UNIVERSITÄT LEIPZIG

Medizinische Fakultät

2015
ANNUAL REPORT

iccas

IMPRINT

EDITOR

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Medizinische Fakultät
Innovation Center Computer Assisted Surgery (ICCAS)

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PRINT

Merkur Druck- und Kopierzentrum GmbH & Co. KG Leipzig

PHOTOS

ICCAS, Swen Reichhold, Thilo Schoch (BMBF)

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PREFACE

First of all, I'd like to sincerely congratulate the ICCAS team on their outstanding achievements in 2015. This year's annual report celebrates ten years of successful research and development at ICCAS and salutes erstwhile scientists' excellent results and their contribution to building up the center. We are indebted to the following professors who were instrumental to the success of ICCAS: Gero Strauß , Volkmar Falk, Dirk Bartz, Oliver Burgert, Werner Korb, Kerstin Denecke, and until today Thomas Neumuth.

The year 2015 saw several important changes and new activities. They include a significant increase in ICCAS's profile thanks to presentations at major conferences in Germany and abroad such as CARS, BMT, CURAC, SMIT, CIRSE and RSNA. ICCAS members also organized special ICCAS sessions and symposia. ICCAS's second DORS summer school received 63 CME credits and 29 continuing education units for the first time and was a resounding success. It was attended by delegates from 5 countries and additional featured hands-on sessions in interventional radiology and image guided cardiac surgery.

In 2015, collaboration was initiated or reactivated with several departments of Leipzig University Hospital: Radiology, Nuclear Medicine, Anesthesia, Maxillo Facial and General Surgery. To support the new areas of work at ICCAS, a new research group devoted to multimodal intraoperative imaging was set up under the leadership of Dr. Claire Chalopin. The exceptional cooperation with HTWK Leipzig University of Applied Sciences is on the way of being formalized with the goal of building up a joint research center of advanced medical technology with joint professorships.

Collaboration was also established and fostered with the Max Plank Institute for Human Cognitive and Brain Sciences, the Fraunhofer MEVIS Institute for Medical Image Computing in Bremen, and the Fraunhofer Institute for Biomedical Engineering in St. Ingbert on MRI-guided light intensity focused ultrasound (LIFUP) for neuro-modulation, leading to a successfully submitted grant proposal. There was also an initial exchange of ideas with the Dresden branch of the Fraunhofer Institute for Machine Tools and Forming Technology IWU, the Fraunhofer Institute for Integrated Circuits IIS Erlangen, and the Fraunhofer Institute for Manufacturing Engineering and Automation IPA Stuttgart (Mannheim Branch) as well as with the leaders of the STIMULATE Research Campus at the University of Magdeburg. Furthermore, crucial first steps were taken towards a 'Meta-ZIK' funding bid by ICCAS and OncoRay (Dresden) to develop MR guided focused ultrasound mediated radiation therapy.

In summary, ICCAS is now well on track to becoming a fully established institute of Universität Leipzig's Faculty of Medicine and has received outstanding support to achieve this goal.

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

10 YEARS OF ICCAS: A BRIEF REVIEW

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

2006

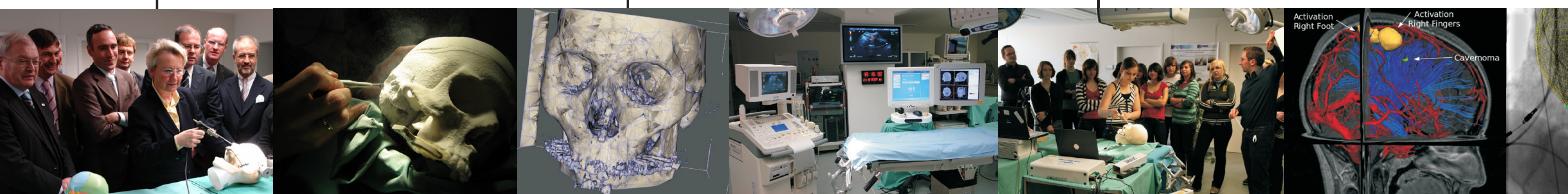
Aspects of CAS included in educational programs of the Faculty of Medicine and the Faculty of Mathematics and Computer Science, University of Leipzig

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)



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)

2009

ICCAS colloquium on Computer Assisted Surgery launched

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

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 IFAM, 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 2015)

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

2015+

Expansion into computer assisted diagnosis and therapy by involving additional medical disciplines such as interventional radiology, nuclear medicine, gastroenterology, urology, gynecology and general surgery

Fostering collaboration with Fraunhofer and Max Planck Institutes

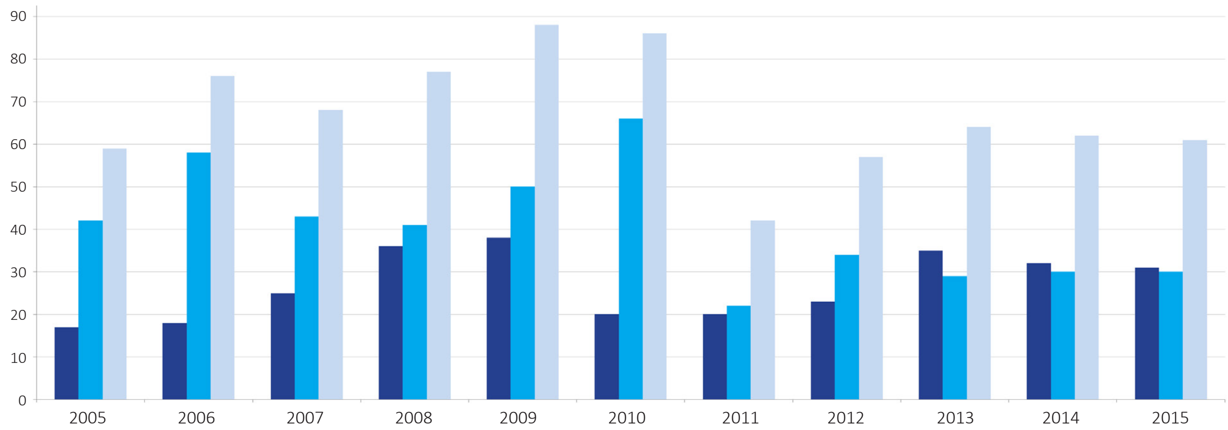
Expansion of the ICCAS network to other leading centers in Europe, the US and Asia

Translation of the results to the environment of the OR to promote personalized surgery and precision medicine

FACTS AND FIGURES

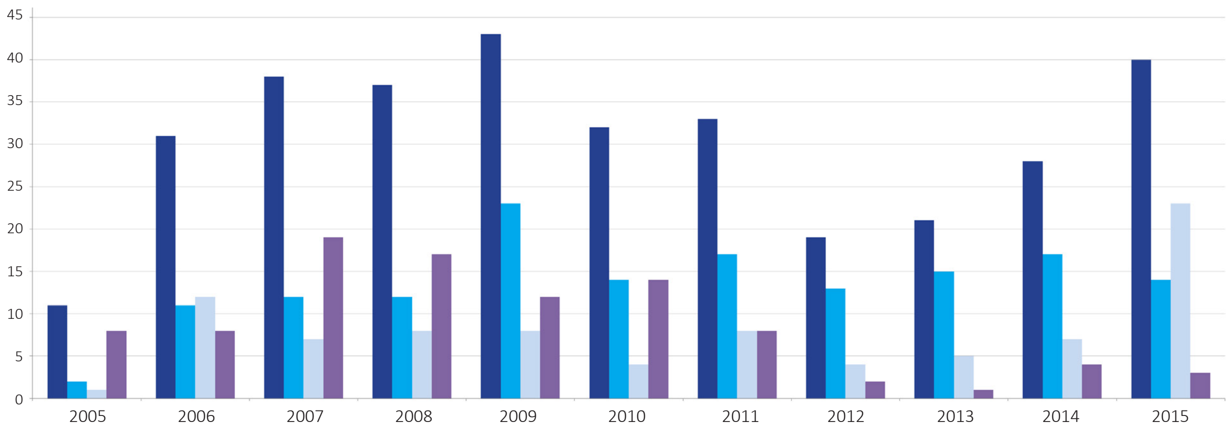
HEADCOUNT

The headcount at ICCAS rose in its first phase (2005–10) from initially 59 to 86. Decreasing substantially in 2011 when fixed-term junior research groups were discontinued as planned, it rose again the following year and stabilized at over 60 members of staff until 2015.



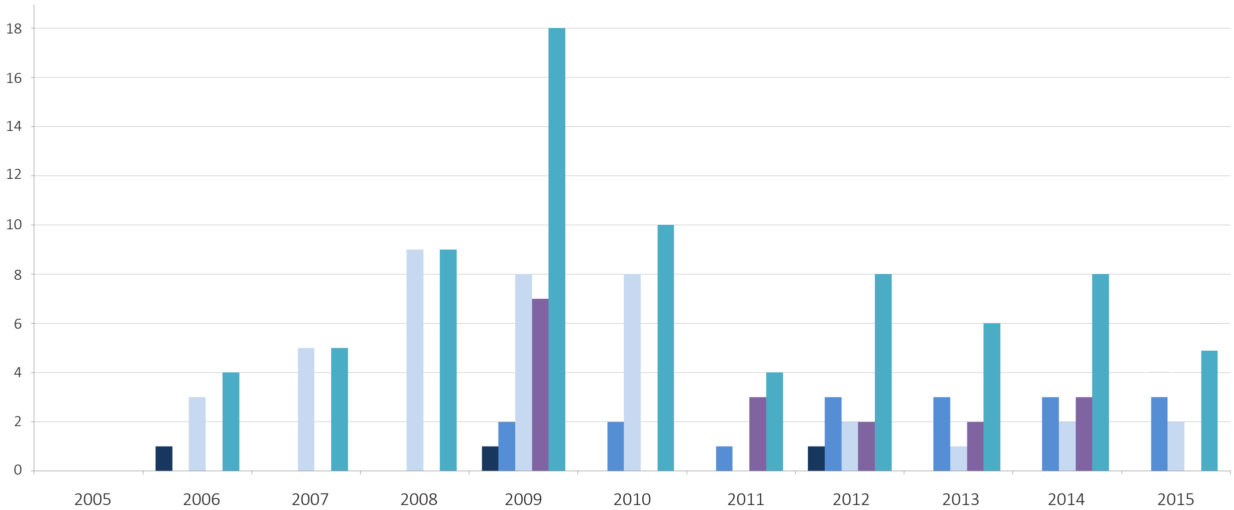
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Staff	17	18	25	36	38	20	20	23	35	32	31
Students	42	58	43	41	50	66	22	34	29	30	30
Absolute	59	76	68	77	88	86	42	57	64	62	61

PUBLICATIONS



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Absolute	11	31	38	37	43	32	33	19	21	28	40
Lead authorship	2	11	12	12	23	14	17	13	15	17	14
Co-authorship	1	12	7	8	8	4	8	4	5	7	23
Book contributions	8	8	19	17	12	14	8	2	1	4	3

GRADUATIONS



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Habilitation	0	1	0	0	1	0	0	1	0	0	0
Doctoral thesis	0	0	0	0	2	2	1	3	3	3	3
Senior thesis	0	3	5	9	8	8	0	2	1	2	2
Bachelor thesis	0	0	0	0	7	0	3	2	2	3	0
Absolute	0	4	5	9	18	10	4	8	6	8	5

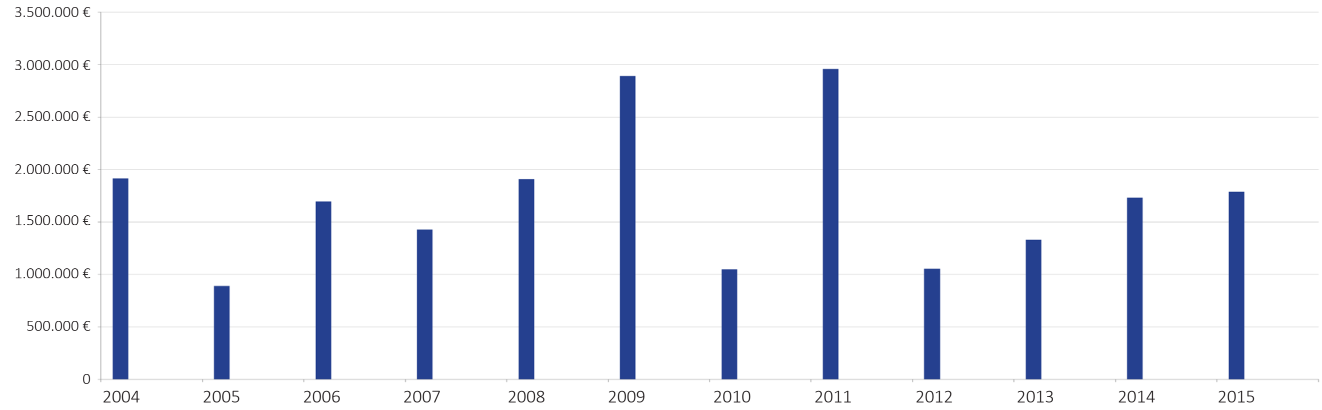
ICCAS GRADUATIONS IN 2015

Dr. Christian Meißner (M.Sc., Dipl.-Ing. (FH))
Dissertation title: „Perspektivenorientierte Erkennung chirurgischer Aktivitäten im Operationssaal"
Institute: Faculty of Medicine, Universität Leipzig
Grade: magna cum laude

Dr. Sandra von Sachsen (Master Multimédia, Dipl. Inf. (FH))
Dissertation title: „Einsatz numerischer Simulationen für einen Vergleich von Stentgrafts in der endovaskulären Gefäßmedizin. Einsatzpotenzial, Anforderungsspezifikation und Mensch-Maschine-Schnittstelle."
Institute: Faculty of Medicine
Grade: summa cum laude

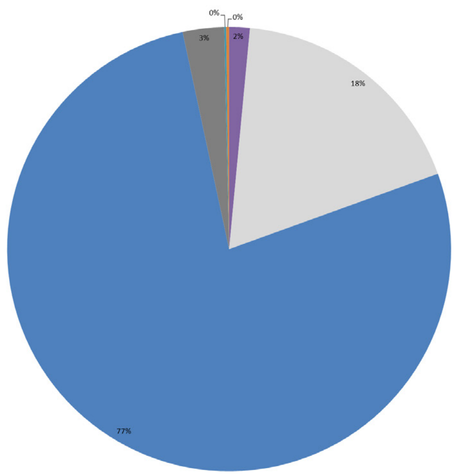
Dr. Jens Meier (Dipl.-Ing.)
Dissertation title: "Structured patient information management for efficient treatment and healthcare quality assurance in oncology"
Institute: Faculty of Medicine
Grade: magna cum laude

FUNDING



Year	Third-party funds
2004	1.913.590,32 €
2005	892.039,98 €
2006	1.695.836,56 €
2007	1.429.355,42 €
2008	1.906.172,98 €
2009	2.890.662,57 €
2010	1.047.238,62 €
2011	2.957.377,42 €
2012	1.055.205,04 €
2013	1.331.902,12 €
2014	1.732.219,43 €
2015	1.792.647 €

DFG	304.542,40 €
SMWK	3.647.976,62 €
BMBF	15.650.196,13 €
BMWI	611.147,53 €
Industry	27.896,46 €
Others	43.309,37 €



External funding spent at ICCAS between 2004 and 2015 totaled €20.6 million. ICCAS is mainly financed by the BMBF Federal Ministry of Education and Research under its ZIK Centers of Innovation Excellence program. Other external funding in this period 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. Universität Leipzig's Faculty of Medicine also provides ICCAS with performance-based funding. Even before ICCAS had been formally established, initial infrastructure investment took place. In 2009, the government of Saxony paid for an operating room at ICCAS to be used solely for research purposes. After the transition between the two ZIK funding periods in 2010, Demo OP 2.0 was opened in 2011 thanks to a strategic investment of €2 million by the BMBF during ICCAS's second funding period. Furthermore, this period saw a steady rise in the number of externally funded projects.

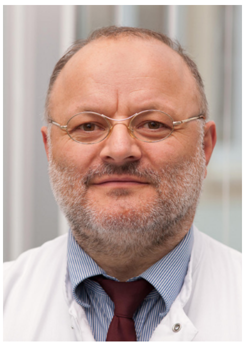
Since 2014, the long vacant position of director was finally filled. In connection with this professorship financed by the government of Saxony, considerable additional funding was received from the Faculty of Medicine to stabilize this Center of Innovation Excellence.

ICCAS PREVIOUS SCIENTIFIC BOARD MEMBERS

The current ICCAS team would like to express utmost gratitude to the following persons who where instrumental building up the center from the very beginning and helped to establish the hitherto very successful research and development in the field of computer assisted surgery.

Prof. Dr. med. Gero Strauß
One of the pioneers of computer assisted surgery in Leipzig, ENT surgeon Gero Strauß was a co-founder of ICCAS and its Chief Executive Officer from 2005 until 2014. Furthermore, he remained on the Board of ICCAS until 2015 and initiated several research activities in the areas of navigated control, preoperative 3D-planning for skull base surgery, surgical simulation, and scientific tools for the evaluation of CAS systems. In 2006, he received his habilitation from Universität Leipzig. Since 2009, he has been the director of the International Reference and Development Center for Surgical Technology (IRDC) and head physician of the Acqua Clinic, both in Leipzig.

Prof. Dr. med. Volkmar Falk
Volkmar Falk was one of the ICCAS's founding members and a member of the board from 2005 until 2009. He was then elected to the Advisory Board of ICCAS. A specialized cardiac surgeon, he worked at Herzzentrum Leipzig from 1998 until 2009, and afterwards was made director of the Department of Cardiovascular Surgery at Zurich University Hospital. Since October 2014, he has been the medical director of the German Heart Institute in Berlin, where he is also the director of the Department of Cardiothoracic and Vascular Surgery. In 2015, he was appointed professor ordinarius of the Clinic for Cardiothoracic and Vascular Surgery at the Charité Berlin. He specializes in minimally invasive heart valve surgery.



Dr. med. Christos Trantakis
Christos Trantakis was one of the founding members of ICCAS and belonged to the ICCAS board from 2005 until 2010. He studied human medicine and graduated in 1991 at Universität Leipzig and worked as a neurosurgeon at Leipzig University Hospital. Since 2010, he is chief physician of the Department of Head and Spinal Microsurgery at Sana Kliniken Leipziger Land. His scientific focus is on intraoperative imaging using MRI and ultrasound, functional neuronavigation and 3D-ultrasound navigation. Special clinical topics are pituitary and skull base tumor surgery.

Prof. Dr. rer. nat. Dirk Bartz
Dirk Bartz studied computer science and medicine at the University of Erlangen-Nuremberg and Stony Brook University in New York. He received his PhD in 2001 and his habilitation in 2005 in computer science from the University of Tübingen. In January 2007, he was appointed professor of computer assisted surgery at Universität Leipzig and headed the “Visual Computing” research group at ICCAS. He passed away in 2010. Prof. Bartz made important contributions to the fields of virtual endoscopy, augmented reality, illustrative visualization and medical imaging.

ICCAS ALUMNI

The following persons have contributed most significantly to the research and development at ICCAS and all have accomplished great career developments.

Prof. Dr.-Ing. Oliver Burgert
Oliver Burgert graduated at the University of Karlsruhe on volume based surgical simulation and planning in 2015. From 2005 until 2011, he was the scientific director of a research group at ICCAS, where he headed the development of a modular model-based system architecture for the operating room. In 2007, he co-founded SWAN (Scientific Workflow Analysis GmbH). Since October 2011, he has been professor of medical informatics at Reutlingen University. He is currently the vice dean of the Faculty of Informatics and head of the „Computer Assisted Medicine“ research group.

Prof. Dr. sc. hum. Werner Korb
Werner Korb studied technical mathematics and computer science at Vienna University of Technology and received a doctorate in medical computer science and medical physics from the University of Heidelberg in 2005. After positions as a research assistant at the German Cancer Research Center in Heidelberg and Heidelberg University Hospital, he joined ICCAS as head of the junior research group “Assessment of Surgical Automation Systems”. Since 2010, he has been the scientific director of the “Innovative Surgical Training Technologies” Research Center at HTWK Leipzig University of Applied Sciences.

Prof. Dr. rer. nat. Kerstin Denecke
Kerstin Denecke received her first degree (2004) and doctorate (2008) from Braunschweig University of Technology. She was then employed as a software engineer at ID GmbH in Berlin and at the L3S Research Center at the University of Hannover. The specific areas she has been working on include information extraction, knowledge retrieval, sentiment analysis and data mining. She joined ICCAS in 2013 as head of the "Digital Patient Model" research group. In 2015, she received a professorship at the Institute for Medical Informatics at Bern University of Applied Sciences.

Prof. Dr.-Ing. Rafael Mayoral Malmström
Rafael Mayoral Malmström is professor of business computing at Kempten University of Applied Sciences. He was awarded his engineering degree and a PhD in computer vision from the Public University of Navarre in Pamplona, Spain. He was subsequently appointed a research fellow at the Centre for Computer Graphics and Visualisation at the University of Luton in the UK. From 2005 until 2010, he headed the "Patient Modeling" research group at ICCAS. He also has private sector experience in the fields of process optimization in healthcare and interoperability in the OR.

Dr. Michelle Audette	Old Dominion University, Norfolk, Virgina, USA
Dr.-Ing. Stefan Bohn	Jena University Hospital, Jena, Germany
Dr. Silvia Born	University of Zurich, Switzerland
Dr. Michael Gessat	Leica Microsystems AG, Wetzlar, Germany
Dr. Ronny Grunert	Fraunhofer Institute for Machine Tools and Forming Technology IWU, Dresden, Germany
Dr. Mohamed Karar	Cairo University, Egypt
Philipp Liebmann	EIZO Europe GmbH, Mönchengladbach, Germany
Dr. Jens Meier	IQTIG- Institut für Qualitätssicherung und Transparenz im Gesundheitswesen, Berlin, Germany
Dr. Christian Meißner	TomTom AG, Leipzig, Germany
Dr. Albert Pritzkau	Fraunhofer Institute (FKIE), Wachtberg-Werthoven, Germany
Dr. Sandra Schumann	German Aerospace Center, Köln, Germany

HIGHLIGHTS OF ICCAS'S 10 YEARS IN 2015

ICCAS SESSION AT CARS IN BARCELONA

During CARS, ICCAS marked its tenth anniversary by hosting a session to present its latest advances and future prospects in key aspects of computer assisted surgery and clinical decision-making. The session opened with an explanation of the advantages of harnessing computer assisted technologies by board member Prof. Andreas Dietz using the example of a laryngeal carcinoma. Prof. Andreas Melzer spoke about MRI-guided focused ultrasound surgery considered as a fully closed-loop computerized surgical procedure to remove tumor tissue via focused ultrasound ablation. Prof. Neumuth's presentation introduced examples of workflow-supported surgery and demonstrated visions for future applications. Finally, Mario Cypko explained how model-based decision support addresses problems of information integration, data interpretation, and the reproducibility of decision-making.

2ND DIGITAL OPERATING ROOM SUMMER SCHOOL (DORS 2015)

In August this year, ICCAS hosted its second Digital Operating Room Summer School (DORS 2015). Participants came from all over the world to further their knowledge about the development of surgical assistance systems for the modern operating room. The one-week intensive course was certified with the highest number of CME credits and included lectures, practical workshops, a teaching session at the Faculty of Medicine's Anatomical Institute, and surgical consultations at both the Heart Center and the newly opened operating theatre of the ENT Department at Leipzig University Hospital. DORS was a valuable opportunity for participants to find out about ICCAS's key areas of innovation such as the Digital Patient Model, operating room infrastructure, and workflow management, not to mention the latest technology used in practical areas. The participants praised the good balance between clinical and technical aspects and above all the practical sessions. Many thanks go out to all the contributors to this event. Planning is already underway for ICCAS's next DORS in September 2016.

