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Medizinische Fakultät

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Innovation Center Computer Assisted Surgery

iccas

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COVER
Presentation of ICCAS's intelligent operating room to the Federal Chancellor Dr. Angela Merkel and further cabinet members at the Digital-Gipfel 2017.

PHOTOS
ICCAS, Swen Reichhold, Sven Döring, Hans-Joachim Rickel

GRAPHIC ARTS
Simon Rosenow

CONTENTS


PREFACE

2017 included several highlights for ICCAS. Above all the presentation of the Intelligent Operating Room to the German Chancellor Dr. Angela Merkel and her Federal Cabinet at the Digital Summit in Ludwigshafen in June. The departments of ENT and Neurosurgery of Leipzig University Hospital (UKL) were significantly involved in the development of the exhibit which was selected by the Federal Ministry of Education and Research (BMBF). Our special thanks go to Prof. Andreas Dietz, Prof. Jürgen Meixensberger and their teams.

Another highlight was the 4th European Symposium on Focused Ultrasound Therapy (EUFUS 2017), where 200 international experts discussed the latest applications of focused ultrasound in Leipzig. Within the scope of the symposium, the SONO-RAY project invited to the pre-conference workshop “Experimental FUS and HIFU” and presented the results of the first research year. At the end of August, the ICCAS hosted its 4th Digital Operating Room Summer School (DORS 2017) and once again received a great response from more than 30 participants and tutors. We would like to gratefully acknowledge all those especially our clinical committee members who have contributed to the success and the high level of international recognition. During the Open Day in May we opened our doors to the general public. About 60 guests followed the invitation.

The research results of the ICCAS were presented at numerous conferences in Germany and abroad, such as DGE-BV, EuroVis, CARS, BMT, CURAC, MedInfo and SMIT. In addition, we presented various exhibits at international trade fairs. The IT-supported robot system RoboDirect and the Digital Patient Model were presented at MEDICA in Düsseldorf. The joint project BIOPASS was a magnet for visitors at the “BMBF Future Congress” in Bonn. The SONO-RAY project was presented at the ISTU in Nanjing (China) and in Seoul (Korea) and further developments for device networking in the operating theatre were displayed at the joint booth of the partners of the newly founded OR.Net e. V. in Berlin as well as in Frankfurt at the EAES congress during a special lunch symposium. In October, first patients were successfully treated by high-intensity MR guided focused ultrasound at the Department of Radiology, UKL. Thanks and appreciation go to Prof. Thomas Kahn and his team (Dr. Harald Busse, Dr. Patrick Stumpp, Tim-Ole Petersen, Leonard Leifels, Nikolaos Bailis and MTRAs involved).

In 2017 several important projects kicked off: the BMBF project MoVE, dealing with the open networking of medical devices, the industry association project IMPACT on the mobile monitoring of the lung function, and the EU project “Modular Field Hospital”, in which the ICCAS will play an essential role in the technical infrastructure of a mobile emergency hospital. The ICCAS team has been able to strengthen existing partnerships and to enable new collaborations. A return visit to the OR.Net sister project SCOT, Tokyo (Japan) and an approach to the ZIK innoFSPEC took place during a workshop regarding the development of joint technologies. In SONO-RAY the project groups of ICCAS and Onco-Ray (Dresden) formed a very fruitful collaboration with the Fraunhofer IBMT in Sulzbach/St. Ingbert.

ICCAS welcomes Prof. Thomas Schmitz-Rode from the Helmholtz Institute of RWTH Aachen University and Dr. Heinrich Kolem from Siemens Healthcare GmbH as new members of the scientific advisory board, and at the same time thanks Prof. Günter Rau for his intensive support.
We would like to thank all partners from science, clinic, industry and politics for their active and valuable support and we are very much looking forward to a continued trustful and successful cooperation.

Prof. mult. Dr. Andreas Melzer
Director

Prof. Dr. Thomas Neumuth
Vice Director

INSTITUTIONAL FACTS

2005

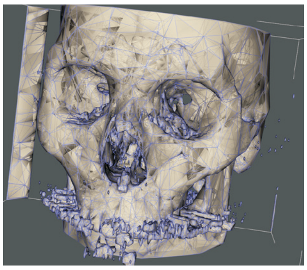
- ICCAS founded as a research initiative at the Faculty of Medicine of Leipzig University, funded by the German Ministry of Education and Research (BMBF)
- TWO RESEARCH GROUPS - Scientific Methods (Dr. Oliver Burgert), Surgical PACS & Mechatronics (Dr. Werner Korb)
- ICCAS BOARD - Prof. Jürgen Meixensberger, 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, Leipzig University

2007

- Scientific Workflow 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

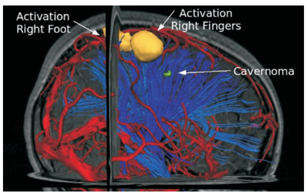
- Germany's Minister of Education and Research visits ICCAS
- CURAC in Leipzig
- FIVE RESEARCH GROUPS:
  Therapy Imaging and Model Management Systems (Dr. Oliver Burgert), Patient Model (Dr. Rafael Mayoral), Workflow and Knowledge Management (Dr. Thomas Neumuth), Assessment of Surgical Automation Systems (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



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

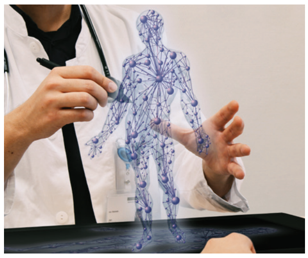
- ICCAS starts academic courses at HTWK
- RESEARCH AREA - Digital Patient Model (Dr. Kerstin Denecke) starts

2013

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

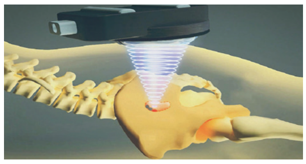
2014

- Prof. Andreas Melzer joins ICCAS as Director as well as professor of computer assisted surgery
- IT Innovation Award for ‚oncoflow‘
- First Digital Operating Room Summer School - DORS 2014



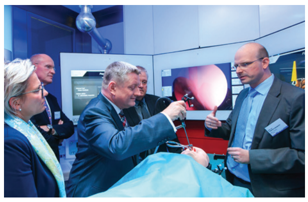
2015

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



2016

- Final presentation of the flagship project OR.Net
- ICCAS receives ISO 13485 certification
- Federal health minister visits ICCAS
- 3rd Digital Operating Room Summer School - DORS 2016
- Project start of Meta-ZIK SONO-RAY



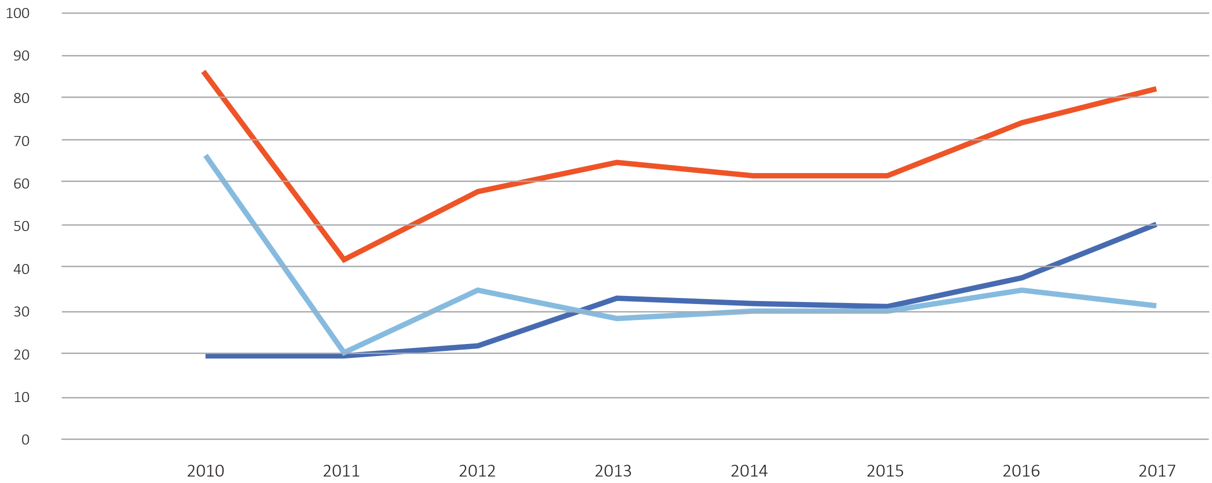
2017

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

FACTS AND FIGURES

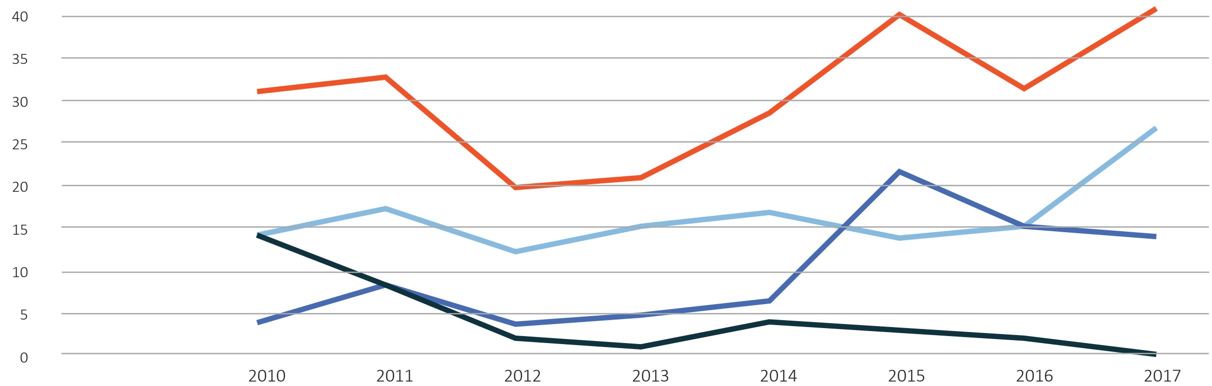
HEADCOUNT

In 2017, ICCAS registers a positive headcount development. It reached a high of 82 staff members similar to the first year of the second funding period (2010).



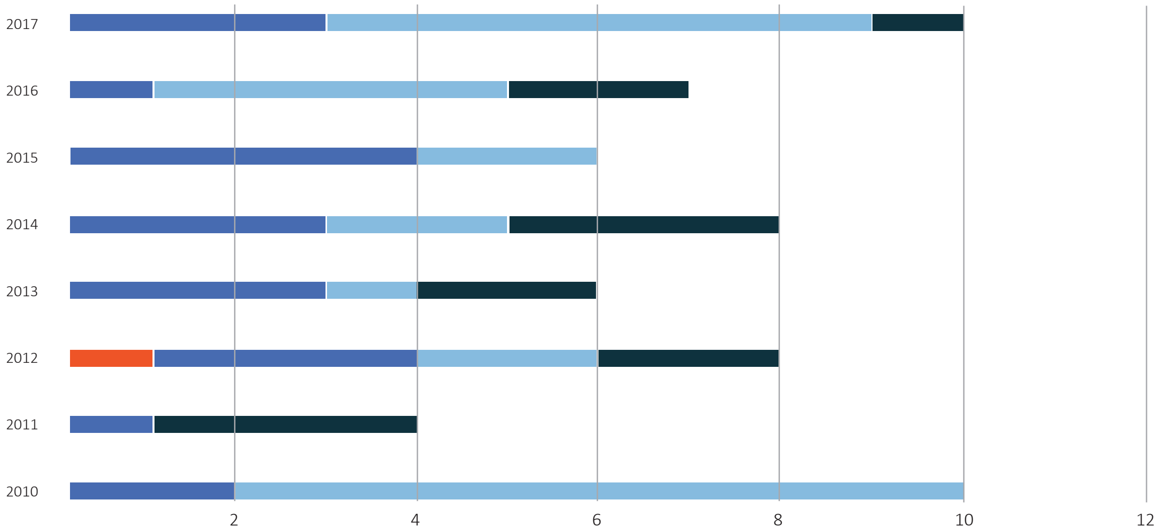
	2010	2011	2012	2013	2014	2015	2016	2017
Total	86	42	57	64	62	61	73	82
Staff	20	20	23	35	32	31	38	50
Students	66	22	34	29	30	30	35	32

PUBLICATIONS



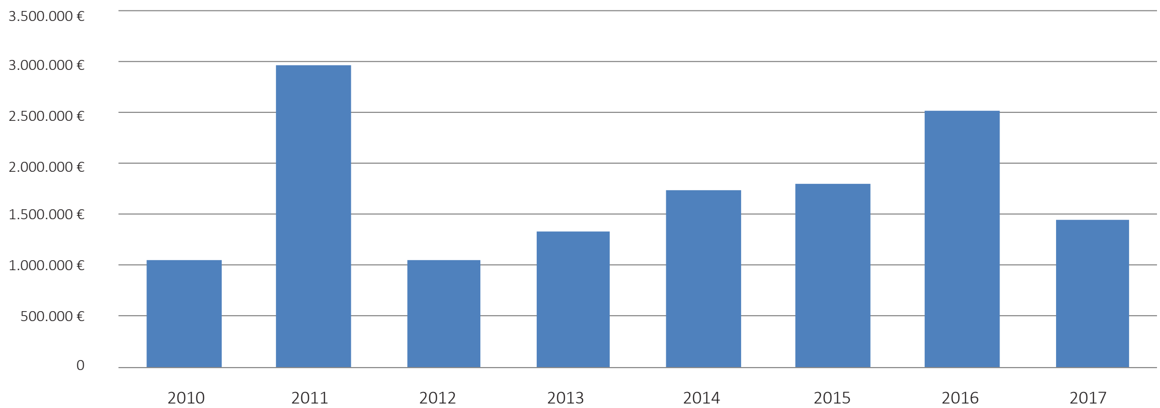
	2010	2011	2012	2013	2014	2015	2016	2017
Total	32	33	19	21	28	40	32	41
Lead authorship	14	17	13	15	17	14	15	27
Co-authorship	4	8	4	5	7	23	15	14
Book chapters	14	8	2	1	4	3	2	0

GRADUATIONS



		2010	2011	2012	2013	2014	2015	2016	2017
	Habilitation	0	0	1	0	0	0	0	0
	Doctoral thesis	2	1	3	3	3	4	1	3
	Master thesis	8	0	2	1	2	2	4	6
	Bachelor thesis	0	3	2	2	3	0	2	1
	Total	10	4	7	6	8	6	7	10

FUNDING



ICCAS is mainly financed by the BMBF Federal Ministry of Education and Research under its ZIK Centers of Innovation Excellence program. In 2017, other external funding was received from the BMWi Federal Ministry for Economic Affairs and Energy for projects related to the ZIM Central Innovation Program for small and medium-sized enterprises as well as from the European Union. Leipzig University's Faculty of Medicine also provides ICCAS with performance-based funding.

