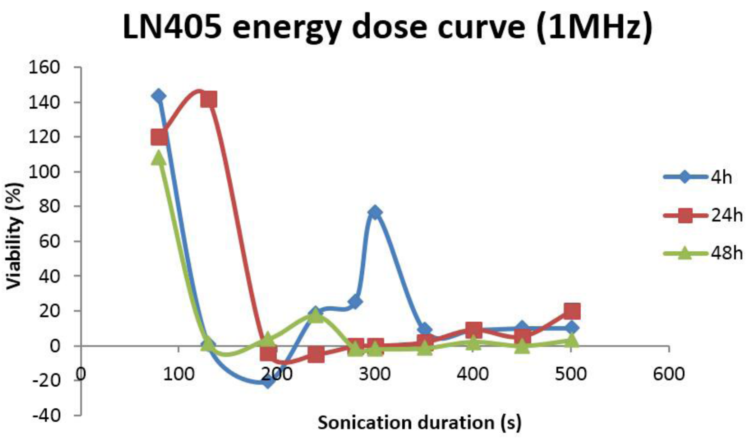

Fig. 2- Primary viability result of glioma cell line LN405, tested at 4h, 24h and 48h post- incubation after sonication by 1MHz FUS transducer.

On the basis of preclinical experiments, the success potential for translational model-based applications in the clinic can be assessed. In addition, combinations of therapy can be defined by the factors of an individualized FUS-RT in order to prove the exact value of the improved therapeutic success for cancer patients clinically. The methods and application concepts to be developed are to be used for patients with newly diagnosed non-metastatic solid tumors, as well as for patients with recurrent and metastatic tumors. Clinical applications could be the treatment of various tumors of the head and neck and the prostate carcinoma.

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FUNDING

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MRI-GUIDED FOCUSED ULTRASOUND IN THE TREATMENT OF SOLID TUMORS

INTRODUCTION

Minimally invasive, image-guided ablations of solid tumors have become a viable alternative to open surgery for a number of clinical indications. High-intensity focused ultrasound (HIFU) ablation is a truly noninvasive technique and can be combined with MR imaging to allow for an accurate treatment planning, monitoring and control ultimately providing a gentle and effective focal therapy for various solid tumors.

MATERIAL AND METHODS

Starting in January 2017, an MR-HIFU system (Philips Sonalleve) will be available for such procedures in the Department of Diagnostic and Interventional Radiology at Leipzig University Hospital. In comparison with other minimally-invasive thermal ablation methods, MR-HIFU is characterized by therapeutic ultrasound waves of high energy (> 100 W/cm2) that are generated outside the body and then focused with high 3D precision at a well-defined spot within the MRI-visible target area. The main effect of this so-called sonication is the local increase in tissue temperature (55° to 90°C) over a few seconds that subsequently results in coagulation necrosis by way of protein denaturation. Consecutive sonications cause multiple lesions in the target area until the entire MRI-prescribed tissue volume has been treated–without any skin incision. Non-invasive MRI temperature monitoring in real time will allow the interventionalist to optimize tumor destruction and protect surrounding tissue at risk. This offers a promising clinical option for a completely non-invasive treatment of solid tumors. The initial focus of clinical MR-HIFU interventions will be on selected patients with uterine fibroids and tumorous bone lesions. Relevant procedural data will also be stored in a dedicated register for future clinical evaluation and scientific analysis.

RESULTS

Optimized clinical imaging and therapeutic protocols are keys to the success of the procedure. Therefore, clinical preparation involved a continuous review of the current literature on indications, results and suggestions in the fields of MR-HIFU and image-guided thermal ablation in general. Valuable practical insights were gained by visiting the Radiology Departments of the Ludwig Maximilian University of Munich and of the University Hospital in Turku, Finland, who had already started clinical therapy programs with that particular HIFU system. These observations and interactions were taken into account for designing an initial Leipzig MR-HIFU therapy concept. This requires a close collaboration and interaction with the local clinical partners from the Departments of Gynecology, Radiotherapy and Nuclear Medicine with whom together future patients with uterine fibroids or tumorous bone lesions will be selected. In addition, an ethical proposal for scientific data analysis within the clinical MR-HIFU program was submitted to the institutional review board of the Medical Faculty of the University of Leipzig awaiting final approval.