2015 ICCAS INTERNATIONAL SYMPOSIUM

On August 29, ICCAS celebrated its tenth anniversary by hosting an international symposium at Universität Leipzig's Paulinum. Attended by distinguished guests, it was opened by ICCAS director Professor Andreas Melzer, who also presided over the scientific program. He thanked those attending for their joint work in advancing computer-assisted surgery. The symposium ended with a discussion between the speakers and the audience. Once again, the important role of the physician was underlined. It was repeated that technical innovations are designed not to replace surgeons, but instead to help them arrive at treatment decisions in a more transparent manner based on verifiable knowledge – and hence create more confidence and reliability for both doctor and patient.
Profound thanks are due to all the speakers for their fascinating presentations:

» Mario Cypko: "Developments in Computer Assisted Medicine – Digital Patient Modeling"
» Prof. Dr. Andreas Dietz: "Developments in Computer Assisted Medicine – Surgical Oncology"
» Prof. Dr. Thomas Kahn: "Developments in Computer Assisted Medicine – Image-Guided Procedures"
» Prof. Dr. Ron Kikinis: Keynote Lecture: "Tsunami in the Procedure Room: The Growing Challenge of Managing Data in Image-Guided Interventions and Surgery"
» Prof. Dr. Ron Kikinis: "Collaboration Fraunhofer Institute for Medical Image Computing MEVIS – ICCAS"
» Prof. Dr. Markus Krabbes: "Cooperation Leipzig University of Applied Sciences HTWK – ICCAS"
» Prof. Dr. Jürgen Meixensberger: "Review and Perspective 10 Years ICCAS"
» Prof. Dr. Heinz U. Lemke: "Standards for Computer Assisted Surgery"
» Prof. Dr. Thomas Neumuth: "OR Infrastructure and Intraoperative Workflows"
» Prof. Dr. Bernhard Sattler: „Developments in Computer Assisted Medicine – Nuclear Medicine: Potential of PET-MR Hybrid Imaging"
» Prof. Dr. Joerg Seeburger: "Developments in Computer Assisted Medicine – Cardiovascular Surgery"
» Prof. Dr. Arno Villringer: "Cooperation Max Planck Institute for Human Cognitive and Brain Sciences – ICCAS"

NEWSFEED 2015

BVM AWARD FOR DR. FRANK HECKEL

Lübeck, March 17, 2015

Dr. Frank Heckel received the BVM Award 2015 for his outstanding thesis at this year's BVM (Image Processing for Medicine) workshop in Lübeck.

ICCAS CONTRIBUTIONS AT CONHIT 2015

Berlin, April 15, 2015

During a satellite workshop at conhIT, the concept and methodology of the Digital Patient Model were presented based on the idea of knowledge-based systems in medicine.

GIRLS' DAY 2015

Leipzig, April 25, 2015

ICCAS scientists welcomed female pupils from the 8th and 9th grades to an experimental afternoon of hands-on experimentation during which they got to grips with medical assistance systems.

ICCAS MARKS 600 YEARS OF UNIVERSITY MEDICINE IN LEIPZIG

Leipzig, July 10, 2015

During the celebrations, researchers from ICCAS hosted a stand where visitors could try out computer-controlled surgical assistance systems.

COOPERATION WITH MPI STARTS

Leipzig, July 2015

With Prof. Andreas Melzer having been a research associate at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, this joint research project will focus on the use of magnetic resonance-guided focused ultrasound (MRgFUS) in neuronal modulation and stimulation.

ICCAS SESSIONS AT BMT 2015

Lübeck, September 16 – 18, 2015

ICCAS researchers held two sessions at the Annual Conference of the German Society for Biomedical Engineering (DGBMT). They explained a prototype system for computer-assisted neurosurgery as well as a general concept for the development of model-guided clinical decision support systems.

ICCAS AT THE 14TH ANNUAL CONFERENCE OF CURAC

Bremen, September 17 – 19, 2015

ICCAS's presentations at CURAC 2015 addressed the use of an open communication infrastructure to support the surgical process, which entails linking up surgical equipment, sensors and workflow management.

CHANGES TO THE ICCAS BOARDS

This year, founder member of ICCAS Prof. Gero Strauß retired from the ICCAS Board while Dr. Gerd Uhlmann left the Advisory Board.
The new additions to the Advisory Board are Prof. Ron Kikinis from the Fraunhofer Institute for Medical Image Computing MEVIS and Prof. Günter Rau from the Helmholtz Institute for Biomedical Engineering at RWTH Aachen University.

CLINICAL ADVISORY BOARD FOUNDED

In September 2015, a new Clinical Advisory Board was set up, comprising selected representatives of various departments at Leipzig University Hospital and Herzzentrum Leipzig.

M2CAI WORKSHOP 2015

Munich, October 9, 2015

For the sixth time, ICCAS co-organized the Modeling and Monitoring of Computer Assisted Interventions workshop, a satellite event at the International Conference on Medical Image Computing and Computer Assisted Interventions (MICCAI).

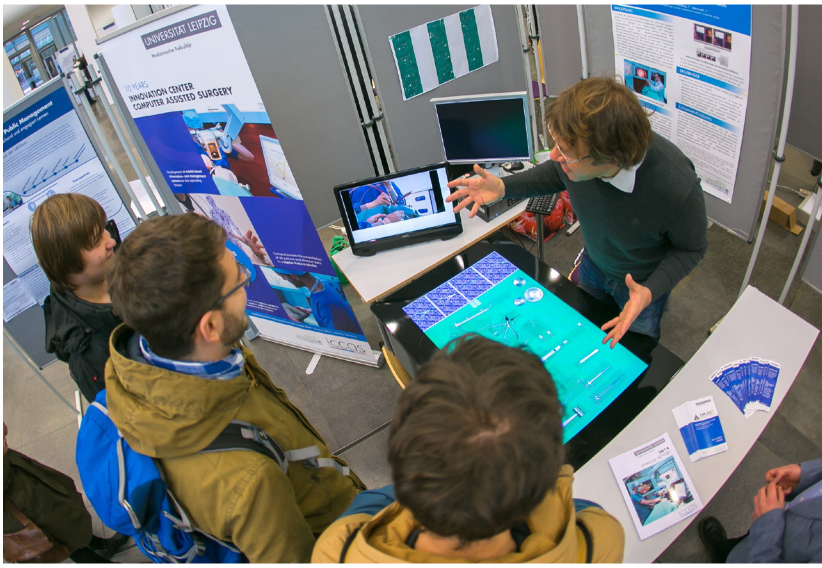
ICCAS AT RSNA 2015

Chicago (USA), November 29 – December 4, 2015

At the 101st RSNA, ICCAS outlined its research work to an international audience and presented the first mobile demo build of CephaLens.

ICCAS PRESENTATION AT 2015 DIES ACADEMICUS

Leipzig, December 2, 2015



At University of Leipzig's 2015 Open Day, visitors were able to try out an interactive training system used by OR personnel to practice the handling of surgical instruments.

ICCAS IN THE WORLD

INTERNATIONAL CONFERENCES, EXHIBITIONS AND SYMPOSIA

SPIE Medical Imaging 2015 / Orlando, Florida, USA / February 21 – 26, 2015

25th European Medical Informatics Conference (MIE 2015) / Madrid, Spain / May 27 – 29, 2015

23rd International Congress of the European Association for Endoscopic Surgery (E.A.E.S.) / Bukarest, Romania / June 3 – 6, 2015

15th Conference on Artificial Intelligence in Medicine (AIME 2015) / Pavia, Italy / June 17 – 20, 2015

3rd eHealth Summit Austria 2015 / Vienna, Austria / June 18 – 19, 2015

Hamlyn Symposium on Medica Robotics 2015 / London, England / June 20 – 23, 2015

29th International Congress of Computer Assisted Radiology and Surgery (CARS 2015) / Barcelona, Spain / June 23 – 28, 2015

38th Annual International ACM SIGIR Conference / Santiago, Chile / August 09 – 13, 2015

15th World Congress on Health and Biomedical Informatics (MEDINFO 2015) / Sao Paulo, Brazil / August 19 – 23, 2015

37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society / Milan, Italy / August 25 – 29, 2015

27th International Conference of the Society for Medical Innovation and Technology (SMIT 2015) / Brno, Czech Republic / September 10 – 12, 2015

Jahreskongress der Österreichischen HNO-Gesellschaft 2015 / Innsbruck / September 17, 2015

Annual Meeting of the Cardiovascular and Interventional Radiological Society of Europe (CIRSE) / Lisbon, Portugal / September 26- 30, 2015

17th International Conference on E-health Networking, Application & Services (IEEE Healthcom 2015) / Boston, MA, USA / October 14 – 17, 2015

3rd European Symposium of the European Ultrasound Charitable Society / London, England / October 15 – 16, 2015

Workshop of the European Association for Endoscopic Surgery and other interventional techniques (EURO-NOTES 2015) / Torino, Italy / November 12 – 14, 2015

European Society for Megnetic Resonance in Medicine and Biology (ESMRMB) School of Safety / Lund, Sweden / November 19 – 21, 2015

101st Scientific Assembly and Annual Meeting of the Radiological Society of North America (RSNA 2015) / Chicago, USA / November 29 – December 4, 2015

INTERNATIONAL PARTNERS

Aalborg University (Denmark), Intelligent Web and Information Systems Department

Children's National Medical Center CNMC (Washington DC, USA)

Chongqing University of Technology CUOT (China)

Delft University of Technology (Netherlands), Department of Biomedical Engineering

ETH Zurich (Switzerland), Computer Vision Laboratory

GE HealthCare (Haifa, Israel)

Universidad de Guanajuato (Mexico), Department of Electrical Engineering

Harvard Medical School (Cambridge, MA, USA), Brigham and Women's Hospital BWH

Image Guided Technologies IGT (Bordeaux, France)

InSightec Inc (Haifa, Israel)

Medrea Inc (Chongqing, China)

Memorial Sloan Kettering Cancer Center MSKCC (New York, USA)

MRInstruments Inc. (Milwaukee, IL, USA)

New York Methodist Hospital (NY, USA), Department of Radiology

Scuola Superiore Sant'Anna (Pondetera, Italy), The BioRobotics Institute

Sheba Medical Center (Tel Aviv, Israel)

St. Anne's University Hospital (Brno, Czech Republic), International Clinical Research Center (FNUSA-ICRC)

University of Bern (Switzerland), Bern University Hospital, ARTORG Center for Biomedical Engineering Research

University of Dundee (UK), Institute for Medical Science and Technology (IMSAT)

University of Graz (Austria), Institute of Medical Informatics, Statistics and Documentation

University of Pittsburgh (PA, USA), School of Information Science, Decision Systems Laboratory

University Torino (Italy), Department of Surgery

University of Trento (Italy), Dipartimento di Ingegeria e Scienza dell'Informazione

University Trondheim (Norway), Department of Imaging and SINTEF Medical Technology

NATIONAL CONFERENCES, EXHIBITIONS AND SYMPOSIA

Skillslab Symposium- MLU Halle-Wittenberg / Halle / March 13, 2015

Workshop Bildverarbeitung für die Medizin (BVM 2015) / Lübeck / March 15 – 17, 2015

Connecting Healthcare IT (conhIT 2015) / Berlin / April 13 – 16, 2015

66. Jahrestagung der Deutschen Gesellschaft für Neurochirurgie (DGNC 2015) / Karlsruhe / June 7 – 10, 2015

ICCAS International Symposium 2015 / Leipzig / August 29, 2015

60. Jahrestagung der Deutschen Gesellschaft für Medizinische Informatik, Biometrie und Epidemiologie e.V. (GMDS 2015) / Krefeld / September 6 – 9, 2015

49th Annual Conference of the German Society for Biomedical Engineering (BMT 2015) / Lübeck / September 16 – 18, 2015

14th Annual Conference of the German Society for Computer and Roboter-Assisted Surgery (CURAC 2015) / Bremen / September 17 – 19, 2015

18th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2015) / Munich / October 5 – 9, 2015

Onkologiesymposium Aachen 2015 / Aachen / October 7, 2015

Joint Meeting American Academy of Neurosurgery / German Society of Neurosurgery / German Academy of Neurosurgery 2015 / Heidelberg / October 10, 2015

Mitteldeutsches Resonanztreffen MDR-36 / Leipzig / November 9, 2015

Compamed und Medica 2015 / Düsseldorf / November 16 – 19, 2015

9th International Live Case Meeting / Leipzig / December 3 – 5, 2015

NATIONAL PARTNERS

Dornheim Medical Images GmbH, Magdeburg
EPflex GmbH, Dettingen an der Erms
Fraunhofer Institute for Applied Optics and Precision Engineering IFO, Jena
Fraunhofer Institute for Computer Architecture and Software Technology FIRST, Berlin
Fraunhofer Institute for Integrated Electronic Circuits IIS, Erlangen
Fraunhofer Institute for Machine Tools and Forming Technology IWU, Dresden
Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Stuttgart
Fraunhofer Institute for Medical Image Computing MEVIS, Bremen
Fraunhofer Institute for Biomedical Engineering IBMT, St. Ingbert
Freie Universität Berlin, Institute of Computer Science, Human-Centered Computing
GMC Systems mbH, Ilmenau
ID Information und Dokumentation im Gesundheitswesen GmbH & Co. KGaA, Berlin
IRDC GmbH International Reference and Development Center for Surgical Technology, Leipzig
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Leipzig University Hospital, Departments of Neurosurgery, Otorhinolaryngology, Nuclear Medicine, Diagnostic and Interventional Radiology, Head Neck and Plastic Surgery, Anaesthesiology
LOCALITE GmbH Biomedical Visualization Systems, Sankt Augustin
Max Planck Institute for Human Cognitive and Brain Sciences Leipzig, Department of Neurology
MRComp GmbH, Gelsenkirchen
MT2IT – your safe medical network, Ratzeburg
Optris GmbH, Berlin
Otto von Guericke University Magdeburg, Institute for Information and Communication Technology, STIMULATE – Solution Centre for Image Guided Local Therapies
PHACON GmbH, Leipzig
Siemens AG, Healthcare Sector, Erlangen
Söring GmbH, Quickborn
SWAN Scientific Workflow Analysis GmbH, Leipzig
Technische Universität Dresden, University Medical Center, Department of Neurosurgery, OncoRay – National Center for Radiation Research in Oncology (Dresden)
Technische Universität München, Institute of Automation and Information Systems, Institute of Micro Technology and Medical Device Technology, University Medical Center
Universität Leipzig, Institutes for Anatomy, Computer Science, Medical Informatics, Statistics and Epidemiology (IMISE), Center for Biotechnology and Biomedicine (BBZ), Herzzentrum Leipzig GmbH
Zuse Institute Berlin

For a complete list of the OR.Net project partners please see page 44.

MODEL-BASED AUTOMATION AND INTEGRATION

GROUP LEADER

Prof. Dr. Thomas Neumuth

PROJECT STAFF

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Dipl.-Inf. Max Rockstroh
Dipl.-Inf. Bernhard Glaser
Dr. Jens Meier
M. Sc. Klemens Birnbaum
M. Sc. Richard Bieck
M. Sc. Erik Schreiber
Dipl.-Inf. Juliane Neumann
Dipl.-Ing. Marianne Maktabi
Dr. Frank Heckel
M. Sc. Marcus Kaiser
M. Eng. Alexander Oeser

SELECTED PUBLICATIONS

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

Meier J, Dietz A, Boehm A, Neumuth T. Predicting treatment process steps from events. J Biomed Inform. 2015 Feb; 53: 308-19

Schumann S, Bühligen U, Neumuth T. Outcome quality assessment by surgical process compliance measures in laparoscopic surgery. Artif Intell Med. 2015; 63(2): 85-90.

Zebralla V, Pohle N, Singer S, Neumuth T, Dietz A, Stier-Jarmer M, et al. Introduction of the Screening Tool OncoFunction for Functional Follow-up of Head and Neck Patients. Laryngorhinootologie. 2015.

Gearing the technical infrastructure in the operating room to the situation-dependent support of surgery.

INTRODUCTION

Surgical therapies are fostered by rapid technical developments and increasing user requirements for inter-device networking. Research by Model-Based Automation and Integration (MAI) revolves around the development of advanced surgical assist systems to provide optimal support for surgery. Our research focuses on the integration and presentation of pre- and intraoperative information to support surgical management within the overall patient treatment process.

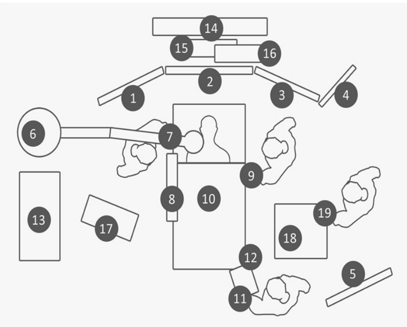
The group’s main developments address advanced technologies such as surgical workflow recognition systems, situation monitoring and the storage infrastructure, workflow management systems, treatment planning and integration systems. In 2015, research focused on completing workflow and medical networking strategies. Our results have been presented at industry expos such as conhIT and international workshops and conferences.

MAI projects are currently funded by the German Ministry of Education and Research (BMBF), the German Ministry for Economic Affairs and Energy (BMWi), the Saxon Ministry of Science and the Fine Arts (SMWK) and Siemens Healthcare.

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

INTRODUCTION

This BMBF 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.



1-3	Configurable screens
4-5	Configurable touchscreens
6	Surgical microskope
7	Surgeon
8	Intraoperative neuromonitoring
9	Scrub nurse
10	Patient
11	Unsterile person
12	Tablet for remote control
13/17	HF-Device, drill, suction device
14-16	IT-infrastructure (Switch, Server, KVM-Switch)
18	Anesthesia-Workstation
19	Anesthesiologist

Fig. 1- Schematic design of the demonstrator for middle ear surgery.

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 addresses also issues of regulatory approval and risk management (Subproject 3), the standardization of data models and interfaces (Subproject 4), and implementability in hospitals (Subproject 5). The holistic project will be completed by demonstrators to present the features as well as for technical and clinical evaluation (Subproject 6, managed by ICCAS). Overall, five demonstrators focusing on different technical aspects and clinical applications will be set up. The ICCAS demonstrator will deal 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.

Fig. 2- Joint demonstrator of all OR.Net partners at conhIT 2015 in Berlin.

DISCUSSION AND CONCLUSION

After the presentation of the demonstrator in December 2015, a technical and clinical evaluation will be conducted with interventions performed by clinicians on a patient phantom. All the data recorded will be analyzed and the participants interviewed. The OR.Net project is a significant contribution to vendor-independent OR integration based on open standards. The ICCAS demonstrator will illustrate the opportunities for implementing novel assistance features for the digital operating room.

Dipl-Inf. Max Rockstroh

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M. Sc. Erik Schreiber

M. Sc. Sebastian Lippert

B. Sc. Gero Kraus

Sascha Vinz

Christoph Georgi

Prof. Dr. Thomas Neumuth

PROJECT PARTNERS

Herzzentrum Leipzig, Leipzig University Hospital, ENT Department, Leipzig University Hospital, Department of Neurosurgery (please see partner list on page 44 for a list of all external project partners)

Funding: German Ministry of Education and Research (BMBF)

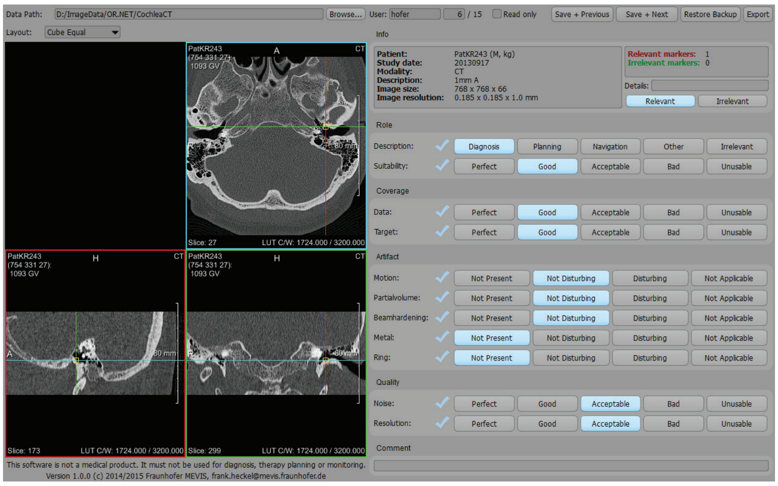

Fig. 1- Tool for the manual assessment of medical image data quality. Specific quality aspects can be rated on a predefined scale. In addition, the purpose of the image is captured and the physician is able to mark findings of interest in the image.

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

SUBPROJECT: INFORMATION QUALITY ASSURANCE IN THE NETWORKED OPERATING ROOM

INTRODUCTION

3D medical images acquired by computed tomography (CT) or magnetic resonance imaging (MRI) are important components of modern medicine. Their usefulness for the physician depends on their quality, though. Only high-quality images allow accurate and reproducible diagnosis and appropriate support during treatment. In particular, computer-assisted systems, such as automated image analysis and intra operative navigation, are known to need high-quality images in order to provide accurate results.

MATERIAL AND METHODS

We performed two studies. In the first study, we analyzed the quality of MRI images for brain tumor surgery. 202 images from 24 patients were rated by a neurosurgeon and a neuroradiologist using a dedicated tool developed in MeVisLab (Fig. 1). Aspects rated included the role of an image in the clinical workflow, its suitability for this specific role, various image quality characteristics, and the presence of imaging artifacts. In the second study, we evaluated the influence of image quality on the quality of semi-automatic segmentation results in CT images for cochlear implantation planning. Images from 12 patients were rated by an ENT surgeon and different structures of the lateral skull base were segmented by 15 physicians using a semi-automatic wizard-based segmentation tool.

RESULTS

Our results show that MRI data acquired for brain tumor surgery do not always meet the required quality standards and reveal significant differences between radiologists and surgeons, the latter being more critical (Fig. 2). Whereas noise, resolution, and the coverage of anatomical structures were the main criteria for the surgeon, the radiologist was mainly bothered by motion artifacts.

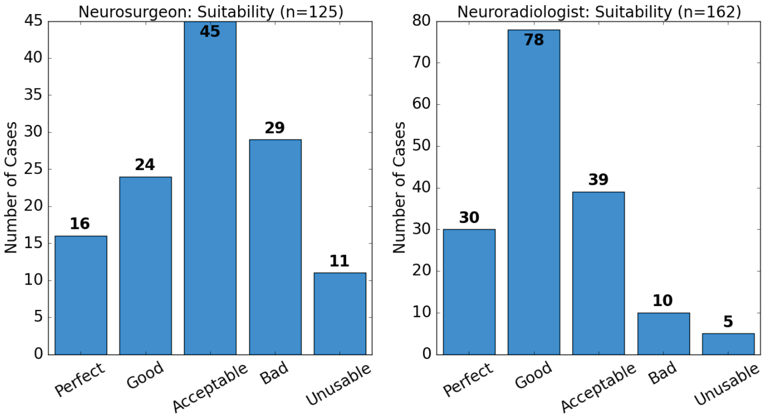

Fig. 2- Suitability of MRI data as rated by a neurosurgeon and a neuroradiologist. Note that images could be skipped in the study if for example the clinician considered them irrelevant for the specific use case.

Concerning the cochlear implantation use case, we found a correlation between the segmentation quality of some of the structures and the signal-to-noise ratio as well as the resolution of the images (Fig. 3). Imaging artifacts affected the reproducibility but not the accuracy of reconstruction.