ACTIVITIES 2017

HIGHLIGHTS

Prof. Thomas Neumuth and Prof. Andreas Melzer explain the Intelligent OR to Dr. Angela Merkel at Digital-Gipfel 2017. | © BMBF | Hans-Joachim Rickel

ICCAS MEETS FEDERAL CHANCELLOR ANGELA MERKEL AT DIGITAL-GIPFEL

ICCAS's special highlight in 2017 was the presentation of its 'Intelligent Operating Room' and the 'Digital Patient Model' at the 'Digital-Gipfel' in Ludwigshafen from June 12-13, 2017. There, Prof. Andreas Melzer and Prof. Thomas Neumuth demonstrated the use of computer technology for an efficient and high-quality patient care to the federal chancellor Dr. Angela Merkel (CDU) and the Federal Ministers Brigitte Zypries (BMWi), Prof. Johanna Wanka (BMBF), Alexander Dobrindt (BMVI), Hermann Gröhe (BMG) and Bitkom President Thorsten Dirks. During a simulated ear, nose and throat intervention the cabinet members could convince themselves of the benefits of ICCAS's digital assistance systems, as there are: finding the optimized therapy and supporting the daily work in operating rooms. Detection of the current surgical process and anticipation of the next steps as well as adaption of the OR lightning to the current situation and display of necessary patient data on medical devices of different producers are only some of the main research outcomes. The exhibit was developed in close cooperation with the ENT Clinic (Prof. Andreas Dietz) and the Clinic for Neurosurgery (Prof. Jürgen Meixensberger) of Leipzig University Hospital and Leipzig Heart Center (Prof. em. Friedrich-Wilhelm Mohr) as well as further clinical and industrial partners. It is financed by funds of the Federal Ministry of Education and Research (BMBF).

4TH DIGITAL OPERATING ROOM SUMMER SCHOOL (DORS) SUCCESSFULLY COMPLETED

ICCAS's Digital Operating Room Summer School (DORS) ended successfully in early September. The feedback of the 26 participants from twelve countries (among them Japan, the United States of America, Iraq and Tunisia) was very positive. They were convinced by the well-balanced combination of theoretical knowledge transfer, OR visits and practical units. Physicians of Leipzig University Hospital and Heart Center Leipzig as well as foreign experts supported the extensive summer school program, certified with 38 European CME Credits (EACCME®).

Participants and tutors of DORS 2017 from around the world.

The course contents included computer assisted applications in the fields of ENT, Neurological, Visceral and Heart surgery, Urology and Radiology, the Digital Patient Model, medical robotics and technologies for the future operating room. In the evening, social activities facilitated contacts and knowledge exchange. The next DORS is scheduled from August 27-31, 2018.

EUFUS 2017 AND PRE-CONFERENCE WORKSHOP OF SONO-RAY IN LEIPZIG

Under the direction of Prof. Andreas Melzer the 4th European Symposium on Focused Ultrasound Therapy (EUFUS) took place at Salles de Pologne in Leipzig from October 26-27, 2017.

EUFUS 2017 at Salles de Pologne in Leipzig. | © C. Melzer

About 200 guests from eleven European and five Asian countries, as well as from USA, Canada and Australia talked and discussed about current research results and state-of-the-art applications in the field of treatment with Focused Ultrasound (FUS) and High intensity Focused Ultrasound (HiFU). On October 25, the project groups of the Meta-ZIK SONO-RAY performed a full day workshop with partners such as the Fraunhofer Institute for Biomedical Technology (IBMT, St. Ingbert) on the subject of 'Experimental FUS and HIFU'. About 70 international guests participated in this pre-conference event of EUFUS 2017. Amongst other topics, they could practically experience the new HIFU system at Leipzig University Hospital, the setup of an ultrasound system and the treatment of cancer cells by ultrasound.

PRESENTATIONS AT FAIRS

NETWORKED OPERATING ROOM AT CONHIT | APRIL 25, 2017, BERLIN

ICCAS and further members of the OR.Net e.V. present their work on concepts for the secure, dynamic and open integration of medical device components in the operating room and clinic.

SONO-RAY PROJECT AT ISTU 2017 | MAY 30, 2017, NANJING (CHINA)

Prof. Andreas Melzer and Dr. Doudou Xu with results of the Meta-ZIK project SONO-RAY at the 'International Symposium for Therapeutic Ultrasound' (ISTU). | © Doudou Xu

BIOPASS AT BMBF FUTURE CONGRESS | JUNE 26, 2017, BONN

ICCAS and partners of the BIOPASS project with a new navigation assistance system for minimally invasive endoscopy at the Future Congress of the Federal Ministry of Education and Research (BMBF). © BMBF | WPR Schnabel

MEDICAL ROBOTIC AT MEDICA 2017 | NOVEMBER 13 - 16, 2017, DÜSSELDORF

Richard Bieck at ICCAS's computer assisted robot system 'RoboDirect' which supports the guidance of instruments during image-guided minimally invasive interventions.

IN-HOUSE EVENTS

STATUS SEMINAR 2016 | JANUARY 19, 2017, ICCAS, LEIPZIG

Presentation of ICCAS's research results and highlights in 2016.

GIRL´S DAY | APRIL 27, 2017, ICCAS, LEIPZIG

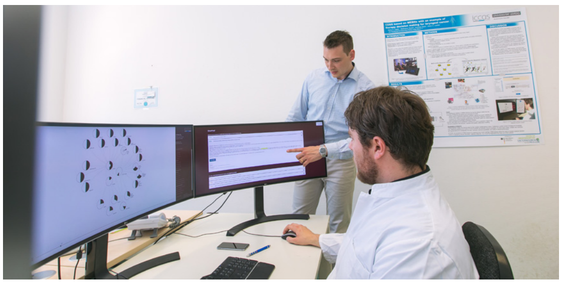
Insight into medical informatics for female pupils at ICCAS.

OPEN DAY | MAY 18, 2017, ICCAS, LEIPZIG

Station: Application of medical robotics for minimally invasive treatments.

CHILDREN'S UNIVERSITY | OCTOBER 20, 2017, AUDIMAX, LEIPZIG UNIVERSITY

Autograph- and question time with Prof. Thomas Neumuth after children's lecture 'How does a robot learn to operate?'
© Katharina Eisermann



DIES ACADEMICUS | DECEMBER 04, 2017, NEW AUGUSTEUM, LEIPZIG UNIVERSITY

DPM exhibit: Model Based Therapy Decision Support for Cancer Therapies.

LAUNCHES AND COLLABORATION WORK

EU PROJECT: EUROPEAN MODULAR FIELD HOSPITAL | START: JANUARY 1, 2017

Under the direction of the European Commission's Directorate General for Humanitarian Aid and Civil Protection (DG ECHO), nine European countries want to develop a modular hospital that can be transported to the scene of an emergency within a very short period of time. The ICCAS is represented by Prof. Thomas Neumuth as a member of the steering committee in this new EU humanitarian project EU-MFH. It contributes its know-how with regard to information technology networking and electronic patient documentation. The project is substantially supported by the World Health Organization (WHO) and Handicap International.

Medical Field Hospital in Nepal during Earthquake 2015.
© Italian Civil Protection Department

PROJECT: IMPACT | START: MARCH 1, 2017

In the industry collaboration project IMPACT research is being conducted on a mobile 3D imaging system based on electrical impedance tomography (EIT). The BMBF project is headed by PD Dr. Andreas Reske from Heinrich Braun Hospital Zwickau. Its partners are ICCAS, the Faculty of Electrical Engineering and Information Technology at HTWK Leipzig University of Applied Sciences as well as the two commercial companies Fritz Stephan Medizintechnik GmbH and Gesellschaft für Intelligente Textile Produkte (ITP GmbH). Their common goal is to develop a market-ready device certified under medical product legislation which substantially improves the monitoring of lung ventilation, particularly in intensive care and emergency medicine.

PROJECT: MoVE | START: OCTOBER 1, 2017

The BMBF project MoVE is coordinated by the OR.Net e.V. with Prof. Thomas Neumuth as project leader. Currently, the market for integration and networking of medical devices is dominated by closed solutions of international producers. For small and medium-sized medical technology manufacturers the access to the market is limited. The objective of MoVE is the development of methods which promote the approval as well as the certification process and risk management of open networked medical products in integrated OR environments.

Project leader Prof. Thomas Neumuth welcomes all MoVE partners at the kick-off meeting in Leipzig.

VISIT OF OR.NET SISTER PROJECT 'SCOT' IN JAPAN | FEBRUARY 2017, TOKYO (JAPAN)

ICCAS has paid a return visit to scientists of the Japanese Smart Cyber Operating Theater (SCOT) project being carried out by the Institute for Advanced Biomedical Engineering & Science at Tokyo Women's Medical University.

ICCAS delegation in the SCOT demonstrator at Tokyo Women´s Hospital.

SCOT is quite similar to the German OR.NET project. It deals with the design and construction of an integrated operating room. Furthermore, Prof. Thomas Neumuth, Dr. Stefan Franke and Erik Schreiber explained ICCAS's work on open OR networking to participants from the Japanese industrial and research sectors during a symposium on biomedical engineering. At a subsequent workshop, possible synergies between German and Japanese activities were explored.

ICCAS AND INNOFSPEC ON COLLABORATION COURSE | JULY 6, 2017, POTSDAM

Innovative Fiberoptic Spectroscopy and Sensing (innoFSPEC), based in Potsdam, and ICCAS started cooperation talks within a workshop at the Leibniz Institute for Astrophysics. While innoFSPEC focuses on astrophysics and spectroscopy, ICCAS works on model-based surgical automation and precision medicine. Research areas of the two BMBF Centers of Innovation Competence have the impact to develop joint technologies. The workshop inspired a strong interest in developing interdisciplinary research projects.

Participants of the collaboration workshop in Potsdam.
© K. Albaum, AIP

SUCCESSFUL NON-INVASIVE TREATMENTS WITH HIFU AT UKL | OCTOBER 2017, LEIPZIG

Under direction of Prof. Andreas Melzer, in January 2017 the Philips Sonalleve MR-HIFU System was put into operation at Leipzig University Hospital's Department of Radiology to establish an MR-HIFU service primarily to provide a clinical therapy option for treatments in gynecology and palliative medicine. The system is approved to treat uterine fibroids and bone metastases. In February 2017, introduction and training were performed on the console and in October the first two patients with uterine fibroids have been treated.

Uterine fibroid treatment with HIFU at Leipzig University Hospital, Dept. of Radiology. © Stefan Straube

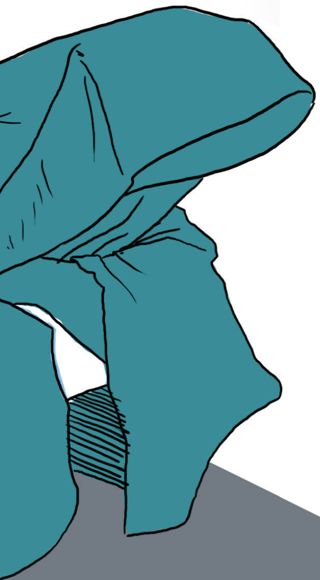
RESEARCH AREAS AND RELATED PROJECT PROFILES


MODEL-BASED
AUTOMATION AND INTEGRATION
DIGITAL
PATIENT- AND
PROCESS MODEL
COMPUTER-ASSISTED
IMAGE-GUIDED
INTERVENTIONS
SONO-RAY

MODEL-BASED AUTOMATION AND INTEGRATION

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

Prof. Dr. Thomas Neumuth
(group leader)



SCIENTIFIC STAFF

Stefan Franke, Erik Schreiber, Johann Berger, Thomas Neumuth (group leader), Michael Unger, Christoph Georgi, Reinhard Fuchs, Richard Bieck, Juliane Neumann, Max Rockstroh (f.l.t.r.)