DISCUSSION AND CONCLUSION

The existing literature has already shown the feasibility and effectiveness of MR-HIFU in the treatment of several solid tumors together with low complication rates. [1,2] The Sonalleve MR-HIFU system was CE-marked in 2009 for the treatment of uterine fibroids, by far the most established clinical indication, and in 2011 for that of bone metastases. A number of MR-HIFU programs are currently in full operation in Germany. Several studies worldwide have shown similar success rates of MR-HIFU compared with surgical and minimal-invasive standard therapies, for example, uterine artery embolization (UAE). [2,3] The clinical evidence for bone metastases is smaller but recent literature suggests that MR-HIFU may be supportive for medical pain therapies with significant side effects or become a non-invasive alternative for more radical treatments that are considered as intolerable. [4] Our aims are to implement MR-HIFU as a clinical therapy option for cancer treatment in Leipzig and contribute to the growing body of evidence in the clinical as well as the research community.

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CORRELATION OF CELL VIABILITY WITH FOCUSED ULTRASOUND ON FIBROBLASTS

INTRODUCTION

Focus ultrasound allows the deposition of ultrasound bio-effects including heating, cavitation and radiation force in cell. High intensity focus ultrasound may heat and induce cell death; however, low intensity ultrasound may enhance cell proliferation. Frequency, sonication duration, sound wave type, duty cycle, these parameters of ultrasound will effect on cells simultaneously. Fibroblasts are the main non-myocyte cells in heart and regulate extra cellular matrix, also play an important role in wound healing. In this study, we want to find the relationship between cell viability and ultrasound parameters, including time, energy and frequency.

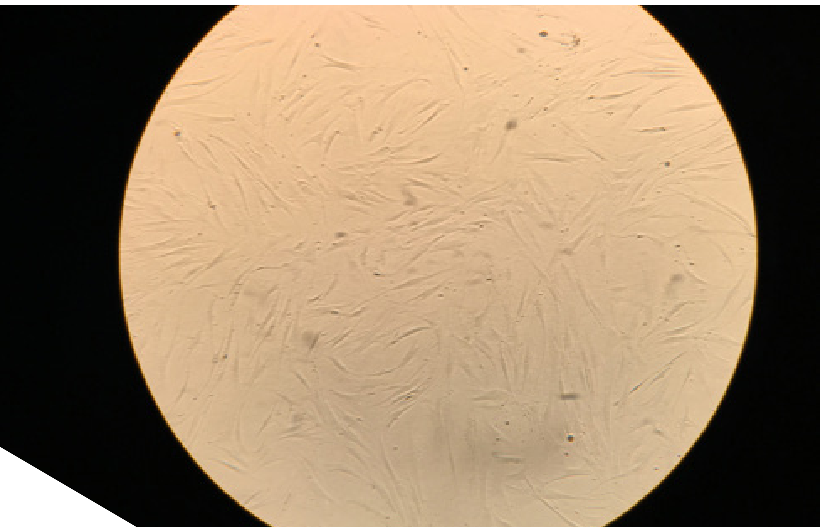

Fig. 1- Fibroblast cells.

MATERIAL AND METHODS

Seed 1000/well Human fibroblast cells in six 96-well plate (black with µ-clear bottom), divide the plates into two groups, time dose group and energy dose group, incubate for 24h, Fill 420ul/well medium and seal the well plate with Titer tops film. Time dose group are sonicated with 280mV energy, time range between 30s- 240s (f=0.4868MHz), 10s-120s (f=1.144MHz), energy dose group are sonicated for 60s, energy range between 120-400mV (f= 0.4868MHz), 80-500mV (f=1.144MHz). After sonication, remove the entire liquid, replace 100 µl /well fresh medium, determined cell viability with WST-1 reagent.

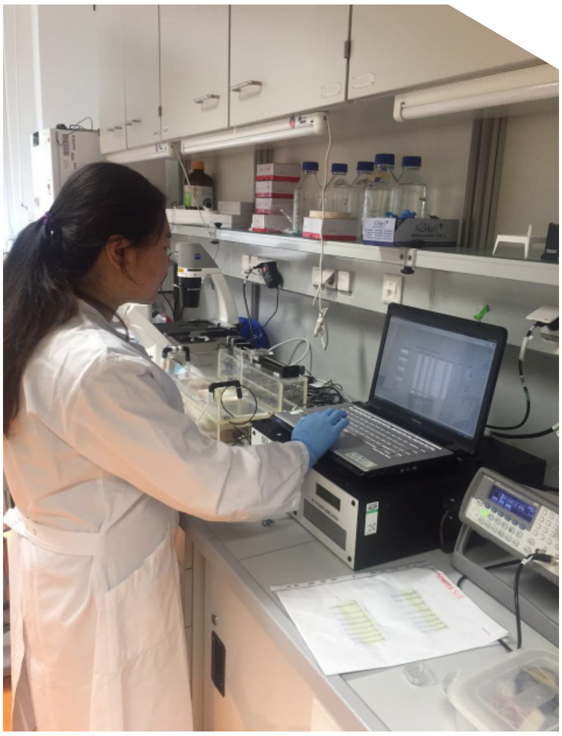

Fig. 2- Focused ultrasound workstation in cell laboratory.