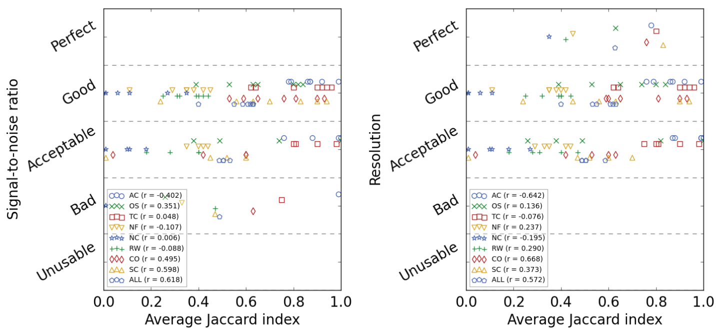

Fig. 3- Correlation between the accuracy of semi-automatic segmentation results and the image quality of CT data. (AC = acoustic canal, OS = ossicles, TC = tympanic cavity, NF = facial nerve, NC = chorda tympani, RW = round window, CO = cochlea, vestibule, inner ear canal, SC = semicircular canal, ALL = average over all structures). r denotes Spearman's correlation coefficient.

DISCUSSION AND CONCLUSION

In various interviews, physicians stated that "images are almost always good and their quality is not a problem in practice". However, particularly in MRI and in contrast to this subjective impression, our results indicate that there is a relevant number of images that do not meet the required quality standards. Even though modern CT scanners typically provide very good images, their quality characteristics are not always sufficient from a clinical angle. Our results suggest that this suboptimal quality also affects the quality of semi-automatic 3D segmentations. Given the growing integration of medical devices, automatically assessing the quality of data streams is becoming increasingly important. To ensure that the individual processing modules work reliably, we are investigating general ways of automatically measuring the quality of medical images. The goal is a monitoring component that permanently reviews the validity of image data streams. This could reduce delays before and during operations and improve the efficiency of software tools for image-guided surgery, increasing surgeons' confidence.

Dr. Frank Heckel

Dipl.-Inf. Max Rockstroh

PROJECT PARTNERS

Leipzig University Hospital, Department of Neurosurgery, Leipzig University Hospital, ENT Department, Fraunhofer Institute for Medical Image Computing MEVIS

Funding: German Ministry of Education and Research (BMBF)

EVENTOR – EVENT-BASED NETWORKING IN THE OPERATING ROOM

INTRODUCTION

The distributed provision of information entities relevant to a patient's treatment results in time-consuming information-seeking tasks, exacerbating surgeons' workload. In recent years, concepts and technical solutions have been devised for integrated operating rooms. Modern surgical assistance systems share their information and control functions via various OR bus implementations, which allow the integration of information and centralized control. Nevertheless, these changes have only partly reduced surgeons' workload. The EVENTOR project is being conducted in cooperation with SWAN – Scientific Workflow Analysis GmbH. Its aim is to enable the workflow-driven interconnection of medical devices.

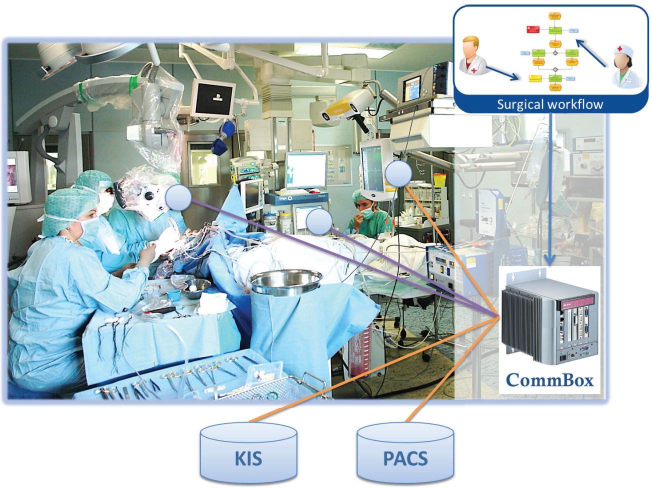

Fig. 1- Diagram of the EVENTOR concept showing the CommBox as the centralized workflow processing unit connected to various medical devices.

MATERIAL AND METHODS

A centralized unit known as the CommBox was designed to integrate process logic and communication frameworks. The interfacing of medical devices is controlled by process logic based on surgical process models. A workflow engine, the core component of the CommBox, processes these models in order to track the ongoing procedure. As an example use case, an event-driven adaptation of surgical displays and documentation screenshots was implemented using a rule set. It derives the video signal pathways which need to be established from the surgical situation provided by the workflow engine.

Fig. 2- The demonstrator system of the CommBox with automatic video routing and process management in the laboratory at ICCAS.

RESULTS

We developed component prototypes for brain tumor removals to confirm the feasibility of this approach. During technical tests, we could demonstrate the features of the implemented system. For instance, the delay between the CommBox signal and the reaction of the information management components (video switching and documentation) was found to be below 200 ms for each of the 682 surgical events in the 60 simulated brain tumor removal interventions.

DISCUSSION AND CONCLUSION

EVENTOR enables the workflow-driven interconnection of medical devices lacking a common interface. A centralized unit integrates process logic and communication frameworks to enable semiautomatic device adaptation. The prototype was evaluated under laboratory conditions using data from real intervention recordings in order to demonstrate the feasibility of the approach.

Dipl.-Ing. Marianne Maktabi

Dipl.-Inf. Stefan Franke

Prof. Dr. Thomas Neumuth

PROJECT PARTNERS

SWAN- Scientific Workflow Analysis GmbH Leipzig

Funding: German Ministry for Economic Affairs and Energy (BMWi)

SELECTED PUBLICATIONS

Maktabi M, Neumuth T. Analyse von chirurgischen Workflows mit Hilfe der Levenshtein- Distanz und der spektralen Analyse. 14. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC); Bremen; 2015.

SURGICAL PLANNING AND CONTROL CENTER

INTRODUCTION

In recent years, various stakeholders have shown growing interest in the integration and modular networking of medical devices in the OR. Because commercial integrated solutions are based on proprietary interfaces and protocols, several initiatives and projects are now working to develop systems of OR integration based on open standards in order to cut costs and improve patient safety. However, growing budgetary constraints in hospitals require new ways of optimization – such as the proposed concept of process control in the OR with centralized supervisory control.

MATERIAL AND METHODS

This work demonstrates vertical integration in a hospital to create a Surgical Planning and Resource Center (SPARC). We chose medical engineers as the first, more closely considered user group to vertically integrate the OR in the hospital structure. An initial user interface prototype and the corresponding database scheme were developed based on surveys among both medical engineers and in-house technicians. Key elements of the implementation of SPARC include aspects of data traffic and data security.

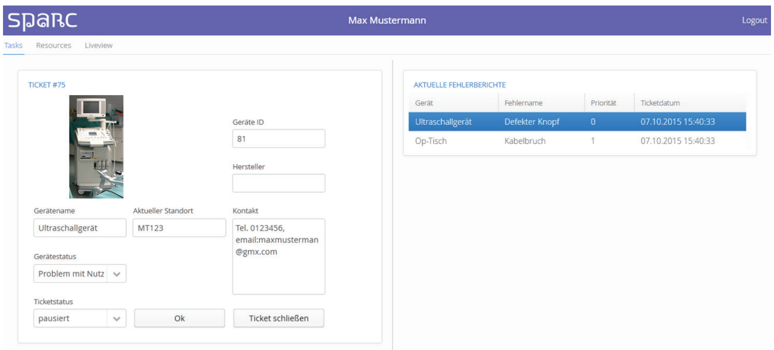

Fig. 1- Web application of SPARC, which enables hospital technicians to check the status of an OR.

RESULTS

We implemented a database schema which can be easily adapted and expanded for other user groups such as hospital controllers and in-house technicians. We assume that several information elements of the OR are transmitted to the control center database. Information like OR status variables (current supply, the surgeon, devices used) and device parameters (e.g. modes of devices, error messages, maintenance messages) has to be saved in SPARC's database. Real-time information from devices (e.g. mill speed) as well as additional information (e.g. gas supply) is required to fully map the OR processes. The incoming information is processed in order, for example, to show the technician outstanding tasks in a web application. The outstanding tasks are illustrated based on a staged alarm scale containing several priority levels based on the use of information such as the criticality value of a device malfunction.

DISCUSSION AND CONCLUSION

Future work will focus on a comprehensive survey to examine usability aspects and draw up a guide for the user interface. The survey may indicate the improvement delivered by the centralized supervisory control web application. The initial demonstration of the supervisor control center prototype resulted in wide approval for the SPARC concept.

Dipl.-Ing. Marianne Maktabi
Prof. Dr. Thomas Neumuth
M. Sc. Klemens Birnbaum
B. Sc. Hans-Georg Schladitz

Funding: German 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 problem 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. Furthermore, the clinicians attend regular tumor boards to determine the best possible treatment for each patient. Therefore, the relevant information must be made available to support the decision-making process.

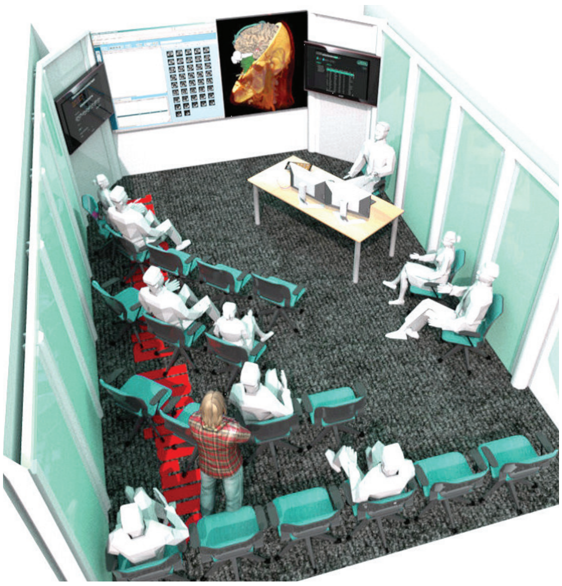

Fig. 1- A novel approach for meeting room design with a V-style seating. arrangement

MATERIAL AND METHODS

In order to support the regular tumor board, a sophisticated IT- infrastructure was developed for the meeting room (Fig. 1). Additionally, we developed a new methodology to predict clinical workflow steps based on hidden Markov models (Fig. 2). The concepts and algorithms were developed and evaluated in a study based on anonymized real-world patient data sets from 40 electronic patient records (EPRs) and a total of 2208 observations. The study produced positive findings regarding the recognition of the patients' current therapy phase based on given observation sequences. Hence, the existing information in clinical information systems can be enriched with additional meta data, such as the treatment phase from which the information entity originates (Fig. 3).

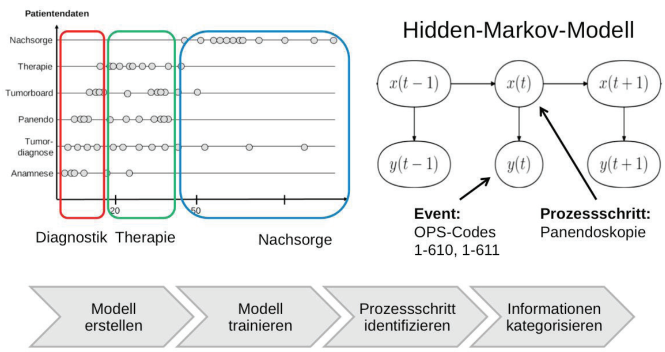

Fig. 2- The modelling of the treatment process with a hidden Markov model.

RESULTS

We developed a novel concept known as the Treatment Planning Unit (TPU) to assist the tumor board participants with additional patient-specific information, endoscopic images and intelligent results documentation. We achieved recognition rates between 82% and 90% when identifying treatment steps from events using hidden Markov models.

SELECTED PUBLICATIONS

Meier J, Bohn S, Glaser B, Birnbaum K, Boehm A, Neumuth T. The Treatment Planning Unit: Concept and realization of an integrated multimedia decision support system for multidisciplinary team meetings. 15th World Congress on Health and Biomedical Informatics (MEDINFO); Sao Paulo, Brazil; 2015.

Meier J, Dietz A, Boehm A, Neumuth T. Predicting treatment process steps from events. J Biomed Inform. 2015; 53: 308-319.

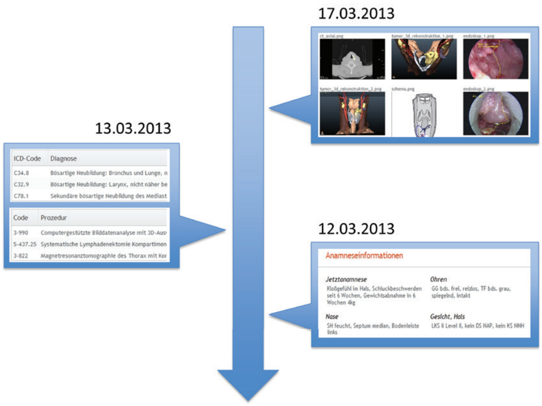

Fig. 3- Concept for the structured arrangement of patient-specific information, based on the treatment summary in OncoControl.

DISCUSSION AND CONCLUSION

Future work will focus on improving the recognition of treatment steps and its integration into daily clinical routines. Firstly, the capabilities of the model must be extended. The current state of development does not support breaks in the process in the event of treatment being abandoned or death, which is very important for use in daily clinical routine. Moreover, the time elapsed between two observations should be incorporated into the model to aid the detection of potential process phase transitions. This information can then be used to refine the transition and observation matrices of the model. Secondly, the ability to train the model for daily use is crucial. This could be done by using a feedback-based approach, in which experts correct errors involving automatically tagged information entities.

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Prof. Dr. Thomas Neumuth

PROJECT PARTNERS

Leipzig University Hospital, ENT Department, Dornheim Medical Images GmbH

Funding: German Ministry for Economic Affairs and Energy (BMWi)

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

INTRODUCTION

Minimally invasive surgical procedures are a constant challenge for both OR equipment and the surgeon using it. Nevertheless, the demand for these procedures is rising in connection with demographic change. Elderly people particularly benefit from the decreased incision size, resulting in improved recovery and shorter in-patient stays. Minimally invasive procedures require exceptional skill in instrument orientation with limited hand-eye coordination and navigation through endoscopic images without a direct view of the operating area. As a result, surgical navigation systems have been established to compensate for in situ orientation problems in clinical routine. They generally use optical or electromagnetical technologies to ascertain the position of the patient and instruments by means of customized markers or coils attached to the patient and the instruments. This technology is prone to errors such as line of sight between a tracking camera and the positioned markers in the OR. Additionally, these markers are a source of infection and patient contamination. Furthermore, when flexible endoscopes are used, visualization cannot be sufficiently supported by current navigation systems. The aim of the BIOPASS project is to develop a safe, efficient, minimally invasive surgical assistance system built with the 'Design for All' premise (Fig. 1).

MATERIAL AND METHODS

The BIOPASS system adapts itself to the individual patient's treatment and demands as well as the surgeon's needs and problem-solving strategies.

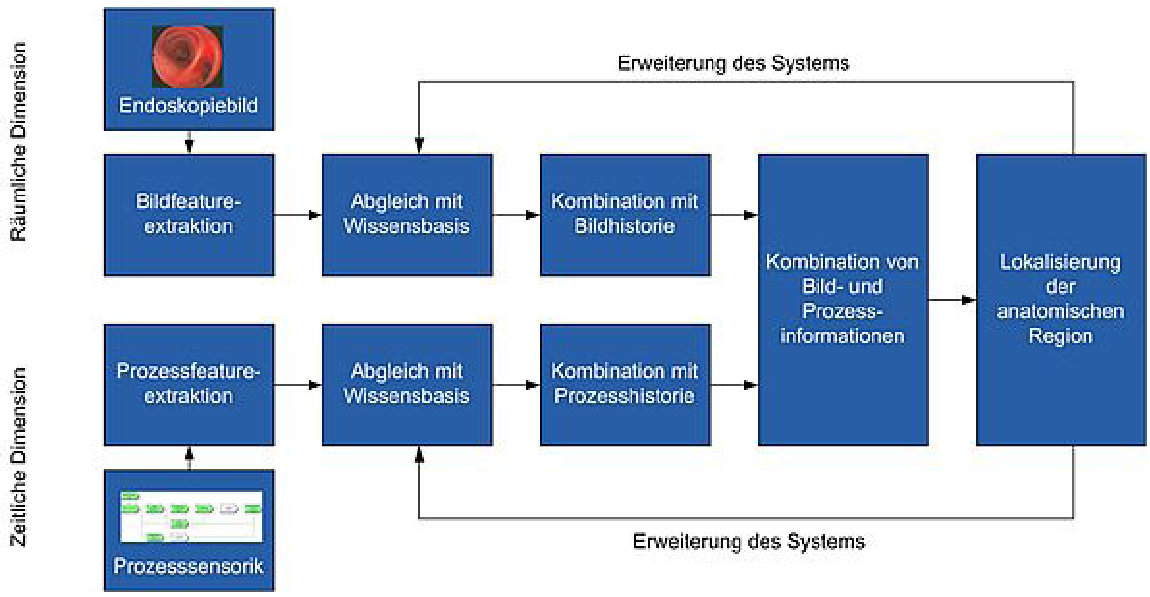

Fig. 1- Overview of the technical aspects of the BIOPASS solution for a markerless navigation system.

The concept consists in analyzing endoscopic video information and the surgical process status to calculate the possible navigation position of the endoscope and other instruments (Fig. 2). By means of an ontology-based description of the surgical workspace, the system uses the surgery's history together with current situation information to predict the following working steps and navigation functions. The key aims of research are to develop an assistance system based on a novel localization approach, to reduce intraoperative navigation hardware, and to support surgical cognition with an adaptive, self-learning assistance system.

RESULTS

Since the beginning of the project in April 2015, progress has been made with the specification of clinical use cases and their corresponding requirements definitions. The ENT Department in Leipzig focuses on functional endoscopic sinus surgery (FESS) while the Visceral Intervention Department in Munich works in diagnostic colonoscopy. Both clinical use cases have a distinct, specialized set of requirements that had to be identified. A general requirements document has been generated for ENT intervention including five major use cases for the novel navigation system with corresponding requirements. Simultaneously, ten endoscopic ENT interventions were recorded for initial annotation processes. The annotation principles are being developed by the Institute for Medical Informatics, Statistics and Epidemiology (IMISE), the ENT Department and ICCAS (all in Leipzig).

DISCUSSION AND CONCLUSION

The aim of BIOPASS is to develop a new surgical navigation concept and assistance principle to increase fail-safety based on inherent information and data from endoscopic imaging and intraoperative monitoring. The assistance system will help surgeons locate the endoscope tip and predict following localizations based on situational data and information. For this reason, the anatomical area surrounding the endoscope tip needs to be identified. The BIOPASS system calculates the possible number of accessible locations for the next surgical step based on current information about the anatomical area. Unlike conventional approaches, image, process and ontology based navigation will remove the registration step of preoperative CT and MR data form the OR space. For the first time, this project will employ process information and an ontology to support spatial location and classification in real time. In BIOPASS, surgical navigation will proceed without markers and thus eliminate the line-of-sight problems of optical tracking systems as well as the general abundance of OR hardware. This ought to improve the efficiency and time management of surgical steps and thus decrease operating and treatment times.

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PROJECT PARTNERS

Leipzig University Hospital ENT Department, Leipzig University Institute for Medical Informatics, Statistics and Epidemiology (IMISE), Zuse Institute for Information Technology Berlin, LOCALITE GmbH, Dornheim Medical Imaging, University of Munich, Minimally-invasive Interdisciplinary Therapy Interventions (MITI) Institute and Visceral Interventions Department, Klinikum rechts der Isar Munich, STORZ GmbH & Co. KG (associated partner)

Funding: German Ministry of Education and Research (BMBF)

FUSION OF FLUOROSCOPY AND INTERVENTIONAL ULTRASOUND

INTRODUCTION

More and more procedures in the field of structural heart disease are becoming minimally invasive and catheter-based. Examples include trans-catheter aortic valve implantation, trans-catheter mitral valve repair, and the closure of atrial septal defects and left atrial appendage. This trend from open-heart surgery to trans-catheter procedures is driven by the availability of new catheter devices and intra-procedural imaging.

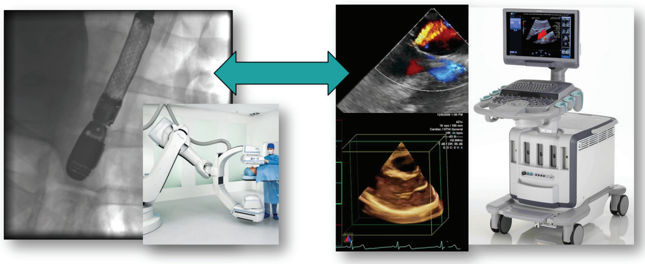

Fig. 1- The fusion of Ultrasound and X-ray combines their advantages and could lead to the better interpretation of image content as well as improved navigation and communication. It could even pave the way for new types of procedures.

Usually these procedures are performed under fluoroscopic X-ray and trans-esophageal echo (TEE). Intraoperatively, these methods are mainly applied independently of each other: X-ray imaging is performed by the cardiologist or surgeon at the left or right side of the patient whereas ultrasound imaging is carried out by the anesthesiologist at the head side. Fusing images from the two systems could initially yield a better mutual understanding of the images' content and ultimately even enable new types of procedures. The ultrasound Ultrasound and X-ray images move relative to each other because the positions of the imaging devices are changed by the operators and because of the patient's heart and breathing motion. Therefore, almost real-time updating is required to synchronize the relative position of the two images. The success of this approach hinges on the clinical usability of a fusion system.

RESULTS

One way of fusing ultrasound Ultrasound with fluoroscopic X-ray is 2D/3D registration. A TEE probe is detected in the X-ray image, enabling the 3D position of the TEE probe to be derived relative to the X-ray detector, which inherently provides a registration of the ultrasound image to the X-ray image. To estimate the 3D position, a model of the TEE probe is registered to the X-ray image via a 2D/3D registration algorithm. Here a 3D position of the probe is

SELECTED PUBLICATIONS

Kaiser, M, John, M, Heimann, T, Brost, A, Neumuth, T and Rose, G, Golland, P, Barillot, C, Hornegger, J and Howe, R (Eds.) 2D/3D Registration of TEE Probe from Two Non-orthogonal C-arm Directions. Medical Image Computing and Computer-Assisted Intervention. MICCAI; Boston; 2014: 283-290.

iteratively adapted using an optimization method until a similarity measure of the projected probe model image and the X-ray image shows high similarity. The TEE probe does not need to be additionally modified and the system need not be specifically set up for each procedure.

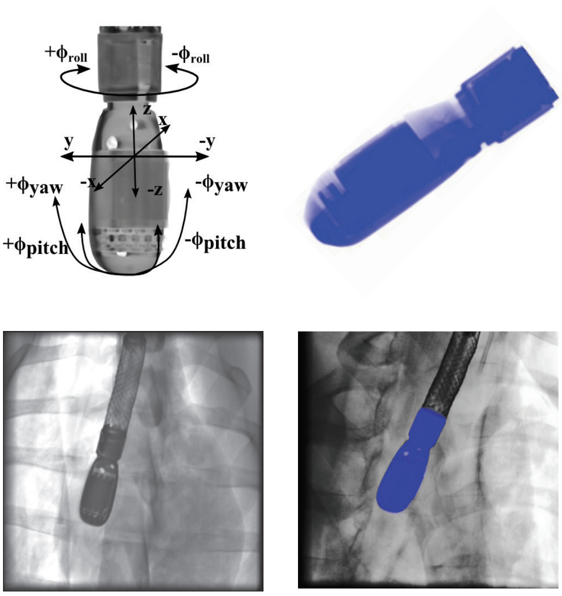

Fig. 2- From top left to bottom right: CT volume of the TEE probe prototype with object axes; DRR of the TEE probe volume; TEE probe under fluoroscopic X-ray; possible visualization of a registration of a TEE probe. 2D/3D registration inherently provides a registration of the ultrasound (symbolized as a pyramid structure) to the X-ray image.

DISCUSSION AND CONCLUSION

An image fusion of ultrasound and fluoroscopic X-ray could potentially improve the whole workflow of today's minimal invasive cardiac interventions. It would enable the better interpretation of images as well as faster, more accurate interventional navigation. This might increase the patient's safety and could shorten the procedure time and may also increase patient safety.