SELECTED PUBLICATIONS

Maktabi M, Birnbaum K, Oeser A, Neumuth T. Situation-dependent medical device risk estimation: Design and Evaluation of an equipment management center for vendor-independent integrated operating rooms. J Patient Saf. 2017 [Epub ahead of print].

Neumann J, Wiemuth M, Burgert O, Neumuth T. Application of activity semantics and BPMN 2.0 in the generation and modeling of generic surgical process models. Int J Comput Assist Radiol Surg. 2017; 12(S1): 48-9.

Rockstroh M, Franke S, Hofer M, Will A, Kasparick M, Andersen B, Neumuth T. OR.NET: multi-perspective qualitative evaluation of an integrated operating room based on IEEE 11073 SDC. Int J Comput Assist Radiol Surg. 2017; 12(8): 1461-69.

BPMN^{SIX} – A BPMN 2.0 SURGICAL INTERVENTION EXTENSION

INTRODUCTION

Surgical workflow management enables process automation, optimization and analysis. It is a prerequisite for computer-aided surgical assistance, situation-awareness and decision support in modern integrated operating rooms (OR). Therefore, the information about the current situation must be provided to the medical devices in the OR for situation-aware configuration and combination of supportive services. For this purpose, the intraoperative processes must be described as Surgical Process Models (SPMs). For a machine-interpretable representation of SPMs, business process modeling languages, like BPMN 2.0 could be used. The goal of the project is to provide a domain-specific extension of the BPMN modeling language for intraoperative surgical workflow modeling and execution in the integrated OR.

MATERIAL AND METHODS

In the first step, an ontology consisting of domain-specific concepts and their relations was created. The ontological entities were then examined in respect to a potential matching to BPMN standard elements. In the next step, an equivalence check was performed, which aims on the identification of BPMN extension elements and their extension requirements. Subsequently, a BPMN extension model with abstract syntax, concrete syntax, and a graphical notation for BPMN^{SIX}, was implemented (Fig. 1).

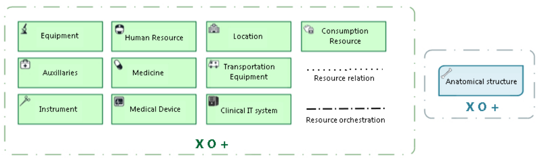


Fig. 1 - BPMN^{SIX} extension elements of BPMN 2.0.

RESULTS

BPMN^{SIX} is partly based on BPMN for clinical pathways (BPMN4CP) and integrates a medical device resource, which can be linked with a IEEE11073-10207-standard compliant medical device representation for integrated ORs. Therefore, the abstract functionalities of the medical devices are combined and orchestrated for situation-aware assistance with a BPMN^{SIX}-resource orchestration relation. BPMN models are executable and could be implemented for surgical workflow management in integrated ORs. The generation of SPM with BPMN^{SIX} was evaluated for a cataract surgery use case. The resulting model provides an efficient representation with different granularity levels without filtering infrequent transitions or losing the clarity of the visual representation. In Fig. 2 an example part of the resulting BPMN^{SIX} process model, is presented.

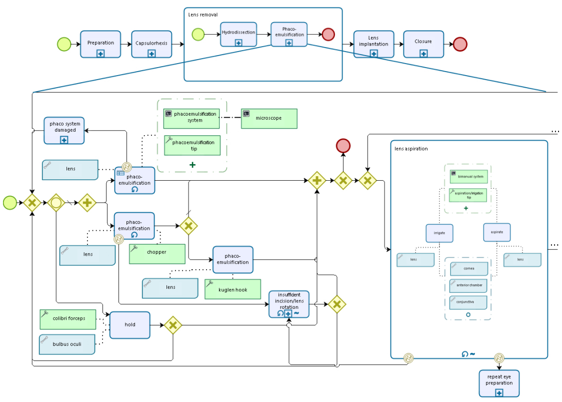


Fig. 2 - High level process of cataract surgery and part of "Phacoemulsification" subprocess.

DISCUSSION AND CONCLUSION

The design of BPMN^{SIX} is an expandable approach of a surgical workflow modeling language for integrated ORs. The OR is a dynamic and changing environment; thus, a continuously occurrence of new requirements could be expected. Due to novel methods for workflow recording, existing concepts might require change and new ones may be added to the BPMN^{SIX}.

PROJECT TEAM

Dipl.-Inf. Juliane Neumann

Dipl.-Inf. Max Rockstroh

Dr.-Ing. Stefan Franke

Prof. Dr. Thomas Neumuth

SELECTED PUBLICATIONS

Neumann J, Rockstroh M, Franke S, Neumuth T. BPMNSIX – A BPMN 2.0 Surgical Intervention Extension. 7th Workshop on Modeling and Monitoring of Computer Assisted Interventions (M2CAI) - 19th International Conference on Medical Image Computing and Computer Assisted Interventions (MICCAI 2016), Athens, Greece, 2016.

Neumann J, Wiemuth M, Burgert O, Neumuth T. Application of activity semantics and BPMN 2.0 in the generation and modeling of generic surgical process models. International Conference on Computer Assisted Radiology and Surgery (CARS 2017), Barcelona, 2017.

Wiemuth M, Junger D, Leitritz M.A., Neumann J, Neumuth T, Burgert O. Application fields for the new Object Management Group (OMG) Standards Case Management Model and Notation (CMMN) and Decision Management Notation (DMN) in the perioperative field. Int J Comput Assist Radiol Surg., 2017; 12(8): 1439-49.

FUNDING

German Federal Ministry of Education and Research (BMBF)

ONTOMEDRISK – ONTOLOGY-BASED PERIOPERATIVE RISK MINIMIZATION

INTRODUCTION

Medical personnel are often under great stress, raising the likelihood of errors and adverse events. The aim of the OntoMedRisk-project was the development of an agent-based software solution to minimize the occurrence of such events. Therefore, the risk identification ontology (RIO) and several software modules were developed to identify risks across medical processes.

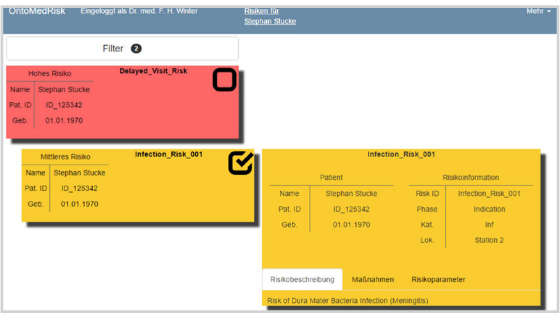


Fig. 1 - Visualization of risk information in the web-based user interface.

MATERIAL AND METHODS

The agent system has been implemented using the Java Agent Development Framework (JADE). The internal data storage of the agent system is based upon the HL7-FHIR specification. Therefore, the data within the agent system is represented as FHIR resources. In addition, a web-based user interface was implemented, which consists of two web pages, a patient overview and a page containing a patient's risks, which are displayed in the user's web browser (Fig. 1).

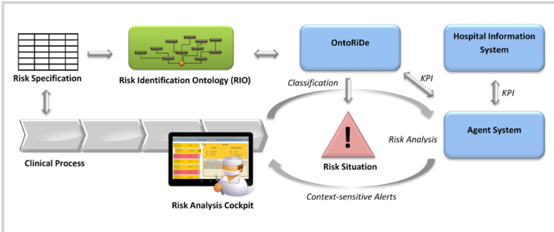


Fig. 2 - Ontology-based identification of perioperative risk situations.

RESULTS

Fig. 2 shows the basic principle and components of the system. Based on RIO, a software module, called Ontology-based Risk Detector (OntoRiDe), was developed, which allows the identification of the ontologically specified risks. OntoRiDe accesses distributed patient and risk related data across various data sources within a hospital for the identification of patient specific risk situations. Therefore, the system monitors risk relevant parameters throughout the entire treatment process. Based on defined rules within RIO, the parameters were then analyzed by a software component, called OntoRA. The results of those analyses are then forwarded to the medical staff as context-sensitive hints and alerts. In the web-based user interface, the user can select a specific patient and the corresponding potential medical risks are displayed. The risks are ordered by the severity of each risk-event combination. In addition, detailed information like the risk description or risk parameters could be displayed.

DISCUSSION AND CONCLUSION

The insertion of cochlear implants was chosen to demonstrate the features and benefits of the risk identification system. The agent system is currently deployed at the Jena University Hospital and integrated in the hospital information system. The agent system collects data from various data sources within the same subnet, from a FHIR server as well as a communication server, which holds patient-related data. Due to the modularity and flexibility of the agent system, further use cases and new modules can be added to the system with little effort. This enables an easy customization and adaption to other clinical environments.

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SELECTED PUBLICATIONS

Uciteli A, Neumann J, Tahar K, Saleh K, Stucke S, Faulbrück-Röhr S, Kaeding A, Specht M, Schmidt T, Neumuth T, Besting A, Stegemann D, Portheine F, Herre H. Ontology-based specification, identification and analysis of perioperative risks, J Biomed Semantics. 2017; 8(1):36.

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FUNDING

German Federal Ministry of Education and Research (BMBF)

BIOMEDICAL INFORMATION TECHNOLOGY FOR THE EUROPEAN MEDICAL FIELD HOSPITAL

INTRODUCTION

Sudden onset disasters such as the 2010 earthquake in Haiti or 2015 in Nepal, the Taifun Haiyan in 2013 or the Ebola epidemic in 2014 are usually associated with a high number of civil victims and injured persons. Therefore, fast and reliable medical care needs to be provided in the event of destruction or restricted functional capacity supply infrastructure often also over a longer period of time.

In 2013, the Global Health Cluster of the World Health Organization, initiated the need for emergency relief with managed quality and standardized services. The Emergency Medical team (EMT) working group of the WHO developed a new standard for the provision of inpatient medical care services. A fully mobile hospital with the minimum requirements of two operating rooms, four ICU beds and 40 inpatient beds is classified as EMT Level 3. Within the European Union, some Member States currently have only mobile EMTs with insufficiant capacity. These can be dispatched within a very short period of time in order to support the supply in humanitarian crisis situations. In the European Union, however, there is no active deployable EMT Level 3.

MATERIAL AND METHODS

Within the framework of the European Modular Field Hospitals (EUMFH) project, the emergency response capacity of the EU disaster response mechanism is being improved. With the help of the combined expertise of the Member States, a joint EMT level 3 hospital will be designed and built. The project is financed by the General Directorate for Humanitarian Aid and Civil Protection (DG ECHO) of the European Commission.

RESULTS

The ICCAS develops medical and information technology concepts for the acquisition and management of diagnostic, therapeutic and administrative information in the EUMFH. The aim of the EUMFH hospital IT is to ensure a constant flow of information within the command center structure in order to enable the EUMFH management to provide a timely decision-making base for the adequate use of the restricted resources in a critical and highly dynamic environment.

DISCUSSION AND CONCLUSION

In order to solve the challenge, the information technology concepts of existing EMTs of level 1 and 2 and / or of the European level 3 field hospitals are evaluated. At the same time, the governance, medical and logistical requirements of the EUMFH working group are analyzed. Based on this, the concept for information and medical technology for the EUMFH is developed, as well as open research and development tasks identified.

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Belgian Ministry of Health

Danish Emergency Management Agency

Estonian Health Board

Romanian Ministry of Internal Affairs

The Johanniter

Association of Slovak Samaritans

Greek National Centre of Emergency Care

World Health Organisation

Handicap International

SELECTED PUBLICATIONS

Neumuth T. The European Modular Field Hospital: Herausforderungen für IT beim Einsatz mobiler Krankenhäuser nach Naturkatastrophen. In: 62. Jahrestagung der Deutschen Gesellschaft für Medizinische Informatik, Biometrie und Epidemiologie e V (GMDS). Oldenburg: German Medical Science GMS Publishing House; 2017.

FUNDING

General Directorate for European Civil Protection and Humanitarian Aid Operations

CONSISTENT AND PRIORITIZED PRESENTATION OF SURGICAL INFORMATION (CPSI)

INTRODUCTION

New assistance functionalities emerge rapidly in the operating room (OR). The amount of available information grows with each solution, but also raises the amount of information that needs to be displayed. To avoid an information overload, all available information needs to be prioritized in respect to the current situation of the intervention so that only relevant information is displayed. Furthermore, a standardized pattern is required to provide a consistent presentation of surgical information across different surgical setups and intervention types (see Figure 1).

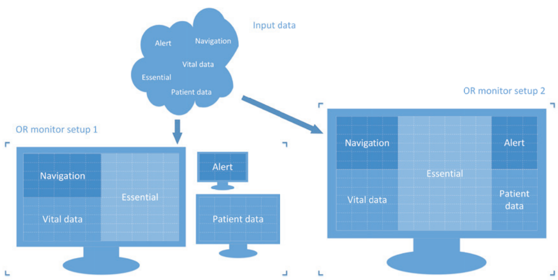

Fig. 1 - Example of information allocation by category on two different monitor setups.