RESULTS

The cells showed different status with different frequency. The cell viability increase after sonication with 0.5MHz transducer, and keep relatively high viability after 120s sonication. With 1 MHz transducer, the cell may be damaged after sonicated for more than 90s. The cell viability increased with low energy and low frequency sonication (have been reported), when sonication energy is more than 330 mV, the growth of cells begin to slow down.

DISCUSSION AND CONCLUSION

The fibroblast cells showed different status with different frequency. There is an obvious negative correlation between time dose and cell viability, however, according to the experiment result, we didn't find a regular relationship between energy and cell viability. When high energy (above 400 mV with 1.144MHz transducer) is applied, the bottom of the 96-well plate will be melted and shape changes have an effect on light absorbance result then lead to errors.

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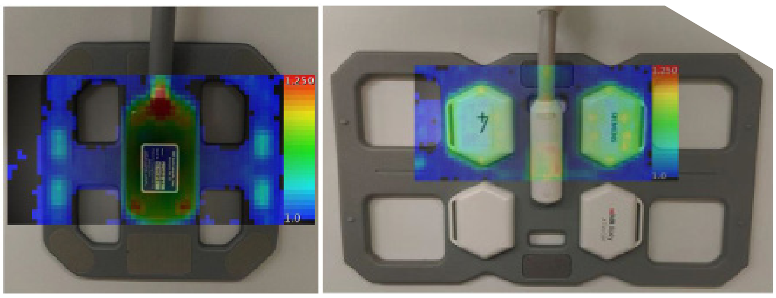
SELECTED PUBLICATIONS

Camacho J, Lindner D, Arlt F, Müns A, Chalopin C. Model-based brain tumor segmentation in intraoperative ultrasound images. 49th Annual conference of the German Society for Biomedical Engineering (DGBMT); Lübeck; 2015.

PRACTICABILITY OF AN INTERVENTIONAL COIL FOR SIMULTANEOUS PET-MRI

INTRODUCTION

Combined Positron Emission Tomography (PET) with Computed Tomography (CT) and particularly Magnetic Resonance Imaging (MRI) provide a unique method for studying anatomy and function of the human body in a simultaneous manner. As such, it would complement interventional procedures by a rich set of diagnostic information. In contemporary PET-MRI systems, both modalities can be operated almost independently. There are a few centers around the world which are attempting to establish PET-CT-guided interventions for the biopsy of otherwise invisible lesions and in particular for the thermal ablation of tumor lesions undetected by Ultrasound, CT and MRI as well as to verify tumor metabolism. Stephen Solomon and his colleagues from the Memorial Sloan Kettering Cancer Center (MSKCC) in New York (a collaborator of Andreas Melzer) have put forward a concept to split the dose of radiotracer into an initial small dose (one third) to visualize the lesion so that thermal ablation can be carried out, and then to inject the second dose to visualize any remaining metabolism inside the ablated lesion.
PET MRI would be favorable due to variable soft tissue contrast, temperature mapping and obviates the ionizing radiation of CT, however, interventional MRI requires additional equipment (e.g. cannulas, probes, catheters, focused ultrasound applicators). This leads to unwanted additional attenuation of the 511-keV PET annihilation photons (gamma radiation) resulting in quantification bias of tracer uptake. Therefore, it is desirable to use equipment with little absorption/scatter of gamma photons. This is usually achieved by using material with low atomic numbers and by placing electronic components with high attenuation outside the region of examination.



Interventional Coil PET-MRI Coil

Fig. 1- Color-coded map of the planar PET attenuation factor overlaid onto a photographic image of the interventional DuoFLEX coil and the standard PET-MRI flexible surface coil.