Dipl.-Inf. Marcus Kaiser

PROJECT PARTNERS

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Funding: Siemens Healthcare

CEPHALENS – ASSISTANCE SYSTEM FOR MINIMALLY INVASIVE NEUROSURGERY

INTRODUCTION

In minimally invasive surgery, the visualization of critical anatomical structures is an ongoing challenge. Taking the real 3D nature of the patient's condition and realistic surgery circumstances into account, the principle of augmented reality (AR) is employed for interactive navigation in neurosurgery. Time- and space-efficient AR applications are required for a high degree of intuitive navigation. One promising approach is the Magic Lens concept, in which a physical lens (e.g. a tablet computer) is used to assist the surgeon's intraoperative understanding of the tissue structures (context) with digital 3D models (focus). This principle is particularly useful in emergency treatment, since the patient could potentially be treated at the bedside. The objective of the CephaLens project is to develop such a mobile surgical assistance system with a tablet-based interaction concept for emergency external ventricle puncture. Close attention is being paid to the interactive visualization of the head anatomy features in order to support the surgeon's control over the cranial access points (Fig. 1).

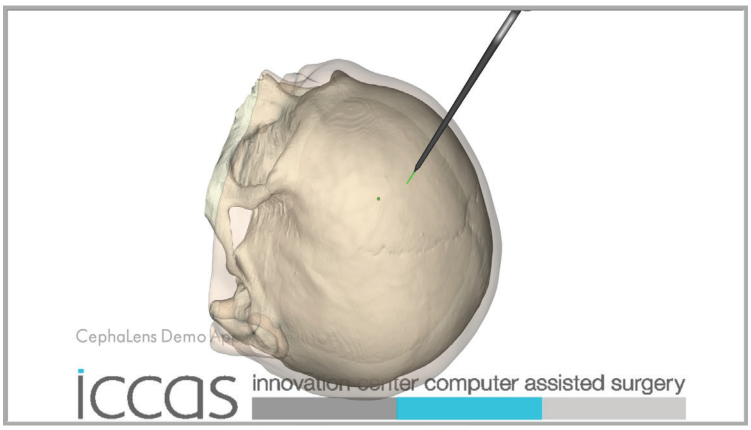

Fig. 1- Overview of the CephaLens environment with patient-specific anatomical surface models and a digital pointer instrument.

MATERIAL AND METHODS

The Magic Lens concept was adopted for a prototype assistance system in minimally invasive neurosurgery. The prototype system involved a preoperative and an intraoperative stage. For visualization, routinely acquired preoperative images were used to generate surface models of anatomical structures (skin, skull, and cortex) (Fig. 2). Intraoperatively, the system used a combination of an optical tracking and a time-of-flight (TOF) camera. With both cameras registered to each other, the system was able to track the surgeon and the CephaLens simultaneously. The system was then registered to the patient.

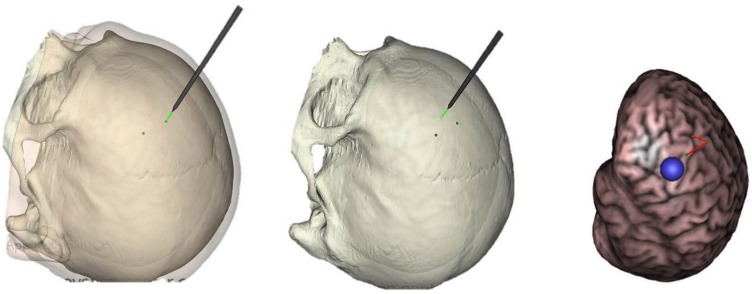

Fig. 2- Visualization of different anatomical layers assisting the surgeon's understanding of the patient's apparent situation when setting specific cranial surface landmarks (green, connected by red lines).

One key feature of the system was the point-of-view dependent display of relevant anatomical structures corresponding to the surgeon's angle of view (Fig. 3). This feature was incorporated in two tablet interaction modes with the aim of decreasing idle time during procedures (Fig. 3). The accompany mode is an indirect interaction mode in which the tablet is placed in a docking station. Visualization follows the surgeon's view of the patient's head while keeping the patient models centered on the screen. Additionally, the system displays the tracking pointer used to select landmarks on the cranial surface. The interaction mode is activated when the tablet is picked up, changing the visualization depending on the actual position of the patient's head to enable increased spatial awareness of the landmarks previously chosen.

RESULTS

A tablet-based surgical assistance system was developed with two distinct interaction modes for emergency ventricle puncture procedures. For an initial evaluation of the system, a head phantom was used. The camera setup had an internal calibration error of 1.5 ± 0.5 mm with a mean tracking error of 0.05 ± 0.007 mm for the patient's head and 0.08 ± 0.06 mm for the navigation pointer. Patient registration was performed with the landmark-based approach and resulted in registration errors of 2.50 ± 0.5 mm. Surface models were reconstructed using a marching cubes algorithm for isosurface extraction from CT data (resolution approx. 4 mm). A preliminary study of the spatial overlap of the real patient's head and the digital patient model was determined with a surface error of roughly 4.0 mm.

Fig. 3- Surgical setup for the evaluation of interaction modes. The CephaLens tablet is positioned contralaterally to the surgeon to follow the instruments' movement and enables interactive exploration when picked up.

SELECTED PUBLICATIONS

Bieck R, Franke S, Lindner D, Neumuth T. Computer Assisted Neurosurgery. Application of a surgical assistance system for cranial surface & cerebral ventricle navigation. 49th Annual conference of the German Society for Biomedical Engineering (DGBMT); Lübeck; 2015.

Bieck R, Franke S, Lindner D, Neumuth T. Computer-assisted Neurosurgery. An interaction concept for a tablet-based surgical assistance system. 14. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC); Bremen; 2015.

In the AM, the instrument substitute pointer was used to navigate along the cranial bone surface to mark a prominent or potential entry point (Fig. 3). For the interaction mode (IM), visualization was adapted from the existing prototype system. Two superimposed anatomical structures revealed no occlusion problems whatsoever.

DISCUSSION AND CONCLUSION

We developed a novel concept for a prototype assistance system in neurosurgical applications. The current technical setup was adopted from a preceding prototype system. Compared to other AR principles of including the additional anatomical data in preexisting displays, e.g. a microscope or endoscope view, the lens view stands out thanks to its intuitive handling in the interaction mode. Tracking accuracy and robustness were highly dependent on the camera fixation. Moreover, since the tablet occupies space in the direct vicinity of the patient's head, how it affects emergency procedures is yet to be evaluated. Overall, the interaction principles are promising for use in neurosurgery.

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PROJECT PARTNERS

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Funding: German Ministry of Education and Research (BMBF)

THE ONCOFLOW CLINICAL INFORMATION SYSTEM FOR HEAD-AND-NECK TUMOR THERAPY SUPPORT

INTRODUCTION

Information management in tumor therapy is a challenging process for physicians and surgeons because the documentation of clinical results is primarily driven by economic rather than clinical considerations. Numerous assistance and decision support systems are used in daily clinical routine to relieve physicians and surgeons from repetitive, time-consuming tasks as well as to provide support for complex therapy planning scenarios (Fig. 1). However, these systems do not integrate smoothly into the clinical workflow and are poorly integrated into the clinical IT landscape.

MATERIAL AND METHODS

We developed a sophisticated, web-based clinical information system known as oncoflow, which is intended to support the physician and clinical staff throughout the therapy process. Relevant patient-specific information is automatically imported from leading clinical information systems such as the Hospital Information System (HIS) and the Tumor Therapy Manager (TTM) into a central database, restructured according to clinical needs, and presented within a web interface. The oncoflow system supports the entire oncological treatment process from the initial consultation until follow-up documentation. Additional information is gathered within each process step to efficiently support clinical studies, quality management and cancer center certification processes.

RESULTS

Two major assistance functions should be explained in more detail. The first consultation consisting of an anamnesis and clinical examination of the patient has been improved significantly with oncoflow. All questions for the patient have been standardized and implemented as a structured web form.

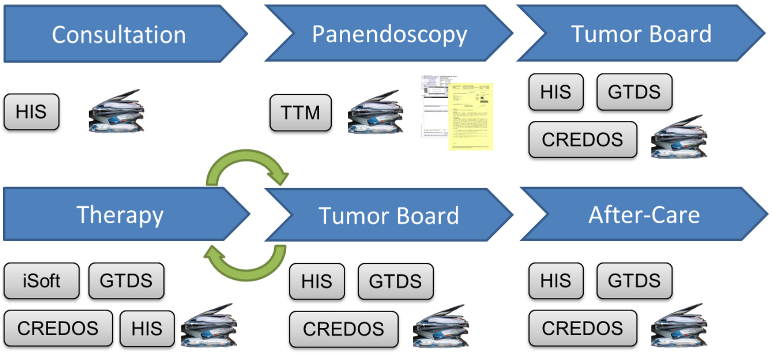

Fig. 1- The clinical workflow supported by oncoflow

A clinical study indicated improved workflow which was 71% more structured than before. Secondly, tumor board management including patient scheduling, invitation mailings, results documentation and protocol mailings has been implemented in oncoflow. It improves the clinical workflow and relieves the physicians and surgeons of the time-consuming handling of numerous Microsoft Word documents every week.

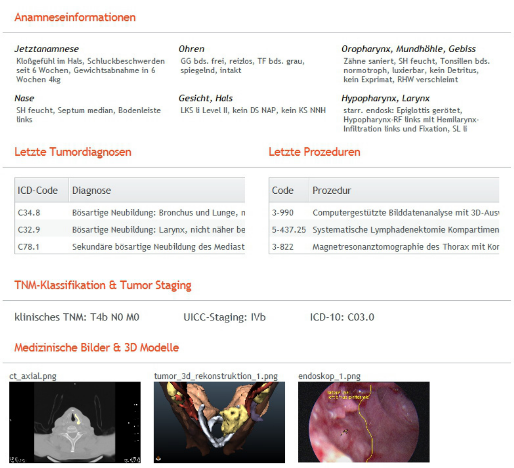

Fig. 2- The treatment summary is an effective tool to give surgeons an overview of a patient's medical history.

CONCLUSIONS

An overview of the current medical status of a patient is crucial, especially for physicians who are not familiar with the current patient. The treatment summary in oncoflow addresses this issue and provides a condensed patient overview summarizing the main information in the current treatment phase. A prototype rule-based implementation aggregates the latest information available from each process step into a one-page overview (Fig. 2).

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Funding: German Ministry of Education and Research (BMBF)

WEB-BASED ANESTHESIA DOCUMENTATION

INTRODUCTION

Anesthesiology, a central discipline in modern hospitals, is increasingly suffering from time and staffing issues. During surgery, sometimes only one anesthetist supported by technical assistants or junior doctors is available for a number of operating rooms. One way of providing a better, faster response in the OR and enabling situations to be assessed remotely is to set up a mobile solution for the visualization of anesthesia data from multiple operating rooms. A solution like this can also enable the patient's documentation to be updated with information such as the drugs administered.

MATERIAL AND METHODS

To this end, a web-based solution based on the Vaadin Framework and an interface for Dräger

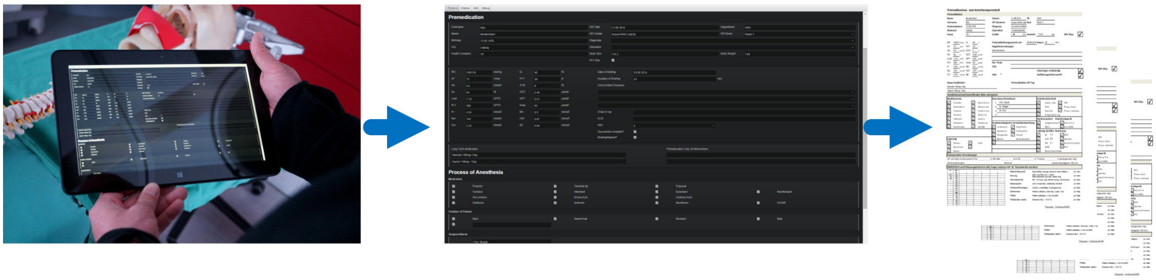

Fig. 1- Filled view of the patient's demographics and history on a tablet and resulting PDF documents.

anesthesia systems is being developed. The application enables the anesthesiologist to observe patient's vital signs from any location in real time. In addition, the patient's demographic data and their medical history can be documented along with the medication used during surgery. To assist permanent medical documentation, a solution for data storage in a PDF document has been developed based on a currently used anesthesia protocol.

Fig. 2- Visualization of vital signs.

RESULTS

We tested various ways of simplifying the documentation of medication doses, for example by using a tablet computer's internal camera or a barcode reader. Different algorithms were tested to address the problem of measurement errors caused for instance by removed electrodes. In addition, authentication concepts need to be developed and tested so that the system can be used simultaneously on different devices by different user groups.

DISCUSSION AND CONCLUSION

The project is another step in the digital representation of the OR. Along with the completed project for the detection of device data and device usage based on medical equipment's video signals and similar ICCAS projects, the data transmitted and received by the anesthesia systems now can be stored in a central location, the surgical recorder. This will support research projects in the areas of workflow recognition, workflow support and documentation.

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Dipl.-Inf. Stefan Franke

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PROJECT PARTNERS

Acqua Klinik Leipzig

Funding: German Ministry of Education and Research (BMBF)

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Rockstroh M, Franke S, Lippert S, Wiegel M, Neumuth T. Mobile Web-Based Interface for Anesthesia Documentation. 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC); Milano, Italy; 2015.

ADAPTIVE PROCESS MODELS FOR WORKFLOW-DRIVEN SURGICAL ASSISTANCE

INTRODUCTION

Workflow management technologies are beginning to catch on in the surgical domain in all kinds of perioperative processes from diagnosis and resource planning to treatment and aftercare. Intraoperative surgical workflow management aims to automate tasks of maintenance and information seeking through intelligent systems' behavior, including based on the prediction of subsequent work steps.

MATERIAL AND METHODS

In the present work, we propose using adaptive surgical process models that are sufficiently flexible to handle ad hoc workflows and yet still able to accurately assess upcoming surgical work steps. The definition of generalized state-transition models is extended. The adaptive models "adapt" their transition probabilities to an ongoing and yet incomplete procedure based on comparison with the training set using dynamic time warping (see Fig. 1). The performance of the approach was compared to a common state-transition model using three different clinical use cases: eye cataract surgeries, lumbar discectomies and brain tumor removals.

RESULTS

The next work step was predicted for each low-level work step included in the recordings. For the eye cataract surgeries, 3,011 predicted transitions were analyzed. The adaptive model achieved a higher mean transition probability (0.581) than the state-transition model (0.478). Mean transition probabilities of 0.203 (state-transition) and 0.266 (adaptive model) were measured for the 3,731 transitions in the 41 discectomies. The improvement was even more significant for the 60 brain tumor removals (11,489 transitions) with an increase from 0.189 to 0.295 for the adaptive models.

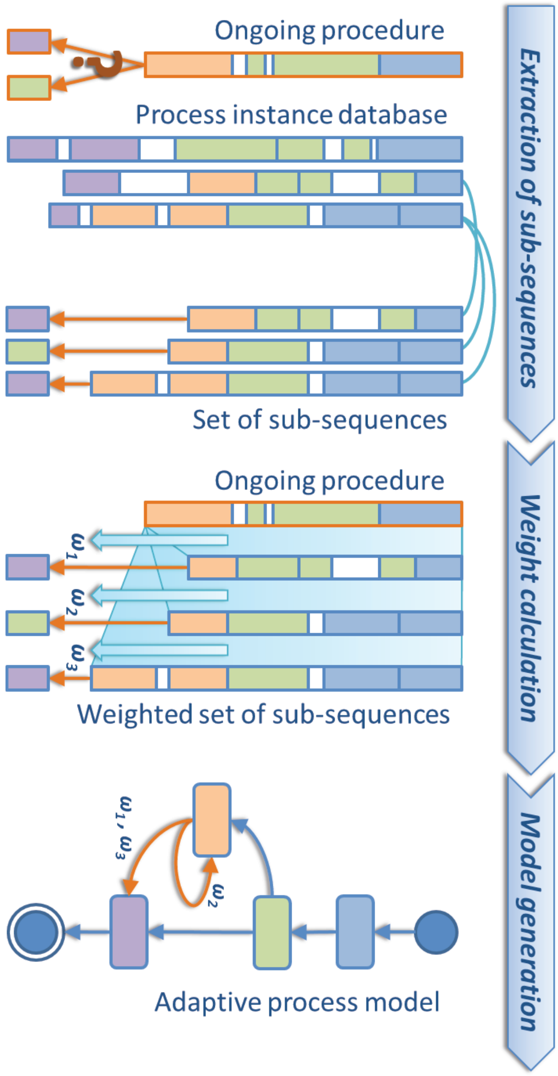

Fig. 1- Schematic overview of the proposed processing pipeline to calculate adapted transition probabilities using a comparison based on dynamic time warping.

DISCUSSION AND CONCLUSION

The results demonstrate an improved ability to anticipate the next surgical work step compared to common state-transition models. Reliably predicting the further course of ongoing interventions will be a significant requirement for intelligent systems' behavior in the OR. The present work contributes to the need

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Franke S, Neumuth T. Adaptive surgical process models for prediction of surgical work steps from surgical low-level activities. 6th Workshop on Modeling and Monitoring of Computer Assisted Interventions (M2CAI) at the 18th International Conference on Medical Image Computing and Computer Assisted Interventions; Munich; 2015.

Franke S, Schreiber E, Neumuth T. Prediction of surgical activities for context-aware workflow management in the operating room. 29th Congress and Exhibition Computer Assisted Radiology and Surgery (CARS); Barcelona, Spain; 2015.

for contextual information in situation-aware medical devices and represents a step towards a managed OR with a cooperative technical environment.

Dipl.-Inf. Stefan Franke

Prof. Dr. Thomas Neumuth

Funding: German Ministry of Education and Research (BMBF)

ONTOLOGY-BASED PERIOPERATIVE RISK MINIMIZATION

INTRODUCTION

Medical personnel are often under great physical and mental stress, raising the likelihood of errors and bad decisions. The aim of risk management is to minimize the occurrence of such adverse events, by for instance providing multiple security layers. Therefore, the OntoMedRisk project uses techniques like risk analysis and risk modeling to minimize medical errors in perioperative patient care.

MATERIAL AND METHODS

An agent-based software architecture has been designed for use by medical staff as a technical support system for cross-process risk identification and error avoidance. The system uses a situation ontology for the description of risk situations and adverse events. In addition, dynamic risk analysis is performed based on patient-related data and sensor data (e.g. data from the digital patient record, the hospital information system, checklists or situations in actual process execution). Context-sensitive hints to help medical personnel avoid errors can be generated. Fig. 1 shows the basic principle of this project.

RESULTS

The insertion of cochlea implants was chosen in order to demonstrate the features and benefits of the agent-based software system. In the first step, the treatment process was modeled and visualized in a process diagram. Critical incidents related to cochlea implantation interventions were examined in a risk analysis. This enabled over 100 potential perioperative risks to be identified and classified, and also mapped to their related process step in the process model. In the next step, a rule-based system will be developed to warn users of potential risks at the current stage of the treatment process and provide decision support.

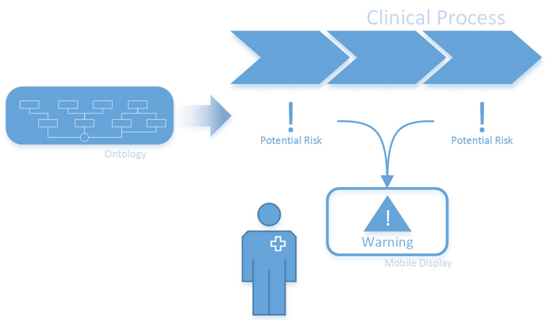

Fig. 1- Ontology-based identification of perioperative risk situations.

DISCUSSION AND CONCLUSION

The OntoMedRisk project has a great potential to reduce the occurrence of adverse events during treatment by providing information and decision support if required. Close collaboration with clinicians and project partners will ensure both high user compliance and seamless integration into clinical routine. Moreover, the ontology will expand the knowledge and semantic understanding of risks and critical incidents in clinical routine.

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PROJECT PARTNERS

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Funding: German Ministry of Education and Research (BMBF)

SURGICAL WORKFLOW MODELING USING COMMON BUSINESS PROCESS MODELING LANGUAGES

INTRODUCTION

Medical and technical innovations for surgical assistance systems and process automation will in future be increasingly used in the OR. Accordingly, workflow management systems should be implemented in the operating room environment. Workflow management support relies on the description and visualization of the underlying surgical processes. The processes must be represented in machine-readable form as surgical process models (SPM). Hence, business process and workflow modeling languages combined with appropriate computer-aided modeling tools can be used. The objective of this project is to identify the specific requirements for business process and workflow modeling languages as well as their corresponding software tools for surgical application.

MATERIAL AND METHODS

In the business domain, the most frequently used modeling languages are BPMN 2.0, event-driven process chain diagrams (EPCs) and YAWL. These languages were analyzed and evaluated for use in the surgical domain. Based on determined criteria, the advantages and disadvantages of these modeling languages were weighed up before selecting a language suitable for describing surgical processes.

RESULTS

In summary, the analyzed modeling languages were tested against 83 requirements for application in surgical process modeling. In addition, different modeling tools were evaluated on the basis of 40 core criteria. The findings revealed that BPMN 2.0, EPCs and YAWL all have the features needed to depict surgical processes.

DISCUSSION AND CONCLUSION

In conclusion, EPCs are the most suitable modeling language for surgical business processes since they allow the modelling of different views of the process, actors and resources as well as data and information flows. For process automation, business process models must be transformed into workflow models. Due to its presentation possibilities and widespread use, BPMN 2.0 can be recommended as the workflow modeling language of choice.

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Funding: German Ministry of Education and Research (BMBF)

IDENTIFYING AND MEASURING IMPACT FACTORS OF CLINICAL PROCESSES

INTRODUCTION

Due to the interaction between patients, medical personnel and technical resources, workflows in medicine are exposed to multiple influences, such as patient- and institution-specific factors as well as organizational characteristics. The impact of these factors on the clinical workflow varies. Knowledge of them is essential for holistic, efficient, patient-specific treatment. Although some clinical studies have tried to identify and evaluate preoperative factors (e.g. patient age, body mass index, surgeon(s) etc.) affecting the treatment workflow, they mainly focus on very specific treatments and address only a fixed set of possible factors.

MATERIAL AND METHODS

The Surgical Workflow and Patient Data (SWAP) module developed at ICCAS provides a method to identify factors affecting the structure of clinical workflows regarding the number of steps required and their composition. It in-

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Neumann J, Vinz S, Neumuth T. Surgical workflow and process modeling- An evaluation of modeling languages and process modeling tools. 6th Workshop on Modeling and Monitoring of Computer Assisted Interventions (M2CAI) at the 18th International Conference on Medical Image Computing and Computer Assisted Interventions; Munich; 2015.

Neumann J, Rockstroh M, Vinz S, Neumuth T. Technical Report: Surgical Workflow and Process Modeling,Innovation Center Computer Assisted Surgery (ICCAS), Universität Leipzig, Technical Report, 2015.

volves similarity metrics of factors of influence and clinical processes, a linear system, correlation analysis and process models. Furthermore, the method enables the impact of each factor to be rated. Since it does not depend on the type of treatment, it can be applied to any treatment process. To compute the impact of a preoperative factor, recorded clinical workflows are linked to their relevant metadata from the patient data management system. Afterwards, parameter weights are estimated using similarity metrics and a linear system. Each parameter weight indicates the impact of the preoperative factor concerned on the surgical workflow.

Parameter	$\omega(P_x)$	ρ	**Effect size**
Surgeons	0.7623	0.4267	medium
Gender	0.5221	0.0704	none
Age	0.6579	0.1363	small
Institution	0.5580	0.4164	medium
Spinal disk	0.5286	0.0741	none
Cut side	0.5277	0.0790	none

Tab. 1- Factor weights , Spearman rank correlation coefficients and Cohen's effect sizes.