MATERIAL AND METHODS

To provide these functionalities, we propose an architecture that consists of three components: a prioritizer, a layouter and a display handler. The components are interposed between the OR network and a variable set of OR displays (see Figure 2). The Prioritizer is connected to a knowledge base containing customizable rules to assign priorities to information entitites depending on the current OR situation. The Display Handler provides information about the available displays in the OR as well as for displaying the prioritized and layouted information, while the Layouter orchestrates the prioritized information before passing them to the Display Handler. The Workflow Information

System is an optional background service that provides required information about the current situation in the operating room.

RESULTS

The effect on information overload was examined in an explorative study at the use case of functional endoscopic sinus surgeries (FESS). A prioritization catalogue was created to prioritize information entities in a simulated surgical environment. The monitor setup consisted of two displays. High priority information was displayed on the primary display. All other information was orchestrated on the second display and scaled down to 25%. Actual displayed information was compared to expectations, manually established based on surgical work steps of FESS process models. For each second the information display was assessed as: “perfect”, “at least visible” or “missing”. Overall, in 94.77% of the time information display assessed as “perfect”, in 1.98% as “at least visible” and in 3.25% information was missing (see Figure 3).

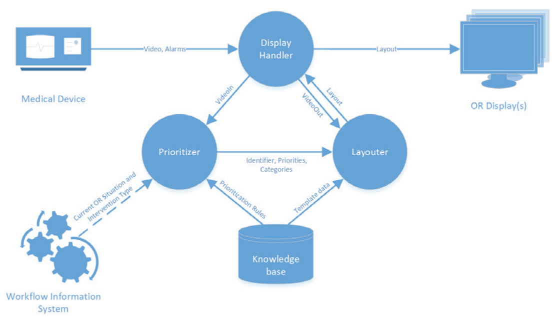

Fig. 2 - CPSI components and data flow.

Information	Perfect (s)	At least visible (s)	Total (s)	Perfect	At least visible	Missing
PACS	641	0	641	100.00%	0.00%	0.00%
Navigation	1314	0	1314	100.00%	0.00%	0.00%
Endoscope	15718	0	16318	96.32%	0.00%	3.68%
Shaver	1810	48	1858	97.42%	2.58%	0.00%
Suction	3356	333	3689	90.97%	9.03%	0.00%
Vital data	3335	812	4147	80.42%	19.58%	0.00%
Light (Endo)	3164	1695	4859	65.12%	34.88%	0.00%

Fig. 3 - Distribution of information entities over assessment terms and surgery time(s).

DISCUSSION AND CONCLUSION

The proposed method seems well suited to minimize intraoperative information overload. Information that would require three displays in total, was orchestrated on two displays without information loss. It may contribute to an efficient surgical workflow by automatically toggling surgical information depending on their relevance to the current surgical situation.

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

INTRODUCTION

In the BIOPASS project a novel localization approach for a markerless navigation systems is developed that reduces the navigation hardware while assisting surgeon cognition with self-learning and adaptive assistance functions. A critical aspect for the development of such an intelligent system is the acquisition and aggregation of multimodal data. The primary goals of the project are therefore, a multimodal acquisition of information in the OR, a comprehensive human-machine-interaction as well as a new way of intelligent navigation assistance.

MATERIAL AND METHODS

An initial online survey with ENT surgeons outlined key requirements for an intelligent navigation system. In a subsequent study, a mock-up demonstrator was built to simulate the ideal navigation process performed. A tracking system for the endoscope position and a FESS phantom were used. In a following development step, multimodal situation information was acquired. IoT-ready communication technology was introduced to integrate different software modules and to achieve system configurability. Further work steps will be the semantic interpretation of multimodal data as well as the integration of presentation and recommender functionalities as well as an evaluation phase.

RESULTS

Over 80 % of surveyed surgeons (between 1 and 28 (9.14) years of experience) stated that smarter behavior of navigation systems could be vital, and surgeons would preferably ask a smart system about context-sensitive data. A mock-up demonstrator was introduced to validate the initial survey results. Subsequently, the demonstrator was optimized by integration of movement and image sensor modules, an interpretation module for semantic inference as well as image and process classification modules.

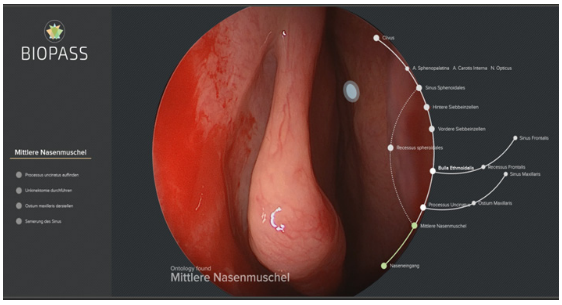

Fig. 1 - Study 1- Concept design for the navigation system interface with different aspects of the analyzed surgical situation information.

DISCUSSION AND CONCLUSION

The need for more sophisticated and intelligent navigation system in the operating room is imperative. We introduced a system with a novel localization approach for a markerless navigation in minimally-invasive endoscopic ENT surgery. The system uses multimodal data to learn surgical situations from endoscopic images and surgical procedure information. With the introduction of a pre-final demonstrator, the upcoming task will be the validation of navigation functions as well as interaction and information presentation studies. Ideally, the navigation system enables us to further investigate the surgeons cognition process during a surgical navigation and therefore benefit ongoing research activities.

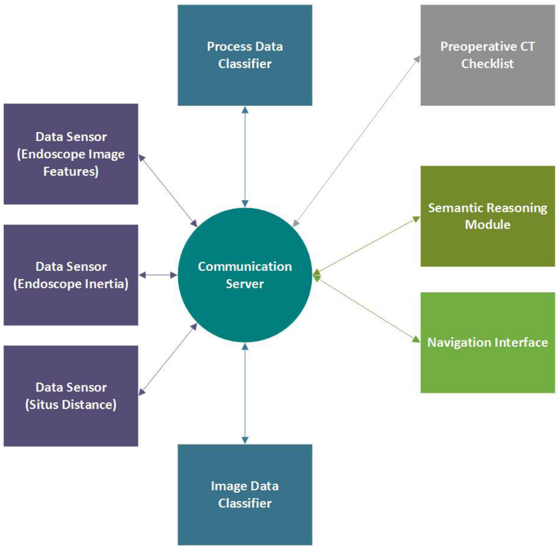

Fig. 2 - BIOPASS System components: Data Management is achieved with a Communication server, sensory modules acquire information which is inferred by classifiers as well as a reasoning module, a navigation interface provides navigation functions as well as insight on system behavior.

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SELECTED PUBLICATIONS

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

FUNDING

German Federal Ministry of Education and Research (BMBF)

CONTEXT-AWARE TECHNICAL ASSISTANCE IN INTEGRATED SURGICAL WORKING ENVIRONMENTS

INTRODUCTION

Although more and more medical devices provide standardized communication interfaces, they yet show only very limited cooperative behavior. The lack of contextual information during surgery hinders autonomous intelligent system's adaptation. We implemented a context-aware assistance, which combines device interoperability, surgical workflow tracking, and behavioral rule sets to establish a surgical working environment that actively cooperates with the surgical team.

MATERIAL AND METHODS

The ICCAS Demonstrator provides a fully integrated operating room, which implements the IEEE 11073 SDC standards family. Based on the open device interoperability, a pipeline for context-awareness was implemented, as depicted in Figure 1.

First, the recognition data, which is collected from various sensor systems and devices, is consolidated and mapped to low-level work steps. The input triggers the classification of these data to derive contextual information, such as abstract task, patient status, or device usage and time prediction. The modules are continuously updated to provide hierarchically structured contextual information. Finally, medical devices evaluate the contextual information to adapt themselves and realize intelligent system's behavior.

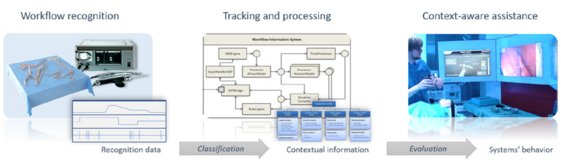

Fig. 1 - The proposed intraoperative processing pipeline for the realization of context-aware assistance in integrated operating room.

RESULTS

Various assistance functionalities were implemented for Functional Endoscopic Sinus Surgery, which included the automated switching of the primary display, the adaptation of ambient light conditions, as well as the parameterization of the medical devices. A technical validation study was conducted with twenty-four procedures on phantoms. The performances with definite input and with noisy recognition input were compared. The achieved accuracies of over ninety-four percent for the various assistance functionalities under noisy recognition input indicate a reasonable robustness of the implemented processing pipeline and context-aware assistance.

DISCUSSION AND CONCLUSION

The assistance is designed to optimally support the OR team during surgery and in documentation. Additionally, the established demonstration setup serves as a basis for a pre-clinical evaluation and further implementations.

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SELECTED PUBLICATIONS

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

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FUNDING

German Federal Ministry of Education and Research (BMBF)

MoVE – MODULAR VALIDATION ENVIRONMENT FOR MEDICAL NETWORKS

AIMS

The integration and networking of medical equipment has become an indispensable component of modern operating theatres in recent years. At present, the market is characterized by closed solutions, which are regulatorily approved as monolithic settings. The aim of the project is therefore to develop methods that support the approval and certification process as well as the risk management of openly networked medical devices in integrated operating theatres and thus ease the access of SMEs to the market with innovative technologies.

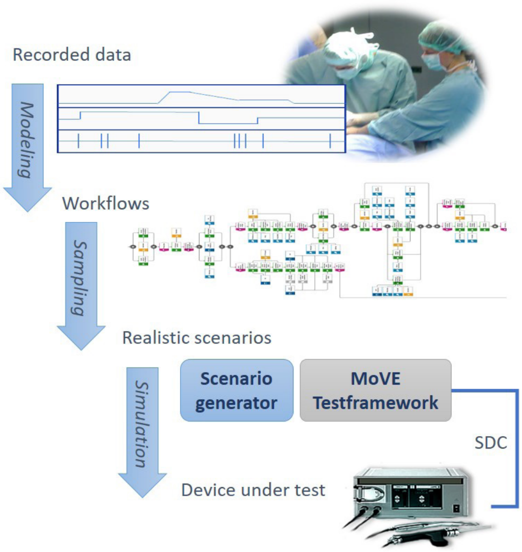

Fig. 1 - Schematic representation of the proposed concept for the automatic generation test scenarios from clinical recordings.

SOLUTION

For this purpose, a simulation environment including communication infrastructure, test scenarios, and test fields will be developed. The test platform will verify the networking of medical devices and software components and validate the communication regarding a large variety of parameters. Realistic, scenario-based simulations of an OR setup and its communication will be implemented by emulators of medical devices. Based on standardized device descriptions, manufacturers develop purely software-based emulators for their device to test the products against the virtual infrastructure and the devices of other manufacturers in a larger network within a simulation environment. In addition, the project aims to further develop strategies to support the conformity assessment procedure for networked open systems based on current communication standards. Guidelines for conformity, intra- and interoperability testing as well as for modular risk analysis are developed, in which the risk profiles are examined from the point of view of the manufacturer and the operator. In the frame of the project, ICCAS is responsible for the automated generation of realistic test scenarios in ENT surgery. Methods are developed that use already well-developed stochastic workflow modeling approaches to sample possible intervention courses and orchestrate the states and parameters of the emulated devices based on the estimated surgeon's behavior. This approach expands the application fields of the developed test platform from the final conformity testing to an early use in the development process of novel medical devices.

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EVALUATION OF A VENDOR-INDEPENDENT OPERATING ROOM AND ITS VALUE-ADDED SERVICES

INTRODUCTION

Networking of the medical devices supports patient treatment by reducing workload. The international initiative OR.NET focuses on interoperability of medical devices and IT systems in the operating room (OR) and clinic. In the initial project, numerous partners, among them OR vendors, manufacturers of medical devices and IT systems as well as research institutes and clinical partners were involved. They aim to create a technical base for an open, dynamic networking in the OR.

MATERIAL AND METHODS

The ICCAS OR.NET demonstrator deals with clinical use cases of head and neck surgery. Additionally, we explored the use of workflow management technologies to actively assist the intraoperative process. An overview is given in Figure 1. Medical devices and information systems share their data and control via the IEEE 11073 SDC standards family. In the work presented here, the OR.NET demonstrator at the ICCAS was evaluated together with doctors and nurses from various disciplines as well as with hospital operators. The OR and its unique features were introduced to the participants, followed by structured interviews with the clinical personnel and a questionnaire survey with the hospital operators.

Fig. 1 - Main use cases evaluated in the study in the ICCAS demonstrator OR.

Question	Range	Median	n.a.
Impact of cross-vendor availability of medical data of devices (eg. measurements) in clinical IT systems on...			
a) ...streamlining of clinical workflows?	6 – 9	**8**	1
b) ...reduction of cost and time consumption?	2 – 8	**6**	1
c) ...improvement of quality of patient care	4 – 9	**6**	0
d) ...increase of patient safety?	3 – 9	**6**	0
Impact of cross-vendor availability of technical device data (eg. time of use) in clinical IT systems on...			
a) ...improvement of technical maintenance workflow?	4 – 9	**7**	3
b) ...reduction of cost and time consumption?	2 – 9	**6.5**	1
c) ...improvement of quality of technical maintenance?	6 – 8	**7**	2
Importance of assistance from vendors for hospital operators in...			
a) ...risk analysis for network-specific properties of devices?	7 – 9	**8**	2
b) ...risk assessment for the networked components?	6 – 9	**7.5**	1
c) ...risk control for commissioning and operation?	1 – 9	**7.5**	1

Fig. 2 - Results of the technical survey for data integration and risk management aspects.