AIMS

This study compares the attenuation properties of an interventional coil (DuoFLEX 3T, MR Instruments Inc., Minnetonka MN, USA) with those of a standard PET-MRI coil (Biograph mMR Body Flex Coil, Siemens Healthcare, Erlangen, Germany). For this comparison, transmission scans were carried out in a standalone PET scanner (ECAT-EXACT-HR+,

Siemes Healthcare, Knoxville TN, USA) equipped with Ge-68 line sources.
Fig. 2 shows that the attenuation is slightly higher for the interventional coil, in particular close to the electronic components of the coil. However, the attenuation factor would still be acceptable for most types of interventions where PET would be used primarily for localization instead of exact quantification based on tracer uptake.

In order to reduce radiation exposure to the interventionist we are currently preparing the installation of the MR compatible Robotic system INNOMOTION .The system provided for the first time position of Biopsy and ablation probes inside the MRI bore and will be equipped to hold a focused Ultrasound system (Fraunhofer IBMT) for PET MRI guided tumor ablation and hyperthermia (Sono-Ray Meta ZIK, BMBF Project).

OUTLOOK

Modifications of the interventional equipment, e.g. by placing most of the electronics outside the region of examination, could help reducing the attenuation and better meeting the requirements of PET-MRI.

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SELECTED PUBLICATIONS

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MRGLIFUP: NEURO-MODULATION USING MRI-GUIDED LIGHT INTENSITY FOCUSED ULTRASOUND

Since 2015, a team made up of partners from ICCAS, the Fraunhofer IBMT (St Ingbert) and the Max Planck NCS (Leipzig) have been developing a technique known as MRI-guided light intensity focused ultrasound (LIFUP) with a view to using it for neuro-modulation. LIFUP builds on experience in MR-guided focused ultrasound for the thermal ablation of tissue (Melzer et al)[1], the expertise of Prof. Arno Villringer, Director of the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig,[2] and the technical knowhow of both Steffen Tretbar, head of the Division of Ultrasound at the Fraunhofer Institute for Biomedical Engineering (IBMT) in St. Ingbert, and Andreas Melzer from ICCAS. The concept (see figures below) is based on recent findings indicating that focused ultrasound can non-invasively induce modulation of neurons in the central nervous system. This would have the potential of suppression and/or activation of neuronal activity. The goal is to use MRgLIFUP to non-invasively modulate certain areas of the brain to treat for example stroke, addiction, chronic OCD (obsessive compulsive disorder),

essential tremor and Parkinson's disease.
The first human trials using a preliminary ultrasound system developed by the IBMT will start in 2017, enabling the effects induced by diagnostic ultrasound energy levels to be evaluated (Prof. Villringer, MPI, Leipzig).

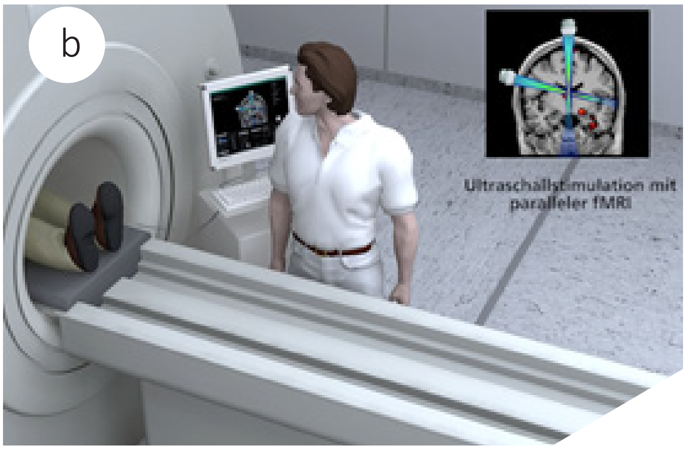

Fig. a & b: © Fraunhofer IBMT

The LIFUP project will employ MR-compatible ultrasound hardware developed by Fraunhofer IBMT. Compared to MRgFUS, MRgLIFUP uses ultrasound at a much lower intensity which does not harm the central nervous system. Based on MRI preplanning (a), modulation is applied under MRI guidance (b).