RESULTS

The developed method was applied to 40 discectomies in an explorative study. The preoperative factors considered were the patient's age and gender, the performing surgeon(s), the hosting institution, the affected spinal disk, and the planned side of the access cut. Correlation analysis was used to determine coherences between process structures and their related preoperative factors. The correlation coefficients were rated according to Cohen (Tab. 1).

DISCUSSION AND CONCLUSION

The factors 'surgeon(s)' and 'institution' were found to have medium impact on the surgical process of discectomies. 'Patient age' was assessed to have a low impact, while 'gender', 'spinal disk' and 'cut side' had no significant impact. The developed method is a first step towards a generic procedure to estimate factors influencing a clinical workflow and provides an important basis for advanced workflow prediction and patient-specific decision support. The findings are plausible and match the results of other research groups. Work will be continued in order to enhance the method.

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Funding: German Ministry of Education and Research (BMBF)

COMPARISON OF SURGICAL WORKFLOWS WITH THE LEVENSTHEIN DISTANCE AND A TIME SERIES ANALYSIS METHOD

INTRODUCTION

In the operating room (OR), the whole medical team has to focus on the patient, whose safety is of course paramount. Nevertheless, economic aspects also play a role, and long waiting times between surgeries as well as cancelled interventions due to missing equipment must be avoided. Automated time and resource management can help reduce the medical staff's workload and shorten waiting times.

MATERIAL AND METHODS

In our work, we used recorded surgical workflows with a low level of granularity to compare two different methods: the Levenshtein distance for the global analysis of surgical activities, which considers all the information regarding the surgeon's physical tasks (action, treated region, the instrument used, the surgeon's body part used), and spectral analysis for the local analysis of surgical activities only involving the surgeon's right hand. For analysis with the Levenshtein distance, we transformed surgical workflows into a sequence of letters, with different combinations of activities resulting in different strings. The following combinations are examples of labels:

» “Cut, dissector, right hand, and skin”: A
» “Coagulate, tweezers, right hand, skin”: B

Spectral analysis was applied to the same recorded surgical processes. In contrast to the Levenshtein distance, we utilized only the use of the right hand to obtain a time series of every surgical workflow. Whether the surgeon was left- or right-handed was disregarded. The time series were square wave signals, in which the signal was deemed 1 at time t if the right hand was used and otherwise 0. The time series obtained were Fourier-transformed into the spectral domain to consider different sets of signal parameters. Spectral analysis was conducted every 60 seconds. We used calculated features of the power spectral density and the spectrogram of the time series for spectral analysis. Spectral parameters such as spectral roll-off were calculated to compare the ongoing surgical procedure to other surgical procedures.

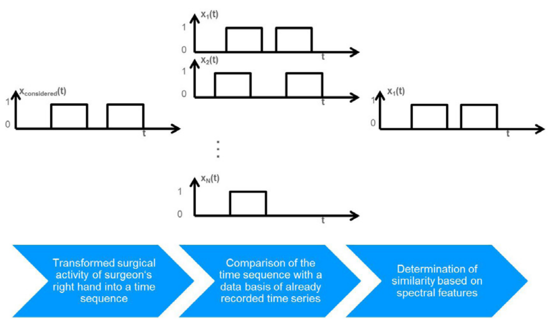

Fig. 1- Pipeline to compare surgical workflows based on the Levenshtein distance.

RESULTS

Both methods were evaluated in a leave-one-out study with 41 lumbar discectomies as a neurosurgical use case. Spectral analysis proved to be the better measure of similarity. The remaining intervention time was more precisely estimated than with the Levenshtein distance.

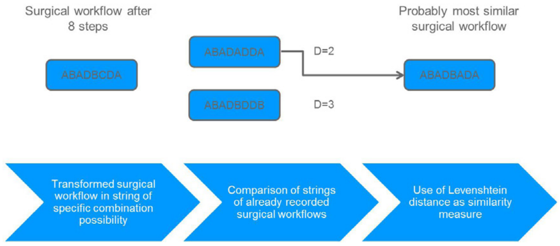

Fig. 2- Pipeline to compare surgical workflows based on calculated spectral features.

DISCUSSION AND CONCLUSION

The two methods compared have the potential to predict the remaining intervention time of an ongoing surgical procedure. Spectral analysis of the surgeon’s right hand was sufficient to achieve similar results to the Levenshtein distance. Considering whether the surgeon is left- or right-handed may deliver more precise results.

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Funding: German Ministry of Education and Research (BMBF)

FREQUENCY-BASED ANALYSIS OF SURGICAL WORKFLOWS

INTRODUCTION

Effective resource management is important for enhancing the handling of financial and critical safety aspects in modern hospitals. The duration of surgery plays a decisive role in many areas of hospitals, such as patient safety and financial aspects. Accurate automated online prediction enables efficient surgical patient care and effective resource management.

SELECTED PUBLICATIONS

Maktabi M, Neumuth T. Analyse von chirurgischen Workflows mit Hilfe der Levenshtein- Distanz und der spektralen Analyse. 14. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC); Bremen; 2015.

MATERIAL AND METHODS

In this work, several surgical activities during an intervention were examined for their potential to forecast the remaining intervention time. The method used was based on analyzing time series in the frequency domain representing the status of surgical activities during an intervention. We used four steps to compare surgical activities in terms of their suitability for intervention time prediction based on spectral estimation. To compare surgical activities of a specific surgery type, they need to be recorded. In our work, we used recordings in the form of individual surgical process models (iSPM). We concatenated the attributes of the perspectives of surgical activities (functional, operational, spatial and organizational) to build an identifier and represented the identified activities' status over the fourth perspective (recorded intervention time). This was done in the form of binary activity sequences over time x(t); x(t) was deemed 1 while the activity was being conducted and 0 otherwise (Fig. 1).

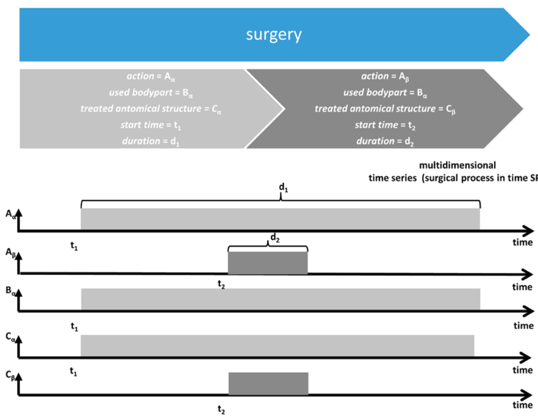

Fig. 1- Procedure to obtain a rectangular activity time series of surgical step sequences included in individual surgical process models (iSPMs).

A nonparametric estimation of power spectral density was calculated for single surgical activity time series during an intervention. The third step is to compare the power spectral densities of the activity time sequences to each other by extracting well-known statistical features (e.g. total power, dominant frequency). These features provide new periodicity information about the activity time sequences and can be used to compare the surgeon's activities.

RESULTS

The power spectral densities of various surgical activities were compared in a leave-one-out cross validation of forty surgical workflow recordings of lumbar discectomies (Fig. 2). The results showed that the activity best suited for determining the remainder of the intervention is irrigation.

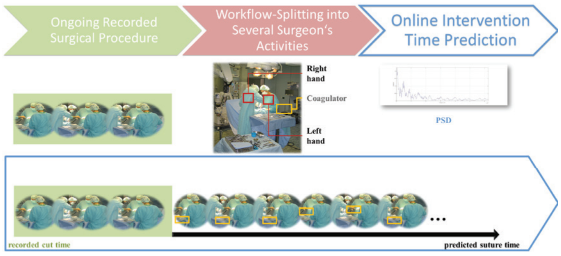

Fig. 2- Pipeline of the spectral recognition system concept for surgical workflows.

RESULTS

The power spectral densities of various surgical activities were compared in a leave-one-out cross validation of forty surgical workflow recordings of lumbar discectomies (Fig. 2). The results showed that the activity best suited for determining the remainder of the intervention is irrigation.

DISCUSSION AND CONCLUSION

To construct a scheduling support for a wider range of surgery types, the actions conducted by the surgeon's right and left hand would be eminently more suitable. In conclusion, improvement of the frequency-based method presented might provide additional general support for time and resource management.

Dipl.-Ing. Marianne Maktabi

Prof. Dr. Thomas Neumuth

Funding: German Ministry of Education and Research (BMBF)

SELECTED PUBLICATIONS

Maktabi M, Vinz S, Neumuth T. Frequency based assessment of surgical activities. 49th Annual conference of the German Society for Biomedical Engineering (DGBMT); Lübeck; 2015.

ANALYSIS OF SURGICAL INSTRUMENT DESCRIPTIONS USED BY SCRUB NURSES FOR THE DEVELOPMENT OF A TRAINING SYSTEM

INTRODUCTION

Verbal misunderstandings in the operating room (OR) often disrupt the surgical flow. Besides the resulting general delay, the surgeon's concentration is interrupted and confusion is common. The project addresses a key aspect of the collaboration between surgeon and scrub nurse and aims to provide a deeper understanding of the factors leading to disturbances in the OR.

MATERIAL AND METHODS

As part of a multicenter study involving three clinics in Germany and Switzerland, we asked 15 ENT (ear, nose and throat) scrub nurses to name 35 instruments from their own and three other surgical domains. For this purpose, we developed custom software to conduct instrument interviews. We used the Jaccard similarity coefficient to measure the level of similarity between their given descriptions.

RESULTS

The results indicate that the working environment of the OR influences the terms used for surgical instruments among scrub nurses. In addition, the terminology used by the two German clinics was found to have a slightly higher level of similarity than when compared to the Swiss clinic. Regional peculiarities such as naming instruments for cities and references to the animal kingdom were also noted. Instruments from non-ENT domains received significantly lower similarity ratings than terms from the familiar ENT domain.

Fig. 1- Rendered concept model of the ICCAS NOSCO scrub nurse training system.

DISCUSSION AND CONCLUSION

Comparison of the study results reveals central factors affecting the common understanding of surgical instruments' names:

- » Changing surgical domain can reduce understanding within the team, e.g. if a scrub nurse is temporarily assigned to an OR in an unfamiliar surgical domain
- » Changing the team, clinic or country can also decrease understanding within the team, e.g. when changing the place of work

A follow-up study will continue examining the aspects discovered by focusing on surgeons. The findings will be used to improve the scrub nurse training environment developed at ICCAS (Fig. 1).

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PROJECT PARTNERS

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Funding: German Ministry of Education and Research (BMBF)

SELECTED PUBLICATIONS

Glaser B, Schellenberg T, Koch L, Hofer M, Modemann S, Dubach P, et al. "Not these scissors, the other scissors."- A multi-center study comparing surgical instrument descriptions used by scrub nurses. 17th International Conference on E-health Networking, Application & Services (IEEE Healthcom); Boston, USA; 2015.

STERILE EYE-TRACKING DRIVEN INTERACTION CONCEPTS FOR THE DIGITAL OPERATING ROOM

INTRODUCTION

With the advancement of technological support systems in the modern operating room (OR), there is also a growing need for sterile interaction concepts. Nowadays, sterile interaction in the OR is typically implemented by using sterilizable parts (such as lamp grips), special plastic covers or foot pedals. Often, interaction simply consists in asking a non-sterile person to carry out a task instead, e.g. to change the parameters of a non-sterile device. Recent concepts use speech recognition, gesture detection or the embedding of functionality for other devices in already sterile interfaces. The advancement of eye-tracking technology may provide a valuable addition to the existing range of interaction methods in the OR.

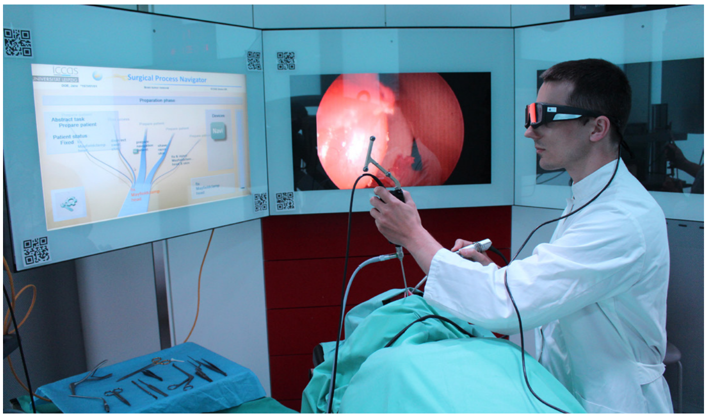

Fig. 1- Setup of the evaluation system in the Demonstration OR at ICCAS.

MATERIAL AND METHODS

The project uses a pair of SMI Eye-Tracking Glasses v2.0 to trace the course of the wearer's eye movements (Fig. 1). Besides the coordinates of the fixed points, the device delivers a constant video stream of the wearer's field of view. By placing easily detectable elements like 2D barcodes in the field of vision, various interaction mechanisms can be implemented, for example based on the duration of a gaze on a certain spot or by triggering an action after a series of spots has been looked at in a certain order.

RESULTS

The project is still in its early stages. An initial working demonstrator as a proof of concept will be used to evaluate appropriate interaction techniques. This will include exploring feedback mechanisms for the wearer
and the creation of an interface to connect the system to existing OR equipment.

DISCUSSION AND CONCLUSION

Suitable use cases in the OR for this new kind of sterile interaction have been identified as a step towards implementation. One range of possible applications focuses on the scrub nurse. Sterile eye-tracking driven concepts would enable scrub nurses to relieve the surgeon by taking over frequently needed support functions – from taking incoming telephone calls in the OR to complex jobs such as marking defect surgical instruments.

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PROJECT PARTNERS
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Funding: German Ministry of Education and Research (BMBF)

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Glaser B, Unger M, Schellenberg T, Neumuth T. Use Cases für sterile blickgesteuerte Mensch-Maschine-Interaktionskonzepte im digitalen Operationssaal. 14. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC); Bremen; 2015.

ONCOCOCKPIT - COMPUTER ASSISTED HUMAN–COMPUTER INTERACTION FOR INTEGRATED, MODEL-BASED MULTIMODAL ONCOLOGICAL THERAPY

Cancer patients need to be treated by means of individualized, specialized therapy made up of systemic, localized treatment components. Increasingly precise surgical and radiotherapeutic interventions are supplemented by systemic or targeted local chemotherapy and immunotherapy. However, treatment planning is complicated and takes place in interdisciplinary tumor boards. As the treatment steps are carried out by different departments, synchronizing interdisciplinary treatment is often hampered by the structure of the hospital.

Fig. 1- Virtual three-dimensional planning of treatment options

The OncoCockpit is a unique system in which highly complex digital patient models are to be used in order to simplify both interdisciplinary collaboration in the tumor board and the performance of treatment. To this end, a visualization environment is to be created which extensively supports this exploration intuitively while simultaneously enabling surgical or interventional access routes, radiation angles, focused ultrasound, targeted local chemotherapy, etc. to be planned. Moreover, the OncoCockpit is to be able to be used virtually by individual or even groups of clinicians at any time. Similar to a flight simulator, high-resolution 3D screens, 3D image projection and holography will be used. Since nothing similar to the OncoCockpit exists, Saxony will be the first region in the world where a system of this type is used.

Subsequently, robotic assisted focused Ultrasound positioning is to be implemented into the OncoCockpit. This will enable focused ultrasound to be applied during electron and proton therapy using two robotic systems without exposing the medical team to radiation. In the OncoCockpit, multimodal ultrasound-guided ablation and radiation therapy is to be monitored and controlled interactively all the way from planning to implementation. While one of the systems guides the treatment transducer, the other will guide the 3D diagnostic transducer. The two robots will receive information from data interfaces in the OncoCockpit and use it for the precise positioning of ultrasound.

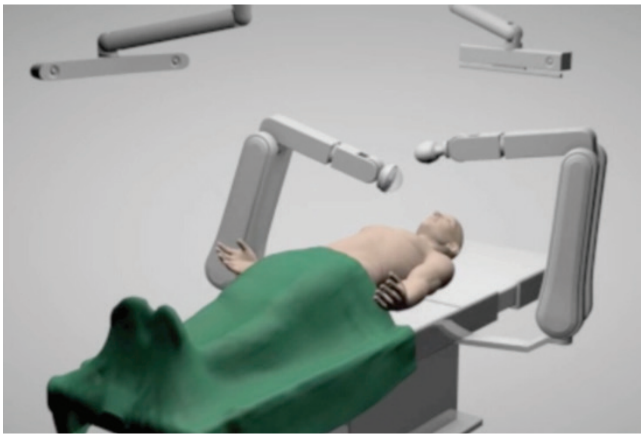

Fig. 2- Robot assisted transducer positioning for high-intensity focused ultrasound

The project is a joint effort of the MAI and NIG groups linked to the basic research on validation how and which kind of ultrasound pulses will generate local effects such as cavitation and hyperthermia that are known to increase the tumor cells' radiosensitivity.

The robotic part will be conducted in collaboration with the FUTURA FP7 project.

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VDE – Verband der Elektrotechnik Elektronik Informationstechnik
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MULTIMODAL INTRAOPERATIVE IMAGING

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Just M, Chalopin C, Unger M, Halama D, Neumuth T, Dietz A, et al. Monitoring of microvascular free flaps following oropharyngeal reconstruction using infrared thermography: first clinical experiences. Eur Arch Otorhinolaryngol. 2015.

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Rathmann P, Lindner D, Halama D, Meixensberger J, Chalopin C. Dynamische Infrarot-Thermographie (DIRT) zur Darstellung der Kopfhautdurchblutung bei neurochirurgischen Eingriffen. 14. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC); Bremen; 2015.

Improving the surgical outcome by developing innovative assistance systems based on non-invasive imaging.

INTRODUCTION

The Multimodal Intraoperative Imaging research group began work in May 2015.
Its objectives are:

» The evaluation of new imaging methods for surgical applications
» The optimization of imaging devices for the operating room
» The development of innovative assistance systems for the interpretation of intraoperative image data

The group's projects focus mainly on non-ionizing and non-invasive imaging techniques because:

» The devices are portable, easy to use and therefore ideal for the operating room;
» Imaging is possible in real time
» These modalities are safe for patients and medical staff
» Theoretically, an unlimited number of acquisitions can be performed

So far, ultrasound imaging and thermography have been studied. However, they have limitations, such as low image quality and limited scanned areas. Therefore, new developments will concentrate on the fusion of different modalities.

PERFORATOR DETECTION USING DYNAMIC INFRARED THERMOGRAPHY

INTRODUCTION

Free microvascular tissue transfer is a reliable, well-established technique in reconstructive surgery. It entails detecting the perforator vessels of the free flap. Currently, indocyanine green (ICG) angiography is used to detect the perforators. However, since administering ICG is an invasive method that may lead to incidents, infrared thermal imaging was evaluated as a non-invasive alternative.

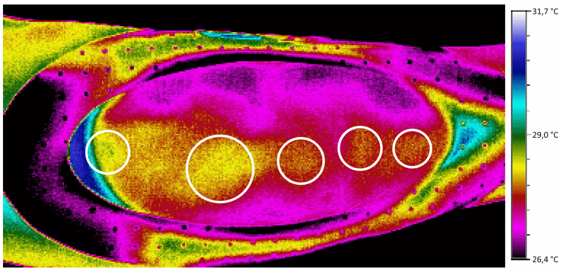

Fig. 1- Detection of the perforator vessels of the free fibula flap after cooling the tissue. Perforators (denoted by circles) show faster reheating than ambient tissue.

MATERIAL AND METHODS

An infrared camera (PI450, Optris GmbH) was used to measure the surface temperature of skin areas. The IR camera has a thermal resolution of 40 mK and an optical resolution of 382 x 288 pixels. The OEM software PIConnect was used to retrieve the thermal image, which was then processed with custom-developed algorithms. Firstly, the image was stabilized to accurately process the scene. Secondly, the perforators were identified based on dynamic analysis. For this purpose, tissue was cooled using a balloon filled with water at room temperature to induce blood perfusion and reheating. The thermal image was divided into blocks in which the mean temperature was analyzed over time. Blocks containing a perforator were expected to reheat faster than those without a perforator. A study on healthy subjects was conducted by our clinical partner and approved by the ethics committee of the University of Leipzig.

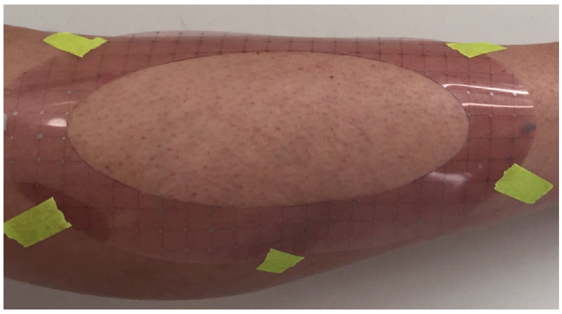

Fig. 2- Visual image corresponding to the thermal image. The use of templates ensures reproducibility between subjects while also providing markers for the stabilization process.

RESULTS

The temperature difference between the perforator and the ambient tissue is Ø 0.6 ± 0.2 K. Blocks containing a perforator show an increased reheating (step height of Ø 4.0 ± 0.4 K) compared to ambient tissue (step height of Ø 2.8 ± 1.1 K). The time constant (time to reach 63 % of the end value) of perforator tissue (Ø 16.8 ± 4.2 s) is different from ambient tissue (Ø 4.6 ± 2.2 s).

DISCUSSION AND CONCLUSION

The study showed that perforators can be detected using infrared thermal imaging. Functions for the automatic identification of perforators need to be improved. A follow-up study involving 20 subjects and 6 types of tissue will be carried out.

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Funding: German Ministry for Economic Affairs and Energy (BMWi)

MODEL-BASED BRAIN TUMOR SEGMENTATION IN INTRAOPERATIVE ULTRASOUND IMAGES

INTRODUCTION

Intraoperative ultrasound (iUS) imaging is currently used to support brain tumor operations. US images show the surgeon the current state of a tumor in real time. Combining the US device with a neuro-navigation system aids the interpretation of the image. However, the representation of the tumor boundary remains unsatisfactory. Therefore, the goal of this project is to develop a segmentation algorithm for brain tumors in iUS images to improve boundary visualization.

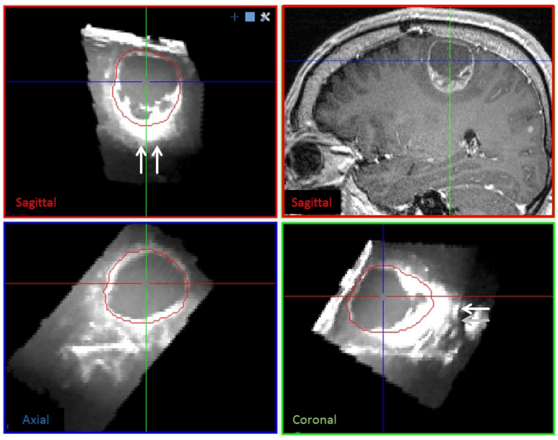

Fig. 1- Segmentation result of a brain metastasis represented in the three planes of 3D iUS data. The tumor is also shown in the corresponding MRI by way of comparison. The advantage of using a tumor model is the ability to reconstruct missing information about the tumor's boundary, e.g. due to image artifacts (white arrows).

MATERIAL AND METHODS

Model-based segmentation methods are more robust when dealing with US data. Therefore, our method consists in registering a tumor model with an iUS image and integrating physical properties of US imaging into the algorithm. The tumor model is semi-automatically segmented in the preoperative MR image. Then, the algorithm proceeds in three phases. In a preprocessing step, the MR and iUS images are centered (transform T1), smoothed and cropped to shorten the computing time. Secondly, image gradients are calculated and then rigidly registered (transform T2). Finally, the tumor model is transformed according to transformations T1 and T2. The result shows the tumor contour in the iUS image.