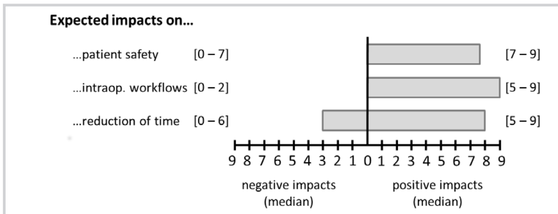

Fig. 3 - Expected impact on patient safety, intraoperative workflows, and time consumption assessed by the clinicians.

RESULTS

In our study, we qualitatively evaluate a subset of the developed concepts and systems based on an open OR integration technology. Hospital operators argued that they need support from medical device manufacturers, for example in the form of documents on risk management, especially for subsequent implementation in hospitals. The results of the survey with the clinic operators are presented in Figure 2.

The clinicians requested a flexible integration, an intuitive human-machine interface and assistance functions in their daily work. A brief summary of the expectations of the clinicians is presented in Figure 3.

DISCUSSION AND CONCLUSION

The implementation of openly integrated ORs will positively affect clinicians as well as the technical personnel and the hospital operators. The evaluation demonstrated the need for OR integration technologies and identified the missing tools to support risk management and approval as the main barriers for future installations.

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FUNDING

German Federal Ministry of Education and Research (BMBF)

SITUATION-DEPENDENT MEDICAL DEVICE RISK ESTIMATION: Design and Evaluation of an Equipment Management Center for Vendor-independent Integrated Operating Rooms

INTRODUCTION

The complexity of surgical interventions and the number of technologies involved is constantly rising. Hospital staff has to learn how to handle new medical devices efficiently. However, if medical device-related incidents occur, the patient treatment is delayed. Patient safety could therefore be supported by an optimized assistance system that helps to improve the management of technical equipment by non-medical hospital staff.

MATERIAL AND METHODS

We developed a system for the optimal monitoring of networked medical device activity and maintenance requirements, which works in conjunction with a vendor-independent integrated operating room (OR) and an accurate surgical intervention time and resource management system. An integrated situation-dependent risk assessment system gives the medical engineers optimal awareness of the medical devices in the OR.

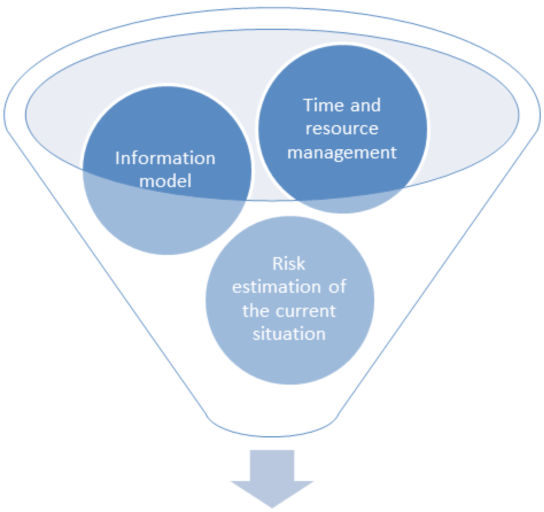

Fig. 1 - To implement a situation-dependent medical device-related incident (MDI) management and information model, a time and resource management and a risk estimation of the current situation is essential.

RESULTS

A qualitative and quantitative survey among ten medical engineers from three different hospitals was performed to evaluate the approach. A series of 25 questions was used to evaluate various aspects of our system as well as the system currently used. Moreover, the respondents were asked to perform five tasks related to system supervision and incident handling. Our system received a very positive feedback. The evaluation studies showed that the integration of information, the structured presentation of information, and the assistance modules provide valuable support to medical engineers.

DISCUSSION AND CONCLUSION

An automated OR monitoring system with an integrated risk assessment and time and resource management system module is a new way to assist the staff being outside of a vendor-independent integrated OR, who are nevertheless involved in processes in the OR.

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SELECTED PUBLICATIONS

Maktabi M, Neumuth T. Situation-dependent Medical Device Risk Estimation: Design and Evaluation of an Equipment Management Center for Vendor-independent Integrated Operating Rooms. Journal of Patient Safety (accepted).

FUNDING

German Federal Ministry of Education and Research (BMBF)

SCORPIO – STANDARDIZED COLLABORATIVE ROBOTICS FOR WORKFLOW ASSISTANCE IN INTERVENTIONAL RADIOLOGY

INTRODUCTION

The rise of "Precision Medicine" has once again set the focus on robot-assisted interventions. With innovations in the field of collaborative robotics, new applications and potential integrations of robotic systems into clinical practice are possible. Furthermore, recent developments in medical device interoperability additionally provide the resources to functionalize new robotic systems. The SCORPIO project thus aims to establish a framework for multiple robot-based assistance functions. A major aspect is the introduction of the IEEE 11073 SDC standards family and therein a service-oriented communication architecture for the operating room (OR) within the scope of the project OR.NET.

MATERIAL AND METHODS

We defined a 11073-conform medical device description of our surgical robotics system. We used a KUKA LWR iiwa 7 R800 with the robot operating system (ROS) framework and integrated it with a service interface that implements 11073-conform control functions. Thereby, the motion and safety control mechanisms are separated from the asynchronous service functions. The service interface is used to automatically register the SCORPIO system to a session in the OR. Furthermore, it provides access to the device metrics that are used to e.g. set coordinate system boundaries, patient registration data, or instrument positions for the ROS.

Fig. 1 - SCORPIO system with KUKA LWR iiwa 7 R800 robotic arms and phantom.

RESULTS

For a first use case of needle placement, the SCORPIO system receives needle placement data from an human-machine interface and sets the planning instructions. Path planning and motion control is then handed to the ROS application. Safety mechanisms are threefold: (a) A footswitch is directly connected to the robot control unit to release and block motion in case of problems. (b) The sent registration data is used to define safe zone bounding boxes to be excluded in the path planning. (c) Force feedback can be used to stop robot motion by hand.

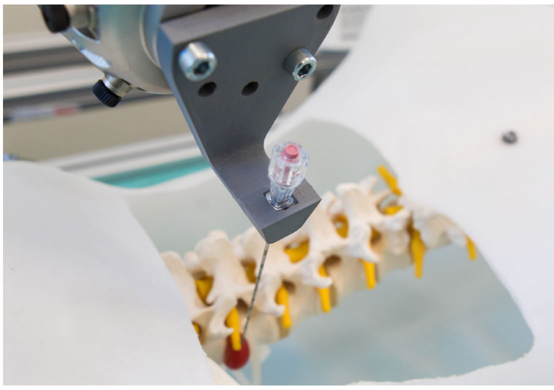

Fig. 2 - Robot arm with 3D-printed needle placement end effector.

DISCUSSION AND CONCLUSION

The topic of interoperability of robotic systems is now more critical than ever. With the introduction of smaller and more sophisticated collaborative setups, the need for easy-to-use functions, e.g. plug-and-play, as well as for advanced safety functions arises. We successfully introduced a communication interface based on an open standard for medical device interoperability and included various safety features. Ongoing developments need to include additional end effectors as well as interaction and safety concepts.

PROJECT TEAM

M. Sc. Richard Bieck

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B. Sc. Christoph Georgi

Leonard Leifels

Prof. Dr. Thomas Neumuth

SELECTED PUBLICATIONS

Bieck R, Kraus G, Neumuth T. Towards standardized surgical robotics interoperability for intraoperative assistance systems. In: Proceedings of the 51st DGBMT Annual Conference. 2017.

FUNDING

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

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

Subproject: Patient-based individual modeling of Paraspinal Collateral Network Perfusion after Segmental Artery Occlusion (PimPaP)

INTRODUCTION

Patients suffering from large thoracoabdominal aortic aneurysms (TAAA) are often confronted with the need for substantial aortic repair procedures achieved with artificial aortic valve replacement. The risks of such an intervention lie with the acute reduction of tissue vascularization resulting in neurological pathologies, e.g. paraplegia. The minimally invasive, selective segmental artery coil embolization (MISACE) is a procedure employed to preemptively close supplying segmental arteries of the aorta to promote collateral perfusion network arteriogenesis prior to such a conservative procedure. Since the MISACE procedure is still in an early application phase, there exist no general guidelines for artery closing patterns and their respective influence on the clinical outcome.

MATERIAL AND METHODS

In a first step, the coiling patterns and their impact on the convalescence of spinal perfusion and the clinical outcome are investigated. Hence, an extensible patient model needs to be developed including multi-modal imaging and procedure parameters, e.g. blood pressure, heart rhythm, CVP, rMAP as well as anatomical parameters, such as Crawford classification, calcification status and artery kinking. Following the model generation, an analysis of the MISACE procedures will be conducted investigating the correlation between coiling patterns and patient outcome. For the support of the treatment planning phase, a prediction method to estimate patient-individual consequences of coiling patterns on the overall procedure risk, the minimal recuperation time and ultimately, the clinical outcome will be developed and evaluated.

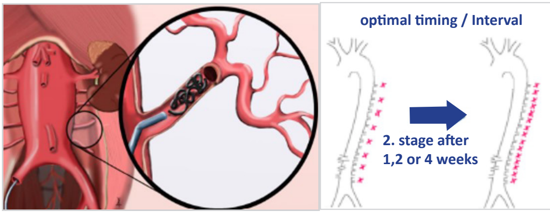

Fig. 1 - (1) Concept of artery embolization by coiling during the MISACE procedure and (2) coiling patterns along the thoracic aortic vessel.

DISCUSSION AND CONCLUSION

The magnitude of impact on the paraspinal collateral network perfusion compensation mechanics and the corresponding risk of ischemia and paraplegia are yet to be observed and understood. Whether a therapy support system for the MISACE procedure will be able to support the pre-operative treatment planning needs to be further investigated. A potential prediction of consequences for coiling patterns on the clinical outcome as well as estimating the overall procedure risk would greatly benefit patients and surgeons along the therapy process.

PROJECT TEAM

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PROJECT PARTNERS

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FUNDING

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733203.


PATIENTENMETRIK
Name
Max Mustermann
Alter des Patienten
64
Charlson Score
6
ECOG Status
1
Diagnosen
NB: bösartig: Larynx, mTeilBüberlapp
FktStör: Tracheostoma
Vorhandensein: Gastrostoma
Ernährungsprobl./unsachgem. Ernährung
Metastase/nnbez. BNB: LK, Kopf/Gesicht/Hals
Mukositis: oral (ulzerativ)
Radiodermatitis: akut
Bösartige Neubildung: Hypopharynx, mehrere Teilbereiche überlappend
DETAILS
KRANKHEITSMETRIK
Staging
pT3 pN3b M0
M Lokalisation
keine Metastasen
HPV Status
Positiv
Tumorentität
SCC
Grading
G2
R Klassifikation
R1
LVPn Staging
L1 V0 Pn1
Lymphknoten Kapselübertritt
5 / 58
BILDDATEN PANENDOSKOPIE
DIGITALES PATIENTENMODELL
M0
69.1%
M_state__patient
N2c
27.5%
N_state__patient
T3
70.2%
T_state__patient
Radiochemotherapie
84.0%
Therapieentscheidung
THERAPIEMETRIK
TUMORBOARD INFORMATION
Tumorboard Anamnese
postoperative Vorstellung nach Laryngektomie am 26.12.2017
Vorhergehende Diagnose
Staging und Panendo
Vorhergehende Therapie
LE, SND bds. 26.012.2017
Fragestellung Tumorboard
adj. Therapie?
Szintigraphie der Nieren: Dynamisch
Nicht komplexe Chemotherapie: 1 Tag: 1 Medikament
Computertomographie des Halses mit Kontrastmittel
Computertomographie des Thorax mit Kontrastmittel
Computergestützte Bilddatenanalyse mit 3D-Auswertung
January 2018

DIGITAL PATIENT- AND PROCESS MODEL

'Model-based medicine is the right answer to the medical information explosion, which cannot be tackled by traditional approaches of evidence-based medicine and increasingly complicates clinical decision making. Model-based medicine provides a framework employing mathematical models for translating and synthesizing evidence and medical knowledge such that both can be efficiently used in finding the best treatment for an individual patient.'

PD Dr.-Ing. Steffen Oeltze-Jafra
(group leader)

SCIENTIFIC STAFF

Mario Cypko, Jan Gaebel, Alexander Oeser, Steffen Oeltze-Jafra (group leader), Juliane Müller, Christoph Georgi, Erik Schreiber, Max Rockstroh, Stefan Franke (f.l.t.r.)

SELECTED PUBLICATIONS

Cypko M, Stoehr M, Kozniewski M, Druzdzel MJ, Dietz A, Berliner L, Lemke HU. Validation workflow for a clinical Bayesian network model in multidisciplinary decision making in head and neck oncology treatment. Int J Comput Assist Radiol Surg. 2017; 12(11): 1959-70.

Cypko M, Wojdziak J, Stoehr M, Kirchner B, Preim B, Dietz A, Lemke HU, Oeltze-Jafra S. Visual Verification of Cancer Staging for Therapy Decision Support. Comput Graph Forum. 2017; 36(3): 109-20.