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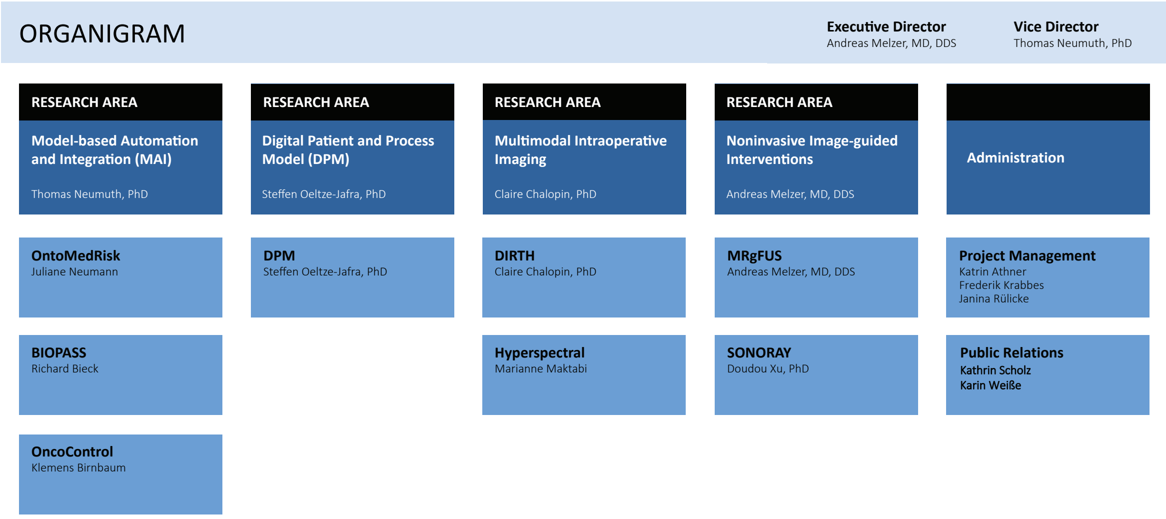

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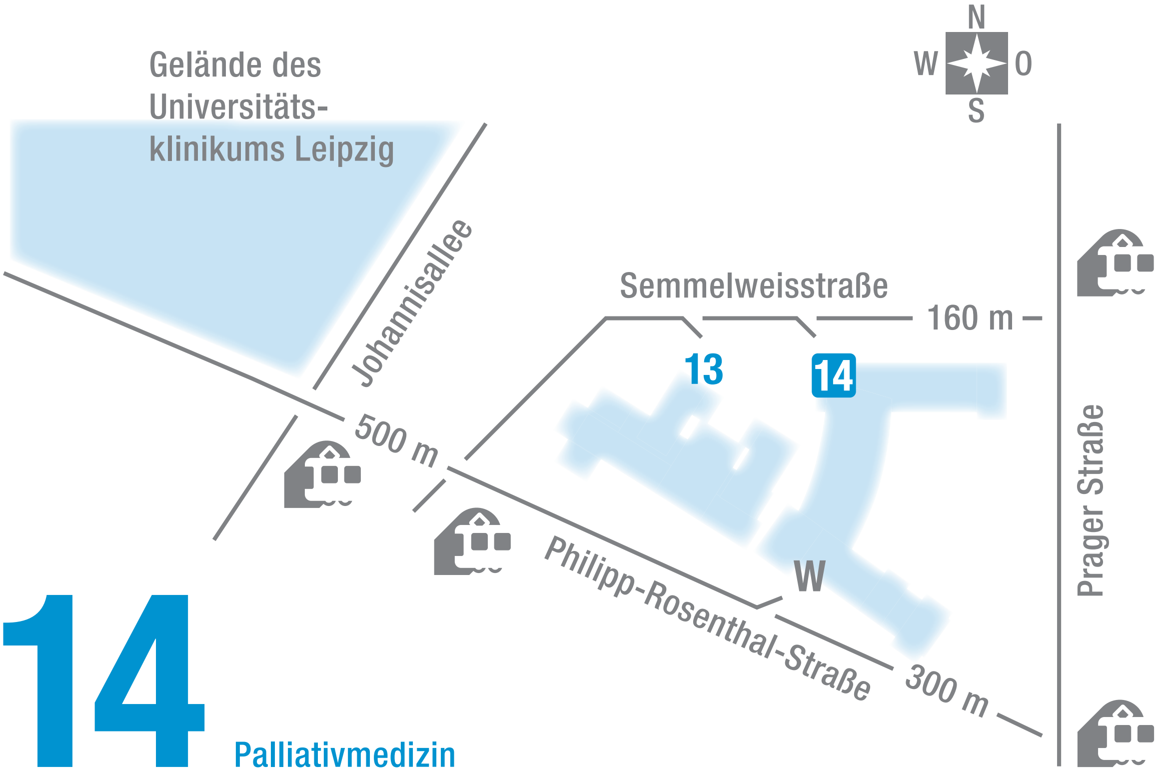

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