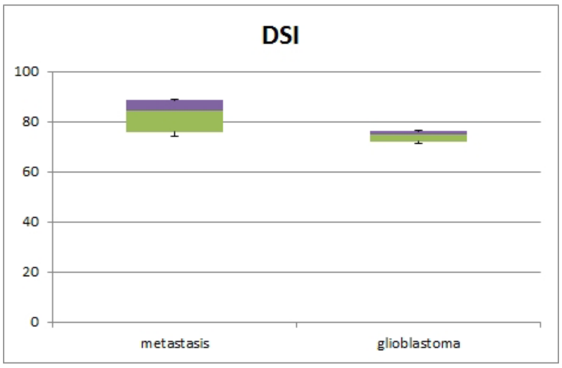

Fig. 2- Boxplot representation of the Dice Similar Index (DSI) computed between the segmentation algorithm result and manual delineation.

RESULTS

The segmentation algorithm was tested on 11 patient data sets with brain metastases (Fig. 1) and 4 patient datasets with glioblastomas. Evaluation consisted in comparing the algorithm result with segmentation provided by an observer using the Dice Similarity Index (DSI) and the mean contour distance (MCD). The mean DSI values were 82.5% for metastases and 74.3% for glioblastomas (Fig. 2). The mean MCD values were 1.6 mm for metastases and 2.0 mm for glioblastomas. Moreover, the mean computing time was below 4 min.

DISCUSSION AND CONCLUSION

The segmentation results are promising and the computing time acceptable for intraoperative use. Enhancing the tumor border in the iUS data helps the neurosurgeon check the position of the tumor after craniotomy and aids any modification of the operating strategy in the event of large deformations after craniotomy.

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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..

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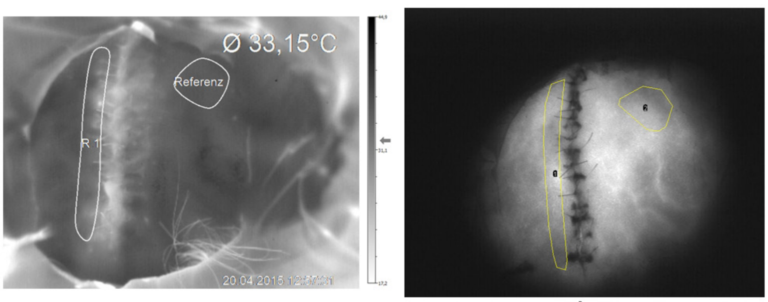
REAL-TIME EXAMINATION OF HEAD SKIN PERFUSION DURING NEUROSURGERY USING DYNAMIC INFRARED THERMOGRAPHY (DIRT)

INTRODUCTION

The good perfusion of skin is crucial for the healing of wounds after surgical interventions. Intraoperative imaging can reduce the rate of postoperative complications by detecting the damaged skin areas and immediately applying appropriate surgical treatment while the patient is still in the operating room. Although the current gold standard is indocyanine green angiography (ICG-A), this contrast agent is expensive and can provoke allergic reactions. The goal of this project is to evaluate the suitability of dynamic infrared thermography (DIRT) as an alternative method.

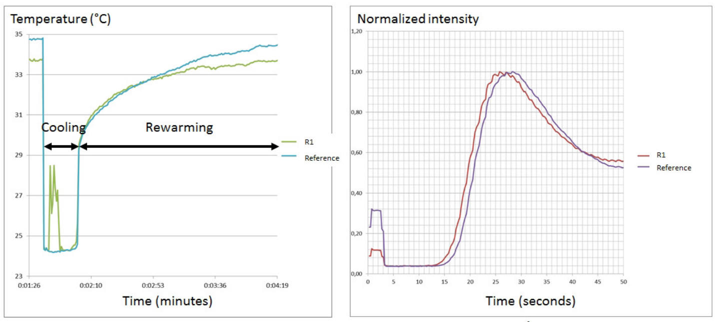


a b

Fig. 1- DIRT (a) and ICG (b) static images of a head wound acquired in the final stage of cranial reconstruction surgery after closing the incision. Two similar skin areas were selected in both imaging modalities for comparison: a region near the wound (labeled R1 in (a)) and a reference region.

MATERIAL AND METHODS

During cranial reconstruction operations, the patient's head skin is examined using an infrared camera (PI450, Optris GmbH). The skin is cooled for 20s with a surgical glove filled with water at room temperature. Tissue cooling induces blood perfusion in order to warm up the tissue, dynamic process which is recorded with thermography (Fig. 1a). In addition, ICG-A data are acquired immediately after the injection of contrast agent (Fig. 1b). The flow of contrast agent is visible at high intensities in the images. For evaluation, two regions are identically selected offline in the DIRT and ICG-A images: the wound area and a reference area, which is correctly vascularized. Time-temperature and time-intensity curves are plotted and compared (Fig. 2).



a b

Fig. 2- (a) Time-temperature curve plotted from the DIRT dataset and representing tissue rewarming after cooling the region of interest. (b) Time-intensity curve extracted from the ICG datasets and showing the arrival and flow of contrast agent in the tissue.

RESULTS

The study was approved by the ethics committee of the University of Leipzig. Five patients have been examined so far. Similar anatomical structures such as blood vessels were detected in both imaging modalities. Curves of tissue rewarming showed a logarithmic function pattern in DIRT. In the example shown in Fig. 2, curve derivatives after cooling were similar in the wound and reference areas. Moreover, the depiction of the flow pattern of contrast agent was identical in both regions in the ICG-A

SELECTED PUBLICATIONS

Rathmann P, Lindner D, Halama D, Meixensberger J, Chalopin C. Dynamische Infrarot-Thermographie (DIRT) zur Darstellung der Kopfhautdurchblutung bei neurochirurgischen Eingriffen. 14. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC); Bremen; 2015.

time-intensity curves (Fig. 2b) and indicated no deficiency in tissue perfusion.

DISCUSSION AND CONCLUSION

Initial results on patients without wound complications showed that similar structures and perfusion processes are visible in both DIRT and ICG-A modalities. Follow-up steps will include a quantitative evaluation of the dynamic perfusion of skin.

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OPTIMIZATION OF ACTIVE CONTOUR METHODS FOR THE SEGMENTATION OF BRAIN TUMORS IN MRI

INTRODUCTION

The extraction of brain tumor boundaries in magnetic resonance imaging (MRI) data is a prerequisite for the calculation of geometrical parameters, i.e. tumor volume and distance to risk structures such as vascular structures. It is also the first step for visualization purposes. However, inhomogeneity regarding tumor size, shape, location, image intensity and texture hamper the success of automatic segmentation methods. Therefore, the aim of this project was to develop a fully automatic segmentation method which was robust to irregular tumor shapes.

MATERIAL AND METHODS

This method comprises two steps. Firstly, the region of interest (ROI) containing the tumor is automatically detected in the images using a robust descriptor based on shape variation, texture, size, pixel intensity and tumor location. This descriptor, known as a hierarchical centroid shape descriptor (HCSD), is a binary shape descriptor built with the centroid coordinates extracted from a binary image. The tumor can be distinguished from other brain tissue by means of the k-d tree algorithm (Fig. 1a). Secondly, a region-based active contour method driven by local Gaussian distribution fitting (ACLGDF) is used to distinguish the tumor boundary (Fig. 1b).

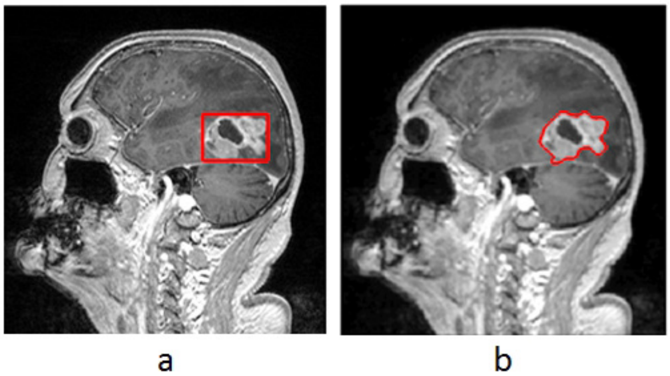

Fig. 1- Automatic segmentation of a glioblastoma in 2D MRI slices. First of all, the tumor is automatically detected in the image (a). In the following step, the active contour algorithm is used to detect the tumor boundary (b).

Initialization of the active contour is performed using the detected ROI including the tumor. This method is especially robust for the extraction of the borders of convex objects.

RESULTS

The algorithm was implemented at the University of Guanajuato (Engineering Division) and tested on 2D MR slices of 14 patients with brain tumor acquired at Leipzig University Hospital (Department of Neurosurgery). A mean similarity index of 93% was achieved between the algorithm result and delineations performed by an expert.

DISCUSSION AND CONCLUSION

The above-described segmentation approach produced promising results. The goal was to help the neurosurgeon segment brain tumors in MRI data, especially in cases of glioblastomas with mostly irregular shapes. This approach is now to be evaluated on MR datasets of lower quality. Another future objective is to extend the algorithm to 3D. The segmented brain tumor can be used as a patient-specific model to guide tumor extraction in intraoperative ultrasound data.

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ARCHETYPE-BASED PATIENT DATA MODELING TO SUPPORT TREATMENT OF PITUITARY ADENOMAS

INTRODUCTION

The pituitary adenoma is mostly a benign tumor located in the sellar region of the brain (Fig. 1). It disrupts hormone production and can also affect patients' visual acuity. Diagnosis and therapy are based on the examination of patient data such as image data, laboratory tests and medical reports. Since these types of data come in different formats, a number of information systems are required to store them at the hospital. The goal of this project is to develop an integrated patient data model for use in the therapy of pituitary adenomas.

MATERIAL AND METHODS

The tools provided by the openEHR foundation were used for modeling because:

- A large database of models known as archeypes is available
- Patient data are structured and represented according to international standards
- Free software is available which supports modeling

Modelling is performed in three steps: (1) The clinical workflow is modeled and the patient data involved in the different treatment phases is listed; (2) Individual patient data is modeled using the corresponding archetypes; (3) The archetypes are assembled according to the clinical workflow into an integrated model.

Fig. 1- MR data of patient revealing a large adenoma (white arrow) in the pituitary gland.

RESULTS

The relevant patient data required for the surgical treatment of pituitary adenoma are image data, radiological reports, laboratory test reports, visual examination reports, operation reports and histopathology reports. The patient data model includes twelve existing archetypes and five new archetypes. For example, the archetype ‘Pituitary tumor image classification’, which models tumor classification based on image data examination results, was implemented (Fig. 2).

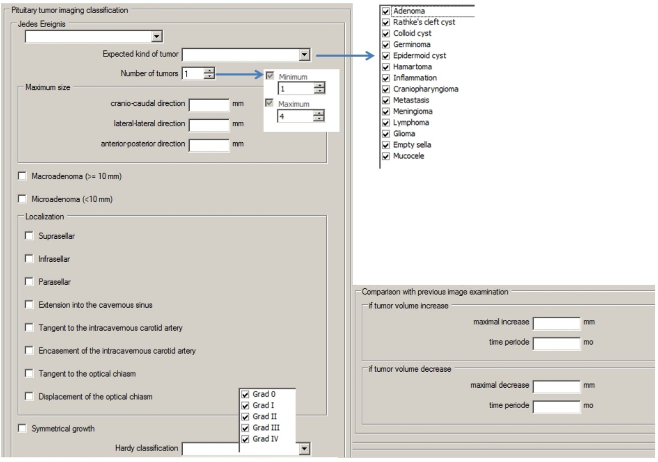

Fig. 2- Preview of the new archetype ‘Pituitary tumor image classification’ recording tumor classification and based on image patient data (mask generated by the openEHR software Template Designer).

DISCUSSION AND CONCLUSION

According to our experience, an additional advantage when using the openEHR tools is the separation of domain modeling from application development. This enables a non-expert to implement the model without a profound knowledge of databases. Once patient data modeling has been completed, an XML document is generated which provides the basis for the development of an application, e.g. a decision support system.

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CONACYT (National Council of Science and Technology) grant scholarship, Mexico

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DIGITAL PATIENT AND PROCESS MODEL

    

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SELECTED PUBLICATIONS

Cypko MA, Hirsch D, Koch L, Stoehr M, Strauss G, Denecke K. Web-tool to Support Medical Experts in Probabilistic Modelling Using Large Bayesian Networks With an Example of Rhinosinusitis. Stud Health Technol Inform. 2015; 216: 259-63.

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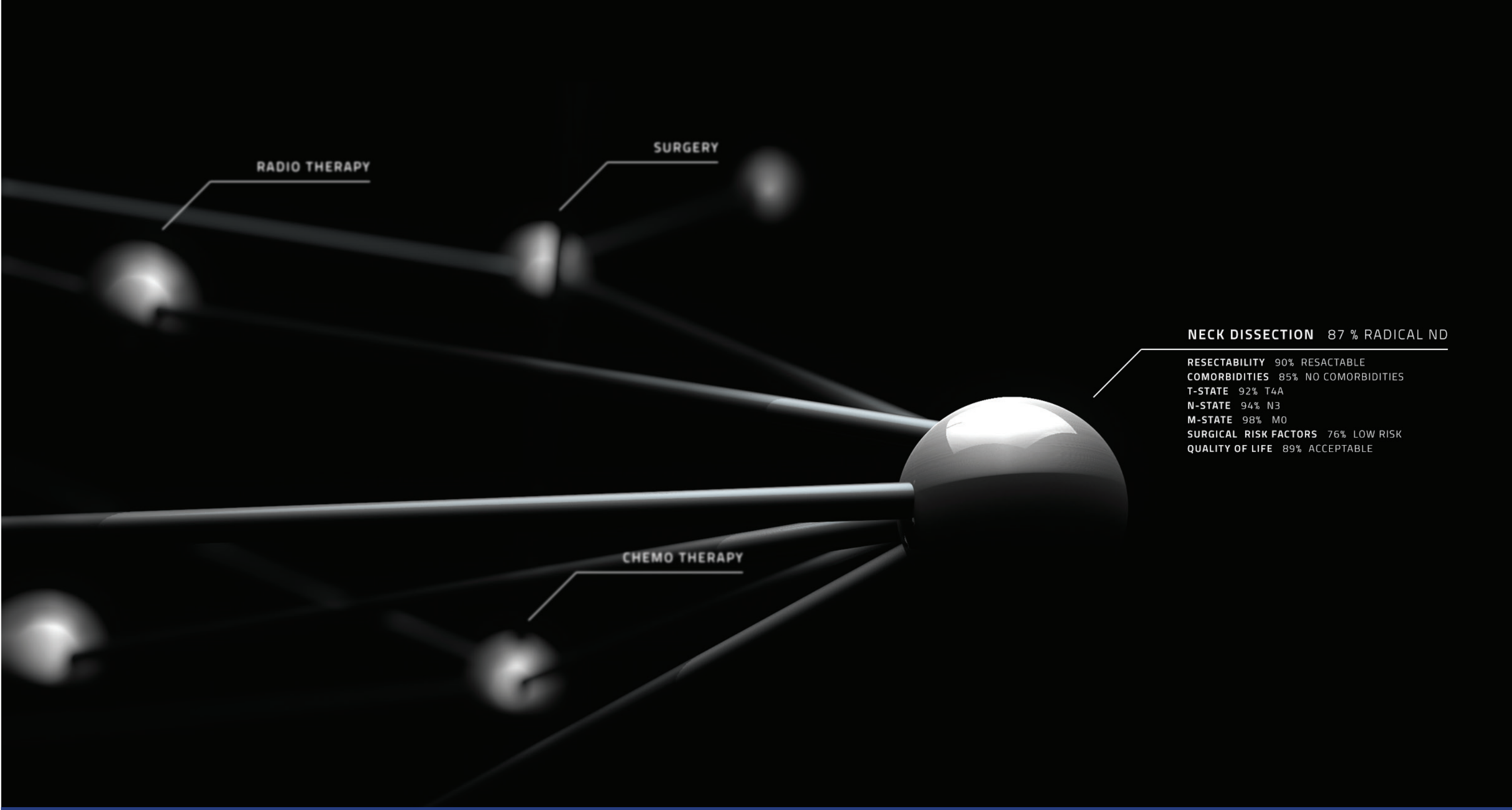

To support patient-specific therapy decisions for better outcomes and more patient safety.

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. But this large amount of information can quickly become too extensive to be fully considered in a clinician's decision making. The Digital Patient Modelling Group at ICCAS is addressing this problem by developing therapy decision support systems, methods for extracting patient data and standardised information models.

In 2015, our research focused on developing new methods for supported therapy decision modelling, model validation, analytic user interfaces, information retrieval, and techniques for data integration at a semantic level. Furthermore, previous work towards modelling of therapy decisions was continued. All these aspects are required for digital patient modelling.

These findings have been presented and discussed at dedicated conferences and workshops as CARS, MedInfo, BMT and GMDS. Projects in this area are currently funded by the German Federal Ministry of Education and Research (BMBF) and the European Regional Development Fund (ERDF).

THERAPY RISKS AND QUALITY OF LIFE: FINALIZING THE GRAPH MODEL OF LARYNGEAL CANCER

INTRODUCTION

Since 2013, we have been developing therapy decision support systems at ICCAS using multi-entity Bayesian networks (MEBN). MEBNs are used to model and simulate abstractions of real-life situations and processes. They are based both on a graph with random variables and directed edges denoting the conditional dependence structure between these random variables, and on the probabilistic model, a mathematical correlation between random variables (representing uncertainty and what is known with reasonable certainty). When an MEBN model is created, patient-specific information can be integrated. Based on the patient-specific data observed, the system makes inferences about the unobserved information entities in the model.

Fig.1- Medical experts and technicians working closely together.

MATERIAL AND METHODS

We spent two years with our domain experts from Leipzig University Hospital creating an exemplary graph model of the therapy decision of laryngeal cancer. Containing over 900 information entities and more than 1100 dependencies, the graph model includes information entities about the tumor, tissue infiltrations, lymph nodes, metastases, comorbidities and therapies. Whereas pre-therapeutic information entities are very specific, therapy options are described only by the main therapies, e.g. surgery, radiation therapy, chemotherapy, or combinations thereof. Generally speaking, we modelled a degree of detail reflecting that applied by our highly specialized ENT tumor board at Leipzig University Hospital.

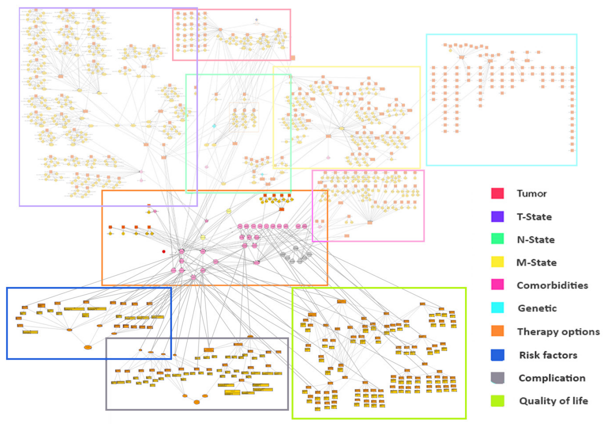

Fig. 2- The extended Larynx Model with detailed therapies and therapy outcomes.

RESULTS

To reach the best patient-specific therapy decision, potential therapy outcomes need to be considered. Therapy outcomes comprise general side effects, complications, and also quality of life factors. Since these outcomes are very therapy-specific, the model needs more precise information on the therapy options. In our examples, surgery is now subdivided into laser surgery, different partial resections and

SELECTED PUBLICATIONS

Stoehr M, Cypko MA, Denecke K, Lemke HU, Dietz A. A model of the decision-making process: therapy of laryngeal cancer. Int J Comput Assist Radiol Surg. 2014; Volume 9(1): 217-218.

laryngectomy. The same is done for radiation therapy and chemotherapy. Altogether, we added over 200 new information entities. Now, the system will be able to infer in both directions: forwards, i.e. along the causality from observed pre-therapeutic data to the therapies, and also inversely, i.e. from preselected outcomes that our medical experts or patients want to avoid.

DISCUSSION

With the detailed therapies and outcomes, the graph model is largely complete. When modelling the graph, we started to add the necessary probabilities. In the next stage, we will validate the new graph model with our clinical experts and also collect the necessary probabilities.

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M. Sc. Jan Gaebel

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Funding: German Ministry of Education and Research (BMBF)

VALIDATION OF BAYESIAN THERAPY DECISION MODELS WITH AN EXAMPLE OF TNM STAGING

INTRODUCTION

For our graph model for decision support in laryngeal cancer, we selected tumor, lymph nodes and metastasis staging (TNM staging) as the first sub-model to be probabilistically valued. TNM staging involves the main part of the laryngeal cancer therapy decision model and is also well described by the generally accepted head and neck cancer guidelines of the National Comprehensive Cancer Network (NCCN).

MATERIAL AND METHODS

In order to use these models in clinical practice as a decision support system, they need to be validated. Validation is usually performed based on real patient cases, either automatically using common validation methods or manually by medical experts. Automatic validation requires a large amount of test data. In the theoretical worst case, the number of test cases is exponential to the number of nodes and their states. The TNM staging model with 324 nodes and on average about three states per node would therefore need over 3324 > 10153 test cases. Although in practice far fewer cases are needed, no method is available which gives a better assessment.

RESULTS

In this project, we teamed up with Professor Druzdzel's Decision Systems Laboratory at the University of Pittsburgh to develop a new method to calculate the quality of available test cases compared to a model. Moreover, if fewer test data is available, this method estimates the minimum number of test cases. With our new method, we know that around 4200 cases are needed to automatically validate our TNM model. We started collecting data in 2013. Unfortunately, with around 80 cases per year at Leipzig University Hospital, we do not have enough data. Therefore, we asked our clinical experts to validate the model manually using the available test cases and existing modelling tools (e.g. the GeNIe software from the University of Pittsburgh) as shown in Fig. 1. Our experts can use their intuition to examine the inferences made by the system and quickly review the causality of decisions if they disagree. In addition, this subjective approach gives us the advantage of considering combinations of states that are not in the available patient data. With more experts, the precision of validation improves.

Fig. 1- Semi-automatic model validation at ICCAS. Expert using modelling tools and new validation methods to analyse the TNM staging model.

DISCUSSION

In our opinion, a combination of automatic and manual validation is the most practical method if the necessary patient data is not available. In the next steps, we will continue collecting more patient cases and also work on supporting tools for collaborative expert-based validation.

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Funding: German Ministry of Education and Research (BMBF)

ANALYTICAL USER INTERFACE TO FIND THE BEST THERAPY OPTIONS IN PATIENT-SPECIFIC BAYESIAN NETWORKS

INTRODUCTION

When treating complex, data-intensive diseases (e.g. in oncology), decision support systems can help clinicians find the best patient-specific therapy decision. At ICCAS, we model such therapy decisions with multi-entity Bayesian networks. Once patient-specific (multi-entity) Bayesian networks are available, they can be presented in a simple manner by their inherent graphical structure with nodes representing information entities connected by directed edges representing their direct causal relationship. This visualization (with all nodes and edges) can by itself help clinicians to quickly overview observed and inferred patient information.

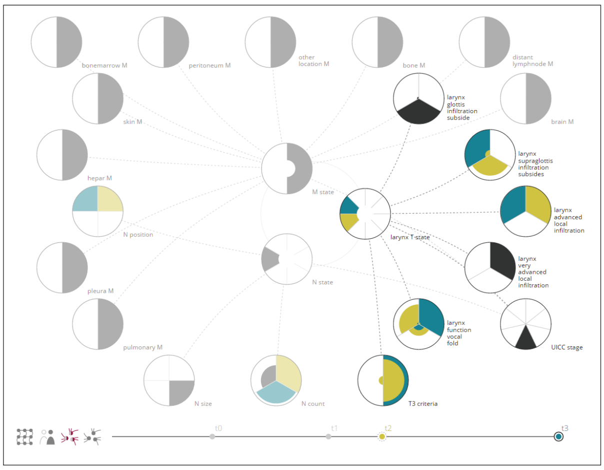

Fig. 1- Visualization tool to support expert-based model analysis.