Gaebel J, Cypko MA, Oeltze-Jafra S. Considering Information Up-to-Dateness to Increase the Accuracy of Therapy Decision Support Systems. Stud Health Technol Inform. 2017; 243: 217-21.

VISUAL VERIFICATION OF CANCER STAGING FOR THERAPY DECISION SUPPORT

INTRODUCTION

Correct classification of the primary tumor, lymph nodes and metastases (TNM staging) is crucial for an appropriate cancer treatment decision.

Inadequate TNM staging can result from missing or misinterpreted examinations and may remain unidentified until a tumor board meeting. Corrections in a meeting require a patient record review or even a repeated presentation in a next meeting, which is time-consuming.

We suggest a Bayesian network-based verification of information and decisions in order to identify shortcomings.

MATERIAL AND METHODS

For decision verification, we use a validated Bayesian network that represents the TNM staging for laryngeal cancer consisting of 303 variables. For the network visualization, we use a software tool that has been implemented in cooperation with the Gesellschaft für Technische Visualistik mbH: GTV, Dresden (Fig. 1). The tool supports the verification task through a comparison of two network computations. Differences are highlighted by two colors (blue and yellow). Exploring the network based on the differences is guiding the user to causes of wrong stagings.

In an evaluation study, we analyzed 20 patient cases retrospectively. We manipulated 9 of the cases randomly by setting wrong T, N or M states. For each patient case, we computed two networks; one based on all information and the other excluding the TNM staging. Five clinicians participated in the study. On individual request, they were allowed to review the official TNM classification table. During this study, we collected the answers as well as measured the investigation time per case and counted TNM table requests.

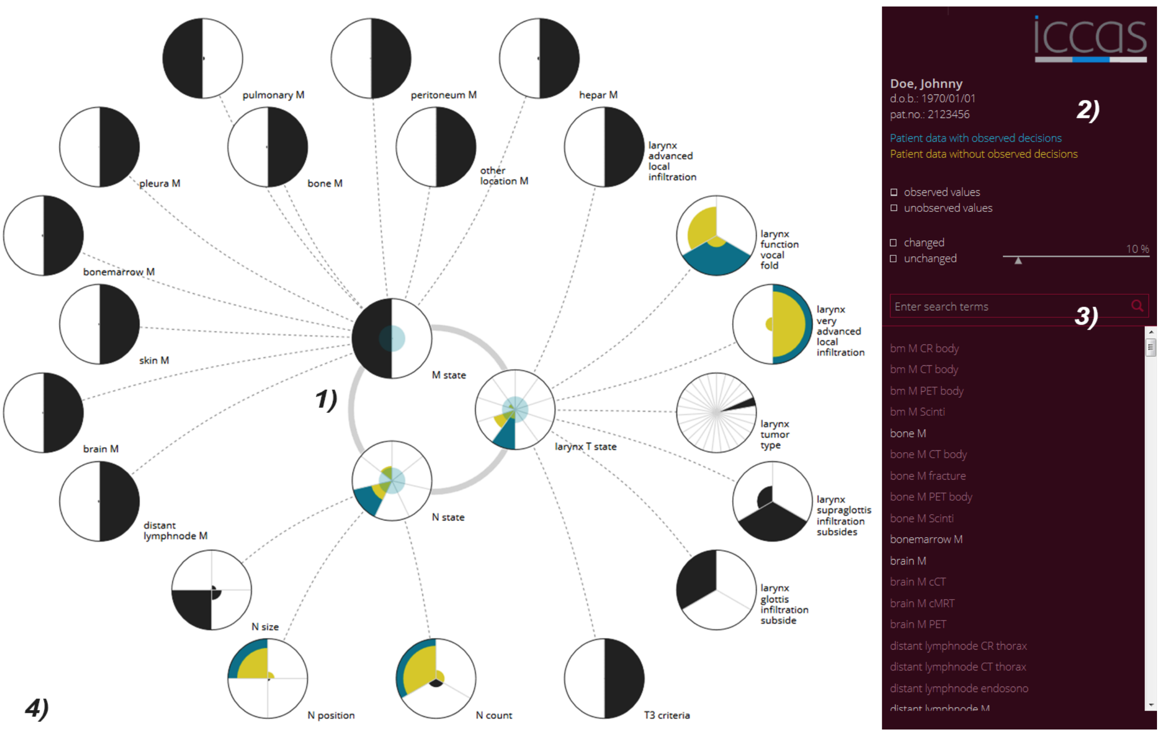

Fig. 1 - The visualization tool presenting a subset of the TNM staging network. Circular glyphs represent variables and their slices represent the variables' states. Colored slices (blue and yellow) indicate a disagreement between two network computations.

RESULTS

The visualization design required an initial introduction to the clinician. For the first four patient cases, each participant required support from a knowledge engineer, afterwards they were able to work autonomously. All participants requested the TNM staging table; the less experienced participants to conclude or verify the T, N, and M states, while the experienced participants requested the table more frequently but mostly to approve their estimates.

Finally, from the 12th patient case, all participants verified all cases correctly and required per case on average less than 3 minutes.

DISCUSSION AND CONCLUSION

A verification prior to the tumor board 1) is possible in a reasonable time, 2) may save time and 3) reduces the likelyhood of suboptimal decisions.

The approach serves as a role model for a wide variety of complex treatment decisions, e.g. related to severe vascular diseases, where precise diagnosis is essential, as well as to select the right combination of treatment options.

PROJECT TEAM

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SELECTED PUBLICATIONS

Cypko MA, Wojdziak J, Stoehr M, Kirchner B, Preim B, Dietz A, Lemke H, Oeltze-Jafra S. Visual Verification of Cancer Staging for Therapy Decision Support. In Computer Graphics Forum, 2017; 36 (3): 109-20.

FUNDING

German Federal Ministry of Education and Research (BMBF)

VALIDITY METRICS FOR PROBABILISTIC PATIENT DATA

INTRODUCTION

Uncertainty and other factors of inaccuracy of clinical data are ubiquitous problems in medicine. This becomes an issue especially with the automatic processing of the data in decision support systems. One major factor is the up-to-dateness of clinical information. The diagnostic delay refers to the duration of the diagnostic process until the final treatment decision is made, e.g. for suspected tumors. It describes how up-to-date specific information entities are. Researchers found a significant correlation between diagnostic delay and advanced tumor stages. It is a challenging task to quantify the consequences of diagnostic delay and implement them in a clinical decision support system.

MATERIAL AND METHODS

We analyzed the diagnostic delay of cases of patients with confirmed laryngeal cancer that were treated in a specialized ENT clinic. For the application decision support systems, we chose these median delays as thresholds beyond which the information is no longer considered reliable. To answer the question of how the impact of delayed information should be reduced, we iteratively calculated the behavior of a model-based decision support system with different probability values.

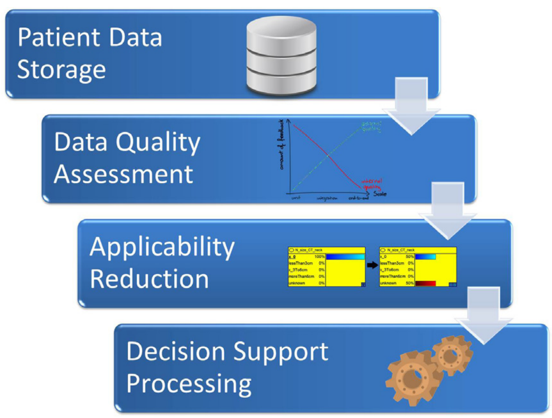

Fig. 1 - Pipeline for Validity Assessment and Processing.

RESULTS

Without any preconditions, our system reached an accuracy of 89.7%. We then calculated with iteratively decreasing impact based on the delay of the respective information. With the application of reduced certainty within the system, we reached an accuracy of 94.8%.

DISCUSSION AND CONCLUSION

Individual information entities are evaluated by the time between the performed diagnostic procedure and point at which the information is used, e.g. calculations in a decision support system. We used retrospectively calculated medians as thresholds beyond which patient data are no longer completely reliable compared to more up-to-date information entities. Unfortunately, there are no clinical guidelines or medical knowledge to denote thresholds for the topicality of clinical information. We extended our therapy decision support system with additional functionalities that assess the validity of the clinical information from the electronic patient records. The interpretation of information validity is implemented as Arden Syntax Medical Logic Modules. This system of intelligent agents acts as an interface between the clinical data base and the decision support system and preprocesses the data in an appropriate way.

PROJECT TEAM

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SELECTED PUBLICATIONS

Gaebel J, Cypko MA, Oeltze-Jafra S. Towards the Consideration of Diagnostic Delay in Model-Based Clinical Decision Support. 16th World Congress on Medical and Health Informatics (MedInfo2017), Hangzhou, China, August 2017.

Gaebel J, Cypko MA, Oeltze-Jafra S. Considering Information Up-to-Dateness to Increase the Accuracy of Therapy Decision Support Systems. Stud Health Technol Inform. 2017; 243: 217-21.

FUNDING

German Federal Ministry of Education and Research (BMBF)

QUALITY MANAGEMENT OF THERAPY DECISION MODELS BASED ON MULTI-ENTITY BAYESIAN NETWORKS

INTRODUCTION

Clinical Decision Support Systems (CDSSs) based on Multi-entity Bayesian Networks (MEBNs) should assist clinicians, staff, and patients in finding the optimal patient-specific treatment decision. They should be (1) based on the best available knowledge, (2) highly adopted to a clinic's situation and population for a most effective use, and (3) continuously improved with new knowledge and decision supporting methods. Therefore, a clinical long-term maintenance of a CDSS, a MEBN model validation and modification (V&M) management is essential.

MATERIAL AND METHODS

Frequent model V&M based on new guideline recommendations as well as adjustments to clinic-specific populations must be supported. To avoid redundant model updates, as well as uncontrolled strong deviations from guidelines, this approach needs multiple levels of controlling authorities. Aiming for a full clinical integration of a MEBN-based CDSS with necessary access to engines and repositories (e.g. for validation, computing, and visualization), as well as model and data communication between institutions, a Therapy Imaging and Model Management System (TIMMS)-like communication architecture is required. Finally, a report system with modeler notification is essential for a transparent and reproducible error and update handling.

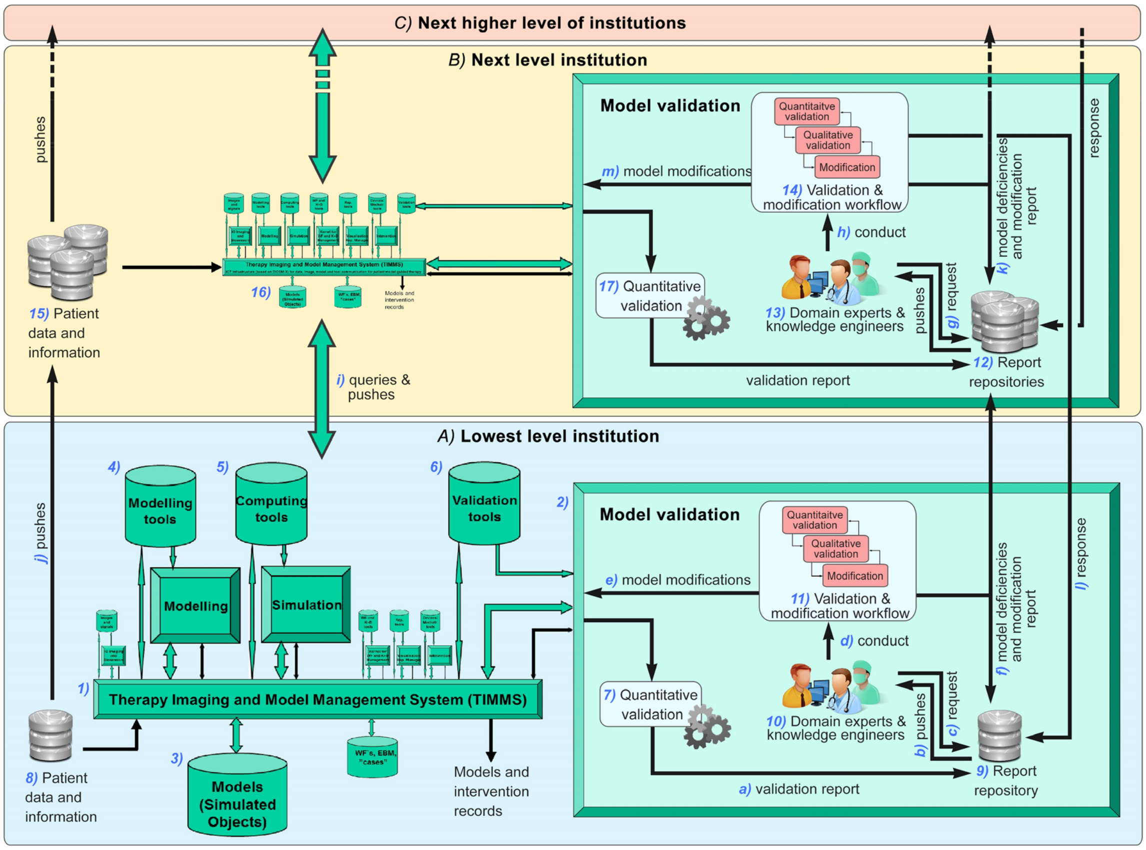

Fig. 1 - Concept for a multi-level quality management of clinical MEBN decision models. This concept is based on the TIMMS-architecture and a V&M workflow.