MATERIALS AND METHODS

In complex patient cases, important information needs to be highlighted and additional argumentations used to corroborate a therapy decision in a tumor board. Underlining relevant information is very important since less relevant data may have a detrimental effect on decisions. As soon as clinicians have an overview, they can discuss and argue about decisions, e.g. by comparing similar patient cases and referring to guidelines and statistics.

RESULTS

In this project, we developed a graphical user interface to analyze large patient-specific Bayesian networks which reflect expert-specific viewpoints and established tumor board argumentations. In Fig. 1, the screenshot of our web tool shows an example of a patient-specific model. Each pie chart represents an information entity with sectors for each possible state. A filled sector represents the patient status. In

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Stoehr M, Cypko MA, Denecke K, Lemke HU, Dietz A. A model of the decision-making process: therapy of laryngeal cancer. Int J Comput Assist Radiol Surg. 2014; Volume 9(1): 217-218.

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this figure, two time steps are compared with different colors representing changes. An initial usability test has shown this to be an intuitive way of quickly grasping a patient's situation.

DISCUSSION

In the next steps, more usability studies will be performed with clinicians. Furthermore, a field trial will be conducted in which current patient cases are analyzed before a tumor board is held. These results will then be forwarded to participating clinicians.

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AUTOMATIC CERVICAL SPINE DEFECT CLASSIFICATION AND RETRIEVAL BASED ON CLINICAL NARRATIVES

INTRODUCTION

Degenerative changes of the cervical spine are reflected in multiple aspects of observation such as the area and position of the defect and additional pathology. For this reason, treatment decision-making regarding the cervical spine requires evidence from all relevant data sources. The most direct way of determining and classifying these defects is to peruse patient records, which is quite laborious. A method of automatic classification and retrieval is urgently needed in clinical practice.

MATERIAL AND METHODS

SURGICAL DEFECT-BASED CLASSIFICATION SCHEMA

Prof. Meixensberger and Prof. Leimert have developed a relatively new mechanism in the pathological classification of cervical spine defects which can be directly applied to surgical planning and decision-making. It involves the quantity of affected cervical segments, the position of the defect, and additional pathologies. 100 patient records in German were anonymized and annotated with their defect features and classified defect codes as benchmarks.

TEXT-BASED AUTOMATIC CLASSIFICATION

We are addressing these issues by establishing a defect terminology and an extraction pipeline as well as developing defect classification rules. The concept and features defined in the defect terminology can be extracted from unstructured texts by means of concept matching. All the extracted entities and features are indexed for further retrieval. The rules govern mapping between extracted features and defect categories.

USER INTERFACE

A web-based user interface is being developed to increase accessibility (Fig. 3). The system provides suggestions for defect classes and shows the relevant information extracted from patients' records including the radiological image to enable cross-checking by the physician. More specifically, users can retrieve patients by defect type, position and additional pathology, while defect-related features are also highlighted automatically.

RESULTS

The precision, recall and accuracy of feature extraction and rule-based classification were measured (Fig. 1, 2). The results of extraction and classification were reached very satisfactory. The retrieval platform was also evaluated by clinical experts, who confirmed the usefulness and relevance of the results.

Defect Category	Accuracy
Type (mono)	93%
Type (bi)	91%
Type (tri+)	66%
Position (medial)	91%
Position (lateral)	98%
Position (m&l)	92%
AP (0)	99%
AP (1)	97%
AP (2)	100%
AP (3)	98%

Fig. 1- Performance of defect extraction.

Target	Precision	Recall	F1
Cervical spine segment	100%	85%	91%
Position	100%	99%	99%
AP	100%	97%	98%

Fig. 2- Accuracy of defect classification.

DISCUSSION AND CONCLUSION

Using this prototype system, we achieved optimal performance (>90%) for extraction and classification based on the current data-set. However, the algorithm still needs to be tested based on a new dataset in order to evaluate its transferability. Moreover, the correlations between different defect categories need to be studied to exclude the confounder in rule based classification. A user study involving more clinical experts has been planned to evaluate the usability of the retrieval functionality.

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Funding: German Ministry of Education and Research (BMBF)

STRUCTURING INFORMATION FROM MEDICAL DOCUMENTATION IN ORDER TO ENHANCE CLINICAL DECISION SUPPORT

INTRODUCTION

The majority of clinical documentation is written in a narrative form. For a physician, assessing all the relevant information is a time-consuming and complex process. To support information processing for specific cases, various clinical decision support systems (CDSS) have been developed. Natural language processing (NLP) methods offer a solution by structuring narrative text and identifying text passages that can then be processed by the CDSS. In this project, we developed an information extraction system that identifies information on adverse events in medical documentation. Since these events impact the patient's health status, they need to be considered by clinicians.

MATERIAL AND METHODS

We developed a system that processes clinical documents by identifying and extracting complex information. Based on expert annotations, we defined information entities that represent adverse events. Our NLP algorithm uses semantic rules to recognize medical and linguistic entities in relation to each other.

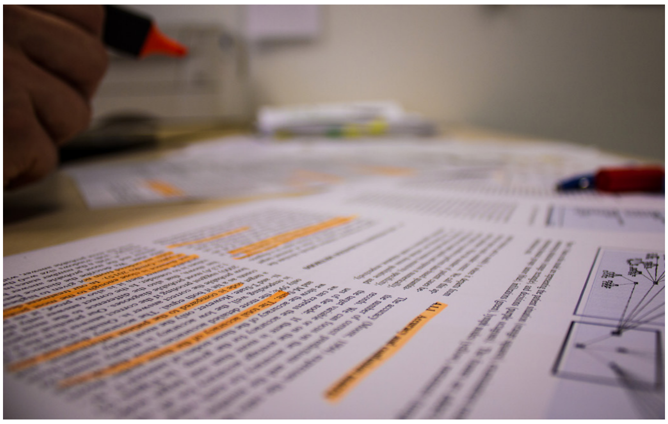

Fig. 1- Processing clinical narratives can enhance clinical decision making.

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RESULTS

In a user-centered validation, we interviewed five physicians in order to compare their notions of adverse events with our system's output. The promising results showed that extracting information on adverse events satisfies the clinicians' information needs. In a second study, we examined the superiority of our method over comparable, established text classification systems by comparing our output to WEKA, an NLP system based on machine learning. We concluded that the extraction of complex medical circumstances is possible with a semantic approach and is a necessary extension to established syntactic methods.

DISCUSSION AND CONCLUSION

The system will be employed in two ways. Used in standardized information models, it will enhance the structuring of medical data in electronic health records, especially the transformation of unstructured data into structured items. Secondly, we plan to integrate information extraction into the decision support system for laryngeal cancer (see page 57) to ensure that all the relevant information in the unstructured texts is taken into account in the patient-specific model.

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Funding: German Ministry of Education and Research (BMBF)

REUSE OF PATIENT INFORMATION MODELS

INTRODUCTION

One advantage of recycling components is that costs can be avoided. The recycling of data structures enables a high degree of semantic interoperability. Caldiera and Basili et al. identified cycles in the analysis of software reutilization and suggested a reuse-oriented process model which is applicable and desirable for our production process. We examined whether scientifically explored concepts of software reuse are suitable for recycling patient information models.

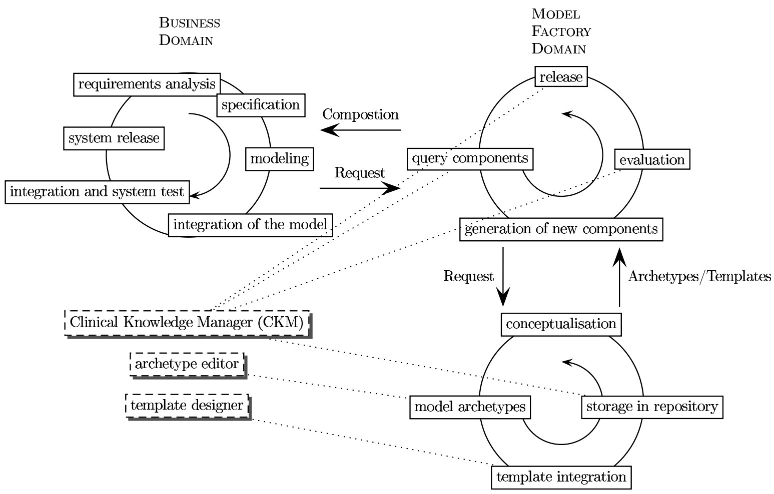

Fig. 1- Reuse-oriented process model developed by Caldiera and Basili et al. adapted to the modeling of patient data with the aid of openEHR tools.

METHODS

A reuse-oriented process model for modeling patient data was devised by combining the experience of software development with our experience in information modeling (Fig. 1). The overarching process starts with the upper left cycle. After a requirements analysis and the specification process, modeling takes place in the factory domain. During the modeling process, archetypes and templates which are reusable components are queried. If no reusable component is available, a generation process has to be triggered: new archetypes have to be modeled and integrated into templates. The modeled archetypes and the templates are stored in a repository. After evaluation, the components are released to the business domain. During the integration process, objects are instantiated out of the models. The objects

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are then integrated into the electronic health record system (EHRS). At the end of the business domain cycle, an integration and system test has to be carried out before the EHRS can be released. The reuse-oriented process of modeling patient data is retriggered when new requirements arrive.

RESULTS

The openEHR tools Clinical Knowledge Manager (CKM), archetype editor and template designer support most of the processes in the factory domain. The following processes are conducted within the CKM: (1) the querying of components, (2) storage in a repository, (3) evaluation (a collaborative review by domain experts), and finally (4) the release of the model. The core of the modeling, the modeling of archetypes, and the integration of these archetypes are done using the archetype editor and template designer.

DISCUSSION AND CONCLUSIONS

Modeling patient data can be structured as well defined cycling processes. The reuse-oriented process model devised by Caldiera and Basili et al. can be adapted to the modeling of patient data. Although processes of the business domain are not supported by openEHR tools, the processes of the factory domain are. The repository CKM being especially valuable. When different systems from different vendors recycle the same components, system boundaries can be overcome because of the increase in semantic interoperability.

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Leipzig University Hospital, Department of Pathology

Unitversity of Pittsburgh, School of Information Science, Decision Systems Laboratory (Prof. Marek Druzdzel)

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NONINVASIVE IMAGE-GUIDED SURGERY

GROUP LEADER
Prof. Dr. Andreas Melzer

PROJECT STAFF
M. Sc. Xinrui Zhan

SELECTED PUBLICATIONS

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Borasi G, Russo G, Alongi F, Nahum A, Candiano GC, Stefano A, Gilardi MC, Messa C. High-intensity focused ultrasound plus concomitant radiotherapy: a new weapon in oncology? Journal of Focused Ultrasound 2013, 1:1-4.

Ryan ER, Solomon SB et al. Split-Dose Technique for FDG PET/CT-guided Percutaneous Ablation. Radiology. 2013; 268(1):288-295. 2015.

Computer assisted MRI-guided focused ultrasound

Fig. 1- FUS transducer placed in correct position by robotig arm (www.trans-fusimo.eu)

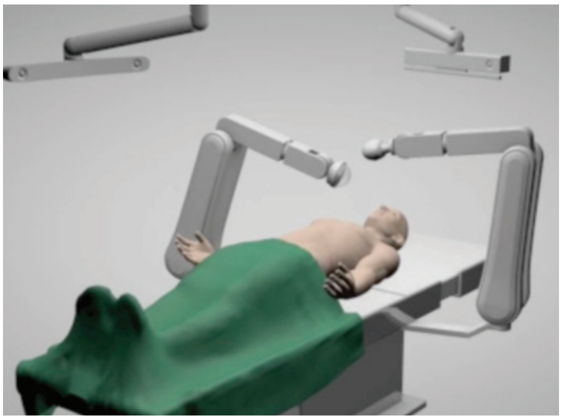

Fig. 2- www.futura-project.eu

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 metastases. MRgFUS of the brain has received the CE mark for the treatment of thalamic induced pain, essential tremor and Parkinson's disease, and is in the final stage of FDA approval. Moreover, significant research is underway into its use in the treatment of benign and malignant bone disease as well as liver metastases and liver cancer (HCC). 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, functional brain disorders and cardiovascular diseases. The collaboration between ICCAS and the Department of Radiology was formalized in 2015, and a clinical focused ultrasound system will be acquired in 2016 so that new applications can be developed and examined in preclinical and clinical trials. In collaboration with the University of Dundee, the application of focused ultrasound on moving organs, the liver and kidneys will strongly support joint research. This work is linked to the TRANS-FUSIMO FP7 project coordinated by the Fraunhofer Institute for Medical Image Computing (MEVIS) in Bremen and Andreas Melzer as medical coordinator (see Fig. 1).

The field of robotic assisted ultrasound-guided focused ultrasound is being developed in the EU project FUTURA coordinated by the Sant'Anna School of Advanced Studies in Pisa, Italy (Prof. Arianna Menciassi, Prof. Paolo Dario) and Andreas Melzer in the role of medical coordinator. Funding from the Saxon government has enabled the acquisition of an equivalent robotic setup with two KUKA LBR6 arms to provide an additional validation platform for FUTURA and develop new applications such as FUS-supported electron beam and proton beam radiation therapy in collaboration with OncoRay Dresden, Germany (see Fig. 2).

SUBPROJECT 1: MRI-GUIDED FOCUSED ULTRASOUND MEDIATED TARGETED DRUG DELIVERY

There is initial evidence that focused ultrasound supports the local delivery of drugs and also facilitates the upload of drugs from encapsulation. For example, doxorubicin is available encapsulated in liposomes (Doxyl and ThermoDox), while preclinical research has proved that focused ultrasound supports the delivery of drugs and their uptake by cancer cells. In 2015, the project was prepared and the first PhD student (Xinrui Zhang) recruited from Chongqing University of Technology (China). Research collaboration has been established between ICCAS and CUOT with the invitation of Andreas Melzer as a professor of focused ultrasound, surgery and drug delivery under China's 1000 Talent Plan. The project will include focused ultrasound application on cell cultures in 24/96-well plates to study the uptake of different drugs by normal cells and tumor cell cultures in order to validate the ultrasound duty cycles in terms of cell attenuation and to study the mechanisms of drug encapsulation and the release of drugs (see Fig. 1).

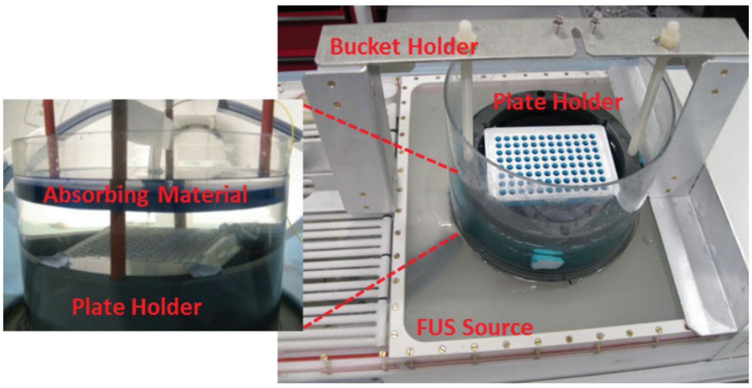

Fig.1 - MR guided Focused Ultrasound of Cell Cultures

This project will be conducted in collaboration with Prof. Andrea Robitzki and Prof. Michaela Schulz-Siegmund from the BBZ Center for Biotechnology and Biomedicine as well as Prof. Ingo Bechmann, Vice Dean and director of the Institute of Anatomy, Universität Leipzig.

SUBPROJECT 2: MRI-GUIDED FOCUSED ULTRASOUND MEDIATED RADIATION THERAPY

Focused ultrasound provides localized and quantifiable hyperthermia enhancement of the sensitivity of tumor cells to radiation therapy. In 2015, a project was initiated at ICCAS to study the effect of focused ultrasound on cell cultures. Small animal trials are planned in order to explore the mechanism that supports radiation therapy. This is part of a project proposal submitted by OncoRay Dresden seeking funding as a 'Meta-ZIK' project (which involves collaboration by two ZIKs or Centers of Innovation Competence). ICCAS will carry out the experimental in vitro part to investigate the effect of FUS on healthy and tumorous human cell lines supported by Prof. Andrea Robitzki and Michaela Schulz-Siegmund (TBC) from the BBZ Center for Biotechnology and Biomedicine in Leipzig, Prof. Ingo Bechmann from the Institute of Anatomy at Universität Leipzig, and Prof. Rolf-Dieter Kortmann from the Department of Radiation Medicine at Leipzig University Hospital.

SUBPROJECT 3: PET-MR-GUIDED INTERVENTIONS AND FOCUSED ULTRASOUND

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

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visualize any remaining metabolism inside the ablated lesion. In collaboration with the Department of Nuclear Medicine (Prof. Bernhard Sattler, Prof. Henryk Barthel, Prof. Osama Sabri and Dr. Thies Jochimsen) and the Department of Radiology (Dr. Michael Moche, Dr. Harald Busse and Prof. Thomas Kahn) at Leipzig University Hospital, the first steps have been taken to set up the PET-MR environment for such procedures and initial experimental tests conducted. This also forms part of the MAI project with preliminary analysis of the workflow of such procedures. In the next phase, robotic assisted focused ultrasound will be established within PET-MRI as a tool for ablation, blood brain barrier opening, and drug delivery (see Fig.2).

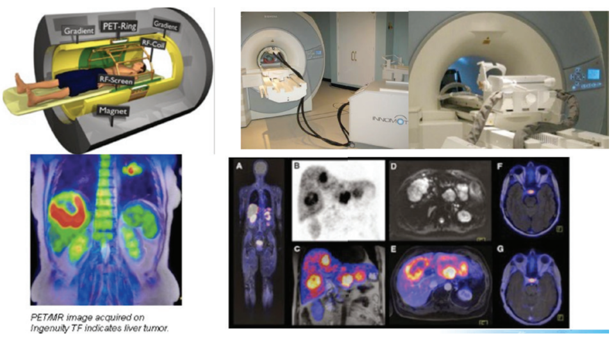
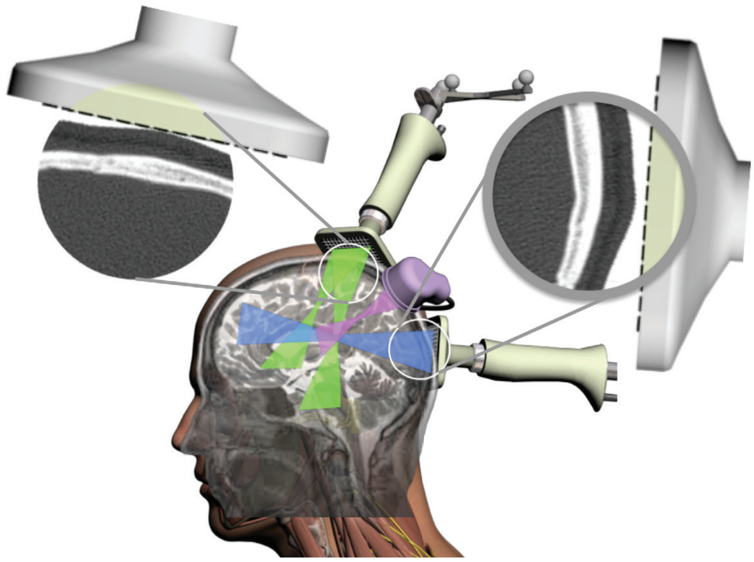


Fig. 2- Concept of Robotic assisted PET MR guided Focused Ultrasound

SUBPROJECT 4: LIGHT INTENSITY FOCUSED ULTRASOUND FOR MRI-GUIDED NEURAL MODULATION (MRGLIFUP)

Recent research has provided evidence that focused ultrasound can non-invasively cause the significant modulation of neurons in the central nervous system. The effect includes suppression and activation of neuronal activity. Therefore, MRgLIFUP has great potential to modulate certain areas of the brain, such as in the treatment of stroke, addiction, chronic OCD (obsessive compulsive disorder), essential tremor and Parkinson's disease. In 2015, a proposal was drawn up for an ICCAS/Fraunhofer/Max Planck project for the development of MRI-guided light intensity focused ultrasound (LIFUP) for neural modulation in collaboration with Prof. Arno Villringer, director of the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Steffen Tretbar, head of the Division of Ultrasound at the Fraunhofer Institute for Biomedical Engineering (IBMT) in St. Ingbert (Germany), and Prof. Tobias Preusser, Prof. Matthias Günther and Prof. Ron Kikinis from the Fraunhofer Institute for Medical Image Computing (MEVIS) in Bremen, Germany (see Figure below).



The LIFUP project is in the final decision stage for funding after it was successfully defended in an interview on October 26 in 2015.

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PEER REVIEWED CONFERENCE PROCEEDINGS

Amato C, Lemke HU, Ratib O. Intelligent operating rooms: preparing for the new digital patient model challenges. 29th Congress and Exhibition Computer Assisted Radiology and Surgery (CARS); Barcelona, Spain; 2015.

Bieck R, Franke S, Lindner D, Neumuth T. Computer Assisted Neurosurgery. Application of a surgical assistance system for cranial surface & cerebral ventricle navigation. 49th Annual conference of the German Society for Biomedical Engineering (DGBMT); Lübeck; 2015.

Bieck R, Franke S, Lindner D, Neumuth T. Computer-assisted Neurosurgery. An interaction concept for a tablet-based surgical assistance system. 14. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC); Bremen; 2015.

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.

Cypko MA, Stoehr M, Denecke K. Web-based guiding of clinical experts through the modelling of treatment decision models using MEBN with an example of laryngeal cancer. 29th Congress and Exhibition Computer Assisted Radiology and Surgery (CARS); Barcelona, Spain; 2015.

Cypko MA, Stoehr M, Schlinke S, Hirsch D, Modemann S, Denecke K. Experiences with Expert-based Probabilistic Modelling of Treatment Decisions unsing Baesian Networks – with an Example of Rhinosinusitis. 49th Annual conference of the German Society for Biomedical Engineering (DGBMT); Lübeck; 2015.

Deng Y, Groll MJ, Denecke K. Rule-based Cervical Spine Defect Classification Using Medical Narratives. 15th World Congress on Health and Biomedical Informatics (MEDINFO); Sao Paulo, Brazil; 2015.

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Denecke K: Clinical Decision Support Based on Integrated Patient Models: A Vision. 15th World Congress on Health and Biomedical Informatics (MEDINFO); Sao Paulo, Brazil; 2015.

Denecke K. Extracting Activities and Observations from Surgical Reports. 60. Jahrestagung der Deutschen

Gesellschaft für Medizinische Informatik, Biometrie und Epidemiologie e.V. (GMDS); Krefeld; 2015.

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Franke S, Schreiber E, Neumuth T. Prediction of surgical activities for context-aware workflow management in the operating room. 29th Congress and Exhibition Computer Assisted Radiology and Surgery (CARS); Barcelona, Spain; 2015.

Franke S, Neumuth T. Rule-based medical device adaptation for the digital operating room. 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC); Milan, Italy; 2015.

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.

Gaebel J, Kolter T, Arlt F, Denecke K. Extraction Of Adverse Events From Clinical Documents To Support Decision Making Using Semantic Preprocessing. 15th World Congress on Health and Biomedical Informatics (MEDINFO); Sao Paulo, Brazil; 2015.

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Neumann J, Neumuth T. Anforderungen für die Realisierung einer standardisierten semantischen Modellierung von chirurgischen Workflows. 60. Jahrestagung der Deutschen Gesellschaft für Medizinische Informatik, Biometrie und Epidemiologie e.V. (GMDS); Krefeld; 2015.

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Image Computing and Computer Assisted Interventions; Munich; 2015.

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Rockstroh M, Franke S, Lippert S, Wiegel M, Neumuth T. Mobile Web-Based Interface for Anesthesia Documentation. 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC); Milano, Italy; 2015.

Rockstroh M, Stefan Franke, Neumuth T. Closed-loop approach for situation awareness of medical devices and operating room infrastructure. 49th Annual conference of the German Society for Biomedical Engineering (DGBMT); Lübeck; 2015.

Rockstroh M, Franke S, Neumann J, Neumuth T. Unterstützung des chirurgischen Prozesses bei der Verwendung einer offenen Kommunikationsinfrastruktur am Leipziger Demonstrator. 14. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie (CURAC); Bremen; 2015.

Schreiber E, Franke S, Meier J, Neumuth T. Towards a surgical process model distribution infrastructure based on Cross-Enterprise Model Sharing (XMS). 29th Congress and Exhibition Computer Assisted Radiology and Surgery (CARS); Barcelona, Spain; 2015.

CONFERENCE PROCEEDINGS 2015

Mihcin S, Karakitsios I, Dennison A, Le N, Melzer A. Thermometry methods for therapy monitoring for MRgFUS applications. American Society of Mechanical Engineers (ASME); Boston, USA; 2015.

Mihcin S, McLeod H, Tanner C, Sat G, Karakitsios I, Xiao X, Houston G, Melzer A. MRI Scans of Healthy Volunteers for Planning of Tumour Treatment Using FUS for the Organs Effected by Breathing Motion in the Abdominal Area. Cardiovascular and Interventional Radiological Society of Europe (CIRSE); Lisbon, Portugal; 2015.

Mihcin S, Dennison A, Xiao X, Karakitsios I, Melzer A. Reusable Tissue Mimicking Phantom with Anatomical Geometries for Multimodality Image Guided FUS Applications. 3rd European FUS Theraphy Symposium; London, UK; 2015.

Mihcin S, Karakitsios I, Dennison A, Melzer A. Thermometry Methods for Therapy Monitoring for MRgFUS Applications. Radiological Society of North America 2015; Chicago, USA; 2015.

Mihcin S, Karakitsios I, Xiao X, Dennison A, Wang J, Melzer A. Robotic assisted positioning for liver tumour ablation by MRgFUS (MR-Guided Focused Ultrasound). 23rd Congress of the European Association of Endoscopic Surgery (EAES); Bucharest, Romania; 2015.

Mihcin S, Wang J, Xiao X, Melzer A. Robotic assisted ultrasound guided HIFU. 23rd Congress of the European Association of Endoscopic Surgery (EAES); Bucharest, Romania; 2015.

Stoehr M, Cypko MA, Dietz A. Das Larynxkarzinom als digitales Patientenmodell zur Unterstützung von Therapieentscheidungen. 24. Jahrestagung der Vereinigung Mitteldeutscher HNO-Ärzte; Gießen; 2015.

Stoehr M, Cypko MA, Lemke H, Dietz A, Denecke K. Modellierung der TNM-Klassifikation des Larynxkarzinoms zur Unterstützung der Therapieentscheidung auf Basis von Multi-Instanz Bayes'schen Netzwerken. 86. Jahresversammlung der Deutschen Gesellschaft für Hals-Nasen-Ohren-Heilkunde, Kopf- und Hals-Chirurgie; Berlin; 2015.

Thurnes CM, Ikovenko S, Nähter S, Münzberg C, Tharmann R, Faller I, Lovich A, Jantschgi J, Adunka R, Neumuth T. One Day at the Museum- Using a Museum as Resource for Teaching and Learning TRIZ. TRIZfest International Conference; Seoul, South Korea; 2015.

EVENTS 2015

SCIENTIFIC EVENTS 2015 ORGANIZED BY ICCAS

ConhIT Satellite Workshop „Evidenzbasierte Entscheidungsunterstützung: Digitale Patientendaten treffen auf digitales Wissen“
April 20, 2015 | Berlin, Germany

ICCAS CARS Session at the 29th International Congress of Computer Assisted Radiology and Surgery
June 27, 2015 | Barcelona, Spain

Workshop “Digital Patient Modeling and Clinical Decision Support” at the 15th World Congress on Health and Biomedical Informatics (MEDINFO 2015)
August 21, 2015 | Sao Paulo, Brazil

ICCAS’s 2nd Digital Operating Room Summer School (DORS 2015)
August 24 – 28, 2015 | Leipzig, Germany

ICCAS International Symposium 2015
August 29, 2015 | Leipzig, Germany

ICCAS Sessions at the 14th Annual Conference of the German Society for Computer and Roboter-Assisted Surgery (CURAC 2015)
September 29 – October 1, 2015 | Bremen, Germany

ICCAS Session at the 49th Annual Conference of the German Society for Biomedical Engineering (BMT 2015)
October 16 – 18, 2015 |Lübeck, Germany

6th Workshop on “Modeling and Monitoring of Computer Assisted Interventions” (M2CAI) at the 18th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2015)
October 9, 2015 | Munich, Germany

Presentation of results of the flagship project OR.Net - Secure and Dynamic Network in the Operating Room
December 16, 2015 | Leipzig, Germany

ICCAS Status Meeting 2005 - 2015
December 17, 2015 | Leipzig, Germany

ICCAS COLLOQUIUM AND SEMINAR

March 24, 2015 | ICCAS Colloquium, Leipzig
PD Dr.-Ing. Thomas Wittenberg, Fraunhofer Institute for Integrated Circuits IIS, Erlangen
Presentation on „Computer-supported imaging and pattern recognition for diagnostic and interventional endoscopy“

April 24, 2015 | ICCAS Seminar, Leipzig
Ashley Waring (Usability Engineer), Fraunhofer Institute for Medical Image Computing (MEVIS)
Presentation on „Usability Engineering“

David Black (Computer Scientist), Fraunhofer Institute for Medical Image Computing (MEVIS)
Presentation on „Auditory Display”

May 28, 2015 | ICCAS Seminar
Prof. Dr. Jörg Matysik | Institute of Analytical Chemistry, Universität Leipzig
Presentation on „MRT mit Hyperpolarisationsmitteln: Ein neuer Ansatz”

July 6, 2015 | ICCAS Colloquium
Dr. Ronald Bauer, Kantonspital St. Gallen
Presentation on “Future potential of transcranial Magnetic Resonance imaging-guided Focused Ultrasound Surgery (tcMRgFUS)”

September 30, 2015 | ICCAS Colloquium
Prof. Dr. Georg Rose, Chair of Healthcare Telematics and Medical Engineering, University of Magdeburg
Presentation on „Der Magdeburger Forschungscampus STIMULATE- Neue Technologien für Bildgebung und Intervention“

November 23, 2015 | ICCAS Seminar
Prof. Thomas Hierl, Head, Neck and Plastic Surgery Clinic, Leipzig University Hospital
Presentation on „Die AG Bildverarbeitung und Biomechanik – Derzeitige Schwerpunkte und Projekte“

November 24, 2015 | ICCAS Seminar
Prof. Dr. Andrea Robitzki, Center for Biotechnology and Biomedicine (BBZ), University of Leipzig
Presentation on „Computergestützte Bio-Zelluläre Forschung und Entwicklung“

November 29, 2015 | ICCAS Seminar
Prof. Dr. Ines Gockel, Visceral, Transplantation, Thoracic and Vascular Surgery Clinic, Leipzig University Hospital
Presentation on „Minimal-invasive Eingriffe in der Viszeralchirurgie“

December 17, 2015 | ICCAS Seminar
Dr. Klaus Irion, Karl Storz GmbH & Co. KG
Presentation on „Patentwesen in der Medizintechnik“

PUBLIC EVENTS 2015 WITH ICCAS CONTRIBUTION

Girls‘ Day 2015
April 25, 2015 | Leipzig, Germany

Leipzig Corporate Run
June 3, 2015 | Leipzig

Hands-on activities at the experience parcours „600 Jahre Universitätsmedizin Leipzig”
July 7, 2015 | Augustusplatz Leipzig

Public presentations of ICCAS projects to the 10th anniversary of ICCAS
August 27, 2015 | Leipzig, Germany

dies academicus Universität Leipzig
December 2, 2015 | Leipzig

INVITED LECTURES 2015

Engineering in Medicine and Biology Society (IEEE) - Colloquium, RWTH Aachen University
January 28, 2015 | Aachen, Germany
Lecture: Dr. Kerstin Denecke „Modell- und evidenzbasierte Medizin durch digitale Patientenmodelle“

Data & Knowledge Engineering (DKE) Forschungskolloquium, Universität Magdeburg
Feburary 18, 2015 | Magdeburg, Germany
Lecture: Dr. Kerstin Denecke „Modell- und evidenzbasierte Medizin durch digitale Patientenmodelle“

7. Österreichischer Gesundheitswirtschafts-Kongress
March 11, 2015 | Vienna, Austria
Lecture: Prof. Dr. Gero Strauß „Der automatisierte OP-Saal am Beispiel der HNO Chirurgie“

Workshop Bildverarbeitung für die Medizin (BVM 2015)
March 15 – 17, 2015 | Lübeck, Germany
Lecture: Dr. Frank Heckel “Sketch-Based Interactive Segmentation and Segmentation Editing for Oncological Therapy Monitoring”

conhIT Satellitenworkshop „Evidenzbasierte Entscheidungsunterstützung: Digitale Patientendaten treffen auf digitales Wissen“
April 13, 2015 | Berlin, Germany
Lecture: Dr. Kerstin Denecke „Modell- und evidenzbasierte Medizin durch digitale Patientenmodelle“

30. Dialog Gesundheitswesen
April 14, 2015 | Berlin, Germany
Lecture: Prof. Dr. Gero Strauß „Automatisierung im chirurgischen Cockpit“

Pathology Informatics 2015
May 6, 2015 | Pittsburgh, PA, USA
Lecture: Prof. Dr. Heinz U. Lemke “Therapy decision making in tumor boards with predictive IT methods and tools”

MR intervention hands-on Workshop (Memorial Sloan Kettering Cancer Center)
May 6 – 12, 2015 | New York, NY, USA
Lecture: Prof. Dr. Andreas Melzer: „MRI guided Biopsy”

MR Safety and Intervention Hands-on Workshop at the Children’s National Medical Center (CNMC)
May 7 – 10, 2015 | Washington, DC, USA
Tutor: Prof. Andreas Melzer

Institute for Computer Science at Bialystok University of Technology
May 20, 2015 | Bialystok, Poland
Lecture: Mario Cypko “Clinical decision support system based on Bayesian networks to support interdisciplinary tumor board decisions”

23rd International Congress of the European Association for Endoscopic Surgery (E.A.E.S.)
June 3 – 06, 2015 | Bukarest, Romania
Lecture: Prof. Dr. Andreas Melzer: „The hybrid OR. What is already there?”
Lecture: Prof. Dr. Andreas Melzer: „Overview: What can we learn?”

Deutscher Evangelischer Kirchentag
June 5, 2015 | Stuttgart, Germany
Lecture: Prof. Dr. Gero Strauß „Intelligente Technik - Kluge Entscheidungen? - Aus der Praxis - Digitale Chirurgie“

66. Jahrestagung der Deutschen Gesellschaft für Neurochirurgie (DGNC)
June 7 – 10, 2015 | Karlsruhe, Germany
Keynote Lecture: Prof. Dr. Andreas Melzer: „MRI Guided Focussed Ultrasound: a Step Back?”

Chongqing University of Technology
June 13 – 19, 2015 | Chongqing, China
Lecture: Prof. Dr. Andreas Melzer “MR guided FUS”

Hamlyn Symposium on Medica Robotics
June 20 – 23, 2015 | London, England
Keynote Lecture: Prof. Dr. Andreas Melzer "Robotic Assisted MRI and FUS"

29th International Congress and Exhibition Computer Assisted Radiology and Surgery (CARS 2015)
June 23 – 28, 2015 | Barcelona, Spain
Lecture: Prof. Dr. Andreas Dietz „Current view on CAS in Head and Neck Surgery. Clinical dimensions in CAS and ENT surgery"
Lecture: Prof. Dr. Andreas Melzer "Future Case: MRgFUS"

IHE Surgery Kick-off Meeting
June 26, 2015 | Barcelona, Spain
Lecture: Prof. Dr. Heinz U. Lemke "Introduction to Digital OR infrastructure and IHE Surgery"

10. Hannoversche Orbitakurs
July 4, 2015 | Hannover, Germany
Lecture: Prof. Dr. Gero Strauß „Assistenzsysteme für die Orbitachirurgie"

Chongqing University of Technology
July 25 – 31, 2015 | Chongqing, China
Lecture: Prof. Dr. Andreas Melzer "MR guided FUS"

37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2015)
August 25 – 29, 2015 | Milan, Italy
Lecture: Stefan Franke "Rule-Based Medical Device Adaptation for the Digital Operating Room"

World Congress of the European Association for Predictive, Preventive & Personalised Medicine (EPMA 2015)
September 3 – 5, 2015 | Bonn, Germany
Lecture: Prof. Dr. Heinz U. Lemke: "An information technology framework for PPPM – A use-case with hepatocellular carcinoma"

Summer School Med Robotics
September 8 – 9, 2015 |Montpellier, France
Lecture: Prof. Dr. Andreas Melzer "Imaging Robotics"

Rhinoplastikkurs
September 9 – 10, 2015 | Kassel, Germany
Lecture: Prof. Dr. Andreas Dietz „Entwicklungen der Computer assistierten Chirurgie in der HNO-Heilkunde"

Conference of the International Society for Medical Innovation and Technology (SMIT 2015)
September 10 – 12, 2015 | Brno, Czech Republik
Keynote Lecture: Prof. Dr. Andreas Melzer "MRgFUS"

Fraunhofer Institute for Medical Image Computing MEVIS
September 13, 2015 | Bremen, Germany
Lecture: Prof. Dr. Thomas Neumuth “Workflow-based surgical automation”

Forum Companion Diagnostics Network
September 16, 2015 | Berlin, Germany
Lecture: Prof. Dr. Heinz U. Lemke „The role of information technology in personalized medicine”

49th Annual Conference of the German Society for Biomedical Engineering (BMT 2015)
September 16 – 18, 2015 | Lübeck, Germany
Lecture: Prof. Dr. Andreas Melzer “MRI-guided focused ultrasound: A computer-assised theragnostic procedure”
Lecture: Prof. Dr. Thomas Neumuth “Workflowmanagement in the operating room”

Jahreskongress der Österreichischen HNO-Gesellschaft
September 17, 2015 | Innsbruck, Austria
Lecture: Prof. Dr. Andreas Dietz “Clinical perspectives in CAS in ENT surgery”

14th Annual Conference of the German Society for Computer and Roboter-Assisted Surgery (CU-RAC 2015)
September 17 – 19, 2015 | Bremen, Germany
Keynote Lecture: Max Rockstroh „OP-Integration durch das Projekt OR.Net- Kurzeinführung und Umsetzung in den Demonstratoren“

Universidad de Guanajuato, Campus Irapuato-Salamanca
September 29, 2015 | Guanajuato, Mexico
Lecture: Dr. Claire Chalopin “Intraoperative imaging: evaluation, system optimization and assistance system for image analysis”

18th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2015)
October 05, 2015 |Munich, Germany
Keynote Lecture: Prof. Dr. Andreas Melzer „MRI gided Interventions“

Onkologiesymposium Aachen
October 07, 2015 | Aachen, Germany
Lecture: Prof. Dr. Andreas Dietz „Entwicklung der Kopf-Hals-Onkologie zur personalisierten Medizin“

Prostata Workshop 2015, AG Uroradiologie und Urogenitaldiagnostik
October 09 – 10, 2015 | Hamburg, Germany
Lecture: Prof. Dr. Heinz U. Lemke „Model based medicine”

Joint Meeting American Academy of Neurosurgery/German Society of Neurosurgery/German Academy of Neurosurgery
October 10, 2015 | Heidelberg, Germany
Lecture: Prof. Dr. Jürgen Meixensberger „Intraoperative 30-contrast enhanced ultrasound (CEUS): A prospective study in 50 patients with brain tumors“

3rd European Symposium of the European Ultrasound Charitable Society (EUFUS)
October 15 – 16, 2015 | London, England
Lecture: Prof. Dr. Andreas Melzer „Evolving Liver Focused Ultrasound Solutions the Fusimo Project”

Meeting am Meer, Führungskräfte-Meeting
October 15 – 16, 2015 |Seebad Heiligendamm, Germany
Lecture: Prof. Dr. Heinz U. Lemke „Impakt der computerassistierten Radiologie und Chirurgie (CARS) auf klinische Prozesse“

Leadership in Health Care
October 24, 2015 | Berlin, Germany
Lecture: Prof. Dr. Gero Strauß „Digitale Automation in der Medizin - Chancen eines selbststeuern-den Systems“

Mitteldeutsches Resonanztreffen MDR-36
November 09, 2015 | Leipzig, Germany
Lecture: Prof. Dr. Andreas Melzer „MR-geführte Intervention und Chirurgie“

Workshop of the European Association for Endoscopic Surgery and other interventional Tech-niques (EURO-NOTES 2015)
November 12, 2015 | Turin, Italy
Lecture: Prof. Dr. Andreas Melzer “The role of multitasking platforms”

Compamed
November 16 – 19, 2015 | Hannover, Germany
Lecture: Prof. Dr. Andreas Melzer “MR compatibel devices”

International Live Case Meeting
December 02 – 06, 2015 | Leipzig, Germany
Lecture: Prof. Dr. Andreas Melzer “MRI based interventions for structural heart disease - future perspective”

HONORS AND AWARDS

Prof. Dr. Andreas Melzer (Director ICCAS) was awarded “1000 Expert Full Professor of MR guided Focused Ultrasound Surgery and Targeted Drug Delivery” at Chongqing University of Technology (China) in January 2015 and has been appointed “Conference Chairman of the 4th European Focused Ultrasound Symposium (EUFUS)” to be held in Leipzig 2017 in October 2015.

Prof. Dr. Gero Strauß was awarded „Professor of high impact in Arab Countries“ by the International Panarabic Rhinology Society (ISIAN-IRS) in January 2015.

The International Reference and Development Center for Surgical Technology (IRDC) was awarded the “Innovationspreis-IT Best of 2014” in the category E-Health for its software General Operation Manager. The IT Innovation Awards were presented by Initiative Mittelstand in March 2015.

Dr. Frank Heckel (Fraunhofer MEVIS, guest researcher at ICCAS) received the BVM-AWARD 2015 for his outstanding dissertation at this year’s workshop on Image Processing for Medicine (BVM) in March 2015.

Prof. Dr. Friedrich-Wilhelm Mohr (Herzzentrum Leipzig – Universitätsklinik) has been appointed “Councilor of the American Association for Thoracic Surgery (AATS)“ in May 2015 and “President of the European Association for Cardio-Thoracic Surgery (EACTS) ” in October 2015.

ACTIVITIES IN TEACHING

Young academics are supported with courses in computer-assisted surgery at Universität Leipzig, the Leipzig University of Applied Sciences (HTWK) and the Technische Universität Berlin. Teaching is aimed at students of computer science who are interested in the use of IT in surgery as well as aspiring physicians interested in computer-assisted surgery. ICCAS also suggests and supervises dissertations in computer-assisted surgery for B.Sc, M.Sc and PhD students, and offers placements to students of computer science and engineering.

COURSES	INSTITUTION
Lecture: “Surgical Navigation, Mechatronics and Robotics”	Universität Leipzig
Practical course: “Computer Assisted Surgery”	Universität Leipzig
Lecture: System Innovation in Medicine	Universität Leipzig
Lecture: Introduction to Computer Assisted Surgery	Universität Leipzig
Lecture “Project Management for Engineers	Leipzig University of Applied Sciences
Lecture „Systems Engineering“	Leipzig University of Applied Sciences
Lecture “Computer Assisted Surgery”	Technische Universität Berlin

Every year the Digital Operating Room Summer School (DORS) takes place at ICCAS. Here, interested parties from all over the world can extend their knowledge of developing surgical assistance systems for the modern operating room. The next CME-certified DORS is planned for September 2016.

Technical topics:
» Digital patient models
» Processes and workflows
» OR infrastructure
» Image-guided interventions
» Standards

Clinical topics:
» Ear, nose, throat surgery
» Craniomaxillofacial surgery
» Neurosurgery
» Cardiovascular surgery
» Visceral Surgery
» Urology
» Interventional radiology

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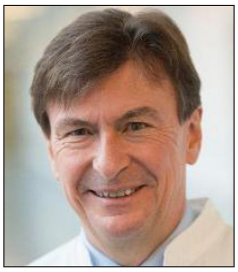

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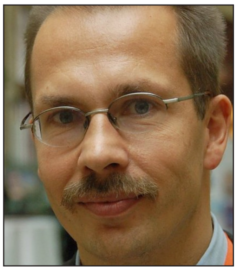

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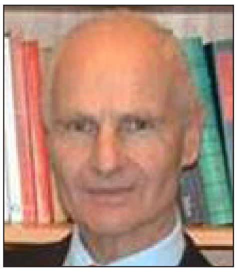

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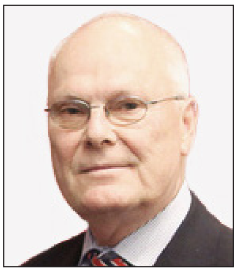

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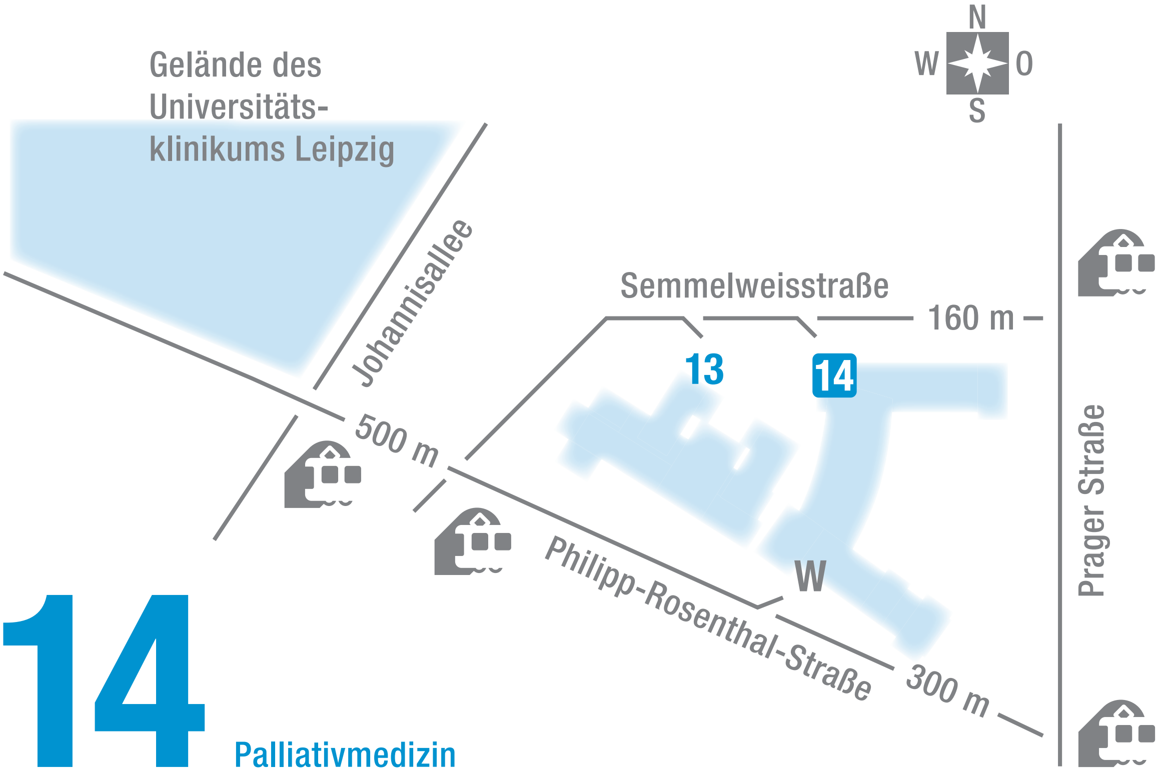

14 Palliativmedizin

UNIVERSITÄT LEIPZIG
Medizinische Fakultät

SIEMENS

ZIM
impulse für wachstum
Zentrales Innovationsprogramm Mittelstand

Gefördert durch:

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