RESULTS

The concept for quality management of CDSS is 1) built on the TIMMS-architecture and 2) describes the V&M management over three institutional levels (Fig. 1). The lowest institutional level performs decision support and is responsible for a regular local quality management (e.g. private practice and hospital). The higher institutions are representing superior authorities (e.g. national and international governmental bodies) with a commission for data collection and quality control of lower level institutions. For V&M, each institutional level consists of a patient data repository, a TIMMS, engines for regular, automatic quantitative validations, and an expert team (domain experts and knowledge engineers) for a model V&M process.

DISCUSSION AND CONCLUSION

A current weakness of this concept is the required inter-institutional data exchange policies. Taking into account that these boundaries will mainly disappear, this architecture allows lower level institutions for patient-specific decision support by requesting models from the patient population. Furthermore, higher level institutions will be able to study and develop model-based medical evidence.

PROJECT TEAM

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SELECTED PUBLICATIONS

Cypko MA, Oeltze-Jafra S, Stoehr M, Dietz A, Lemke HU. Quality Management of Therapy Decision Models based on Multi-Entity Bayesian Networks. Int J Comput Assist Radiol Surg. 2017; 12(Suppl 1).

Cypko MA, Stoehr M, Kozniewski M, Druzdzel MJ, Dietz A, Berliner L, Lemke HU. Validation workflow for a clinical Bayesian network model in multidisciplinary decision making in head and neck oncology treatment. International Journal of Computer Assisted Radiology and Surgery, 2017; 12(11): 1959-70.

FUNDING

German Federal Ministry of Education and Research (BMBF)

MODULAR INFRASTRUCTURE FOR PROBABILISTIC PATIENT MODELS IN CANCER THERAPY

INTRODUCTION

Computerized decision models based on Bayesian Networks promise to be a valuable addition to personalized medicine. Clinical decision support systems (CDSS) using these models can evaluate complex diseases, such as cancer, and propose different suitable treatments. Their calculations must be based on routinely recorded patient data. Working with these systems must be associated with little to no additional efforts for the physicians. To be fully integrated into the physicians' workflow, CDSS must also interlink smoothly with hospital information systems.

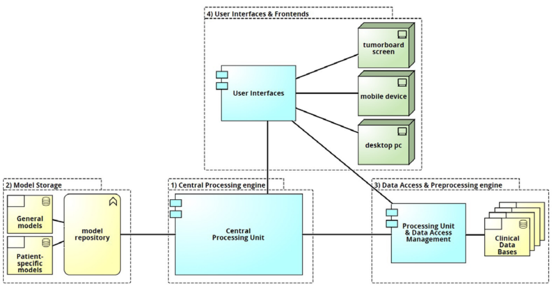

Fig. 1 - The four core components of the model-based decision support system.

MATERIAL AND METHODS

We built a modular decision support system using web services to connect the different modules with the underlying information system. The four modules are: 1) a central processing unit containing methods from artificial intelligence to process the patient's status, 2) a model repository for storage and revision control of the patient specific decision models, 3) a data access unit connecting to several clinical data bases and 4) a connector to different user interfaces to provide the results in a suitable form (Fig. 1).

Fig. 2 - Integrating model-based decision support into clinical daily routine.

RESULTS

We prototypically implemented our infrastructure with a decision model for laryngeal cancer. Patient data is provided by a relational data base. The processing and therapy calculation is realized by a server based implementation of the SMILE engine (a framework for processing Bayesian Networks). Different model types are stored in a file-based MongoDB. Results, e.g. TNM-staging and personalized treatment options, are presented via dedicated web applications.

DISCUSSION AND CONCLUSION

This modular infrastructure allows for exchanging individual modules. For instance, the same processing unit could be connected to a different clinical data base. This is especially important when translating this kind of specific decision support to clinical practice, since different clinics use different information systems. Calculated results on the other hand might be presented in another user interface, e.g. on a mobile device depending on the clinical setting.

PROJECT TEAM

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FUNDING

German Federal Ministry of Education and Research (BMBF)

CROSS-ENTERPRISE MODEL SHARING

INTRODUCTION

Sharing data across work stations, wards and healthcare enterprises is crucial for treatment efficiency and success. The IHE profile "Cross-Enterprise document sharing" (XDS) provides a standards-based specification for sharing clinical documents between healthcare enterprises. Documents are uploaded into federated document repositories. Additionally, metadata and the repository of each document are stored in a registry to provide a quick access without the need for a time-consuming search ranging over all available repositories.

For this, XDS supports all kinds of documents that are bound to a specific patient. Thus, documents, which are not linked with a specific patient, cannot be shared via XDS. Nevertheless, there are plenty of patient-independent documents, which are worth sharing for a greater benefit. These are for instance surgical process models, treatment guidelines or study data.

MATERIAL AND METHODS

To resolve this discrepancy, ICCAS aims to develop a generalized data model within a new integration profile named Cross-Enterprise Model Sharing (XMS). XMS covers all kinds of clinical documents, irrespectively whether they are bound to a specific patient or not. Within the scope of a requirements analysis, document types available in medicine were identified and examined. All documents can be classified into four categories: segmentation models, workflow models, patient models and other. Each category contains patient-specific as well as patient-independent document types. (Fig. 1)

RESULTS

XMS is based on the XDS architecture but expands its potential by stripping off limitations. A model source (e.g. a physician) provides new documents by registering and uploading them into a repository. The new documents are registered in the registry and can now be queried by model consumers. In case of patient-specific documents, the patient identity source identifies the according patient. When retrieving a document, a model consumer will query the registry for a required document. The registry provides the model consumer with information about the documents storage repository and other metadata. Subsequently, the model consumer is capable of retrieving the required document directly by using the information provided by the registry. (Fig. 2)

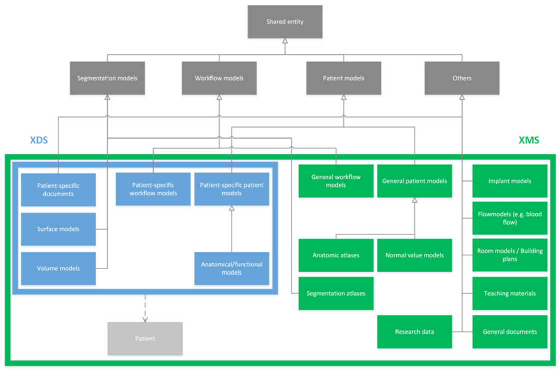

Fig. 1 - Overview of specific and abstract document types in medicine. While IHE XDS includes only patient-specific documents (blue), XMS can handle additionally patient-independent documents (green) as well.

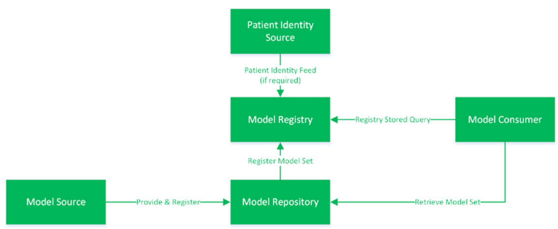

Fig. 2 - Scheme of all XMS actors and transactions. The Patient Identity Source is only required when handling patient-specific document types.

A XMS registry contains entries referencing documents in a repository. New entries can be submitted by a repository as single entry or in a submission set together with other entries. Entries may be associated with one or more folders to group them. Furthermore, each entry belongs to a clinical affinity domain (e.g. a specific hospital) and may reference a specific patient.

DISCUSSION AND CONCLUSION

Hence, XMS systems allow to share all kinds of clinical documents between work stations, wards or healthcare enterprises as well as communicating patient-specific data with XDS-compliant systems.

PROJECT TEAM

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Prof. Dr. Thomas Neumuth

FUNDING

German Federal Ministry of Education and Research (BMBF)

DEVELOPMENT OF A PATIENT-SPECIFIC DASHBOARD APPLICATION FOR DECISION-MAKING IN ONCOLOGY

INTRODUCTION

Decision-making in oncology involves an interdisciplinary review of the medical case by experts from different medical domains. This procedure is realized in a collaborative meeting – the tumor board. Although the different participants share the overall goal of finding the best possible therapy for each individual patient, their viewpoints on the case can be substantially different. While some physicians might know the respective patient in person from prior examination during anamnesis, others might base their decision making only on radiological or pathological data. Since the best therapeutic option involves the effective treatment of the tumor as well as a preferably high posterior quality of life, the foundation of the decision-making process needs to include a comprehensive overview of the case for all participants. This can be achieved by an integrated, consolidated view on all aspects of the patient as well as the associated disease in order to provide an equal information base.

MATERIAL AND METHODS

Our specialized dashboard application includes multiple views that provide a patient-specific overview of the case as well as detailed information in additional front-end components. The basic interface is separated into five parts, each presenting different information clusters.

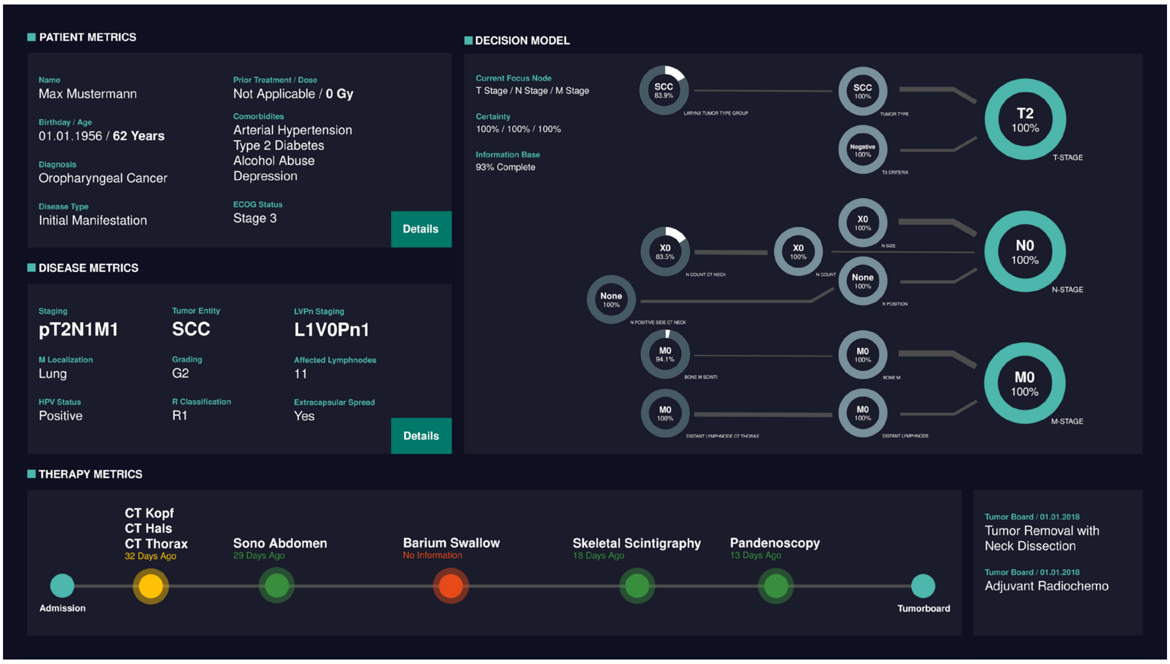

Fig. 1 - Patient-specific dashboard supporting the therapy decision making process in a tumor board.

Patient inspector

The patient inspector provides information about the patients' administrative data, his profession, overall health status as well as individual preferences for the therapy.

Information quality metrics (ICM)

The ICM module displays individual ratings for the available information at the time of the scheduled tumor board meeting. It provides instant feedback in order to unveil missing or outdated information.

Therapy timeline

This module features a timeline-based view of all the prior procedures as well as their findings. It features structured metrics, annotations as well as image data.

TNM-Staging

Pathological examinations are crucial in order to gain certainty about the TNM-staging of the patient. The corresponding module features all relevant information about the histopathological results.

Decision model

The decision model based on the works of Cypko et al. offers a calculated probabilistic assessment of the available treatment options, tailor-made for the respective case. It features an intuitive visualization of the underlying Bayesian network as well as a separated view on the causality of the models' decision-making process. In this way, deviations in the preferred therapeutic option of the model and the experts can be examined in an optimized and graphical way.

PROJECT TEAM

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FUNDING

German Federal Ministry of Education and Research (BMBF)

COMBINING STOCHASTIC AND KNOWLEDGE-BASED MODELING FOR THERAPY PROCESSES MODELS

MOTIVATION

The formal modeling of diagnosis and treatment procedures gains increasing interest in the frame of model-guided therapy. Although semi-formal models and guidelines proposed by the clinical societies emerged over the years, there is yet a lack of methods, which allow to directly incorporate formally modeled clinical knowledge into stochastic models of these diagnosis and treatment procedures. A comprehensive patient-specific model of the therapy would enable a broad set of assistance application in clinics. Among these applications are an efficient resource planning, a data-driven outlier detection, situation- and patient-specific treatment summaries as well as data visualization. The pituitary adenoma treatment is an interesting clinical use case for such applications, especially due to the complexity of the therapy and the long-lasting follow-up.

SOLUTION

In the Digital Patient and Process Modeling group, we are developing methods to model the therapy process, which combine stochastic modeling approaches with knowledge-based decision support. As a starting point, stochastic models of therapy steps and patients' states are generated from training data. Thus, the foundation of the proposed novel modeling strategy is a stochastic, Hidden Markov-based model that covers the potential therapy courses. Transitions between the states of these models are often characterized by clinical decisions, which are primarily based on clinical knowledge and patient-specific data. We propose knowledge-based decision models of various types, including logic modules. As the requirements on the modeling of those decision points highly differ, an agent-based concept with decision specific modules is proposed. By means of that, context-aware applications can be triggered and will profit from a comprehensive modeling of therapy procedures.

PROJECT TEAM

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FUNDING

German Federal Ministry of Education and Research (BMBF)

INTERACTIVE VISUALIZATION OF FUNCTIONAL ASPECTS IN HEAD AND NECK CANCER AFTERCARE

INTRODUCTION

The treatment of Head and Neck Cancer leads to impairment of multiple functional aspects in patients' lives, such as pain level, quality of life, and depression. To find the best aftercare for each patient, not only the health conditions, but also the functional aspects need to be considered. For their recording, the physicians of the Clinic of Otolaryngology, Head and Neck Surgery at the University of Leipzig conduct a voluntary, questionnaire-based interview before each patient consultation. The answers are then evaluated and presented to the physician during the consultation. This visualization shows only the current state of the patient's functional aspects. It neither conveys the aspects' development over the years and consultations nor the aspects of other patients for a comparative evaluation.

MATERIAL AND METHODS

We have developed a web-based interactive visualization of the functional aspects during the years of follow-up and consultations. Our presentation is inspired by Parallel Sets, Sankey diagrams and Cartesian diagrams. The visualiza-

Fig. 1 - The developed interactive visualization of the individual patient over years of follow-up in comparison with all patients. A set of filters allows for further refinement of the comparison group.

tion shows the value for functional aspects per consultation and the arranged measurements. Through interaction methods, the number of patients per year of follow-up for each threshold are presented. Icons with the look of faces give a threshold-based, simplified overview of all patient answers. The rehabilitation of patients is illustrated through arcs between the years. Multiple interaction methods, e.g. filter methods and selection of patient groups, are provided for visual analysis.

RESULTS

Our interactive visualization depicts the development of functional aspects of patients over time and provides different interaction methods for visual analysis. Furthermore, an improved presentation of the doctor's view has been developed.

DISCUSSION AND CONCLUSION

This work allows the physician to study the development of an individual patient in comparison with others while supporting filters. The aim of this presentation is to estimate a patient's most probable prognosis through looking at patients with comparable developments and to adapt the aftercare in case of a bad forecast.
In coordination with physicians, it was decided to depict the follow-ups for three years after therapy. Through the course of the questionnaire, this range can be extended.

PROJECT TEAM

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SELECTED PUBLICATIONS

Müller J, Zebralla V, Wiegand S, Oeltze-Jafra S. Interactive Visualization of Functional Aspects in Head and Neck Cancer Aftercare. 7th Visual Analytics in Healthcare (VAHC); Phoenix, AZ, USA; 2017.

VISUAL VERIFICATION OF BAYESIAN NETWORKS – REQUIREMENTS AND VISUALIZATION METHODS

INTRODUCTION

Bayesian networks are employed in biomedicine and healthcare for diagnostic and prognostic reasoning, treatment selection, and discovering functional interactions among components of a system. They are frequently learned from huge data collections generated and maintained in both domains. While sophisticated learning techniques exist, a validation of the resulting networks by domain experts is indispensable, e.g. to identify causalities among the learned dependencies and remove wrong dependencies resulting from data quality issues. The experts verify 1) how the network operates and 2) what the network produces. Different information need to be highlighted in this course.

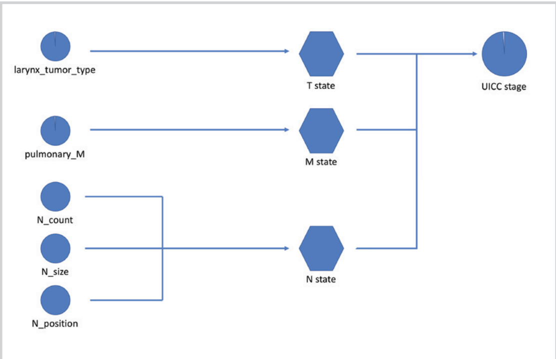

Fig. 1 - Causality flow presentation of TNM-classification for laryngeal cancer. Glyphs are used as node presentation.

MATERIAL AND METHODS

We first defined the requirements on the visualization of Bayesian networks based on our own experience and a literature review. Then, we comparatively assessed multipe visual presentations regarding these requirements.

RESULTS

As a result, we have identified the causality flow presentation as the best fit for presenting the general structure and node relations of the generated Bayesian network (Fig. 1). The presentation of the node states can be accomplished through glyphs. Colormaps and table views in a linked view could be used for presenting the Conditional Probability Tables (CPT).

DISCUSSION AND CONCLUSION

We compared the causality flow and force-directed layout algorithm for their suitability to present Bayesian networks for validation. Because of the pleasant and symmetrical structure as well as the familiarity, the force-directed presentation would be a good choice. However, because of the missing presentation of causal semantics and domain specific knowledge, the causality flow is the preferred visualization. Furthermore, there are still problems to be solved, e.g. the presentation of large BNs and large CPTs, the visual comparison of BNs generated through different learning algorithms, the visual presentation of time-dependent changes in networks, and the usage of consideration of previous domain experts' modifications in current modeling tasks. In the future, these problems could be addressed as well as additional use cases and the related requirements could be collected through structured interviews.

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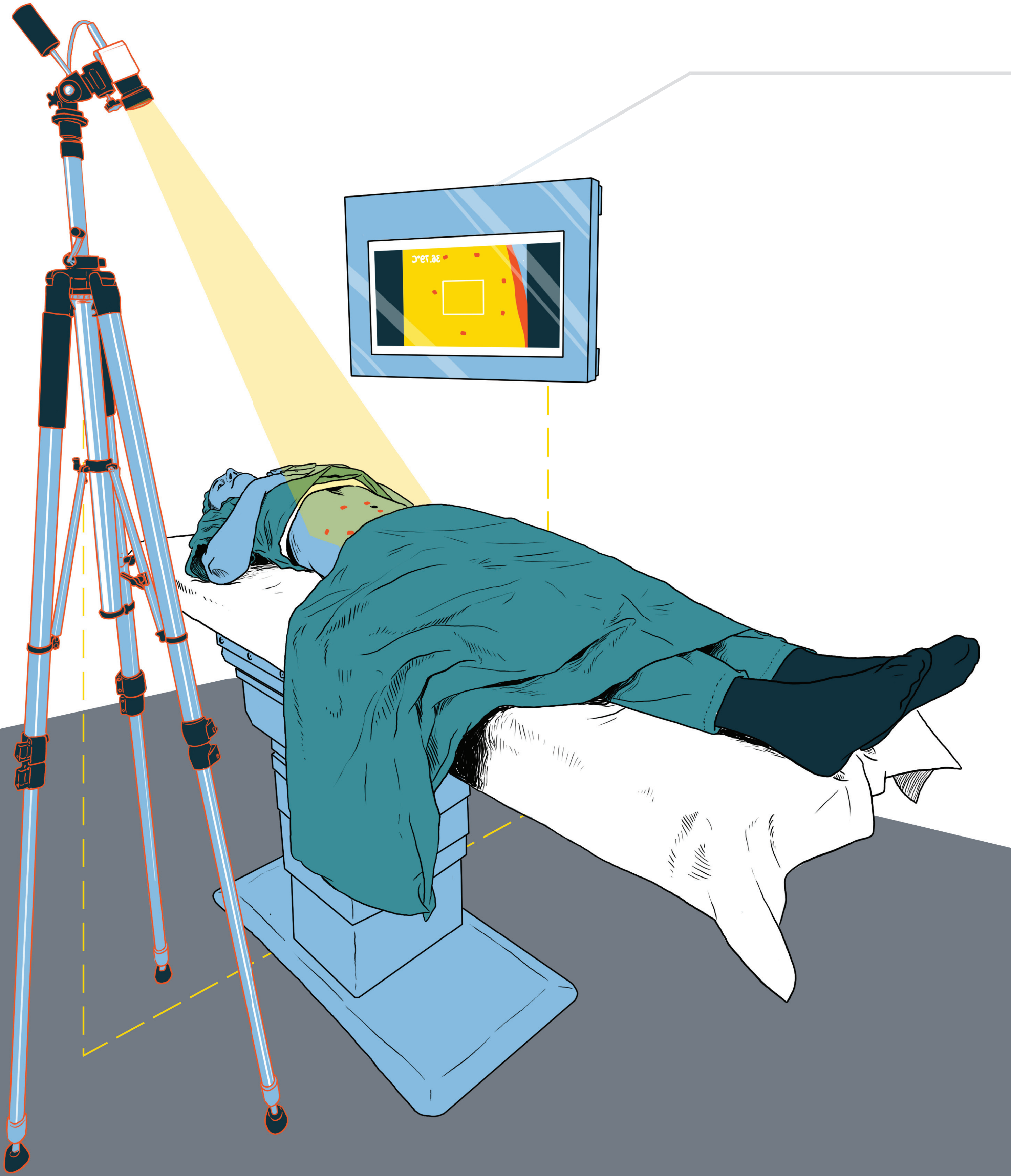
FUNDING

German Federal Ministry of Education and Research (BMBF)



INTRAOPERATIVE MULTIMODAL IMAGING

'The development of new imaging methods which are minimally or non-invasive is crucial to support the surgeon in the assessment of the success of the surgical intervention still in the operation room. This can significantly reduce postoperative complications for patients and therefore improve the outcomes of the operation while being safety for patients and clinical staff.'

Dr. Claire Chalopin
(group leader)

SCIENTIFIC STAFF

Michael Unger, Jesús Guillermo Cabal Aragón, Marianne Maktabi, Claire Chalopin (group leader), Norbert Lang, Hannes Köhler (f.l.t.r.)

SELECTED PUBLICATIONS

Ilunga-Mbuyamba E, Lindner D, Avina-Cervantes JG, Arlt F, Rostro-Gonzales H, Cruz-Aceves I, Chalopin C. Fusion of intraoperative 3D B-mode and contrast-enhanced ultra-sound data for automatic identification of residual brain tumors. Appl Sci. 2017; 7(4): 415.

Chalopin C, Ilunga Mbuyamba E, Cabal Aragon JG, Camacho Rodriguez JC, Arlt F, et al. Application of Image Processing Functions for Brain Tumor Enhancement in Intraoperative Ultrasound Image Data. 7th Eurographics Workshop on Visual Computing for Biology and Medicine (VCBM). Bremen, Germany; 2017.

Maktabi M, Chalopin C, Wahl P, Neumuth T. Measurement of Moisture at Skin Surface Based on Hyperspectral Technology. Jahrestagung der Biomedizinischen Technik und Dreiländertagung der Medizinischen Physik (BMT). Dresden, Germany; 2017.

SOFTWARE TOOL FOR THE SEMI-AUTOMATIC SEGMENTATION OF BRAIN TUMOR IN PREOPERATIVE MR DATA

INTRODUCTION

The planning of brain tumor operations is performed based on preoperative image data of patients which are acquired in the previous days of the surgery. The generation and visualization of a 3D patient specific model of the clinically relevant brain structures would support the surgeon in the planning step. In this project, a software tool for the segmentation of brain tumors was implemented.

MATERIAL AND METHODS

The segmentation of the brain tumor is performed in four steps. (1) The user delineates in a couple of slices of a selected view, for example the axial view, the tumor borders. The slices are interpolated to generate a 3D model (Fig. 1). New contours can be interactively added to refine the result. (2) Contour active methods are optionally used to automatically fit the model contours to the image intensities in order to improve the manual step. (3) The obtained 3D model can be overlapped in the other views, for example the coronal and sagittal views, to be still improved. In this case, the final 3D model is the merging of the different models in the different views. (4) The final model is exported as a mesh and visualized in the planning software of the navigation system (Fig. 2).

RESULTS

This semi-automatic approach enables to generate in short time and in a robust way a 3D patient specific model of brain tumor. The model can be imported in the navigation system during brain tumor operations. The goal is the enhancement of the visualization of the tumor margins, especially in the case of brain tumors of complex shapes and because the navigation system is often positioned far away from the surgeon.

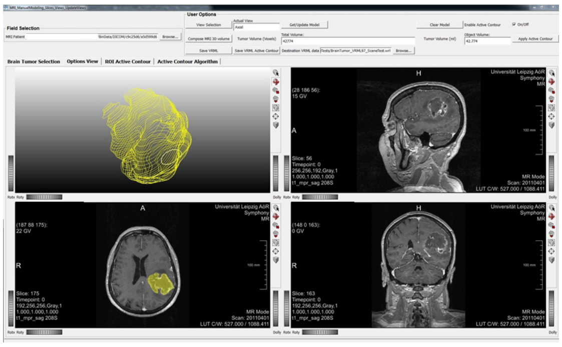


Fig. 1 - Interface of the segmentation tool implemented with MeVisLab. The brain tumor boundary was manually delineated in a couple of slices in the axial view of the preoperative MR data (lower left panel). A 3D tumor model was generated by interpolating the contours between the slices (yellow contours in the upper left panel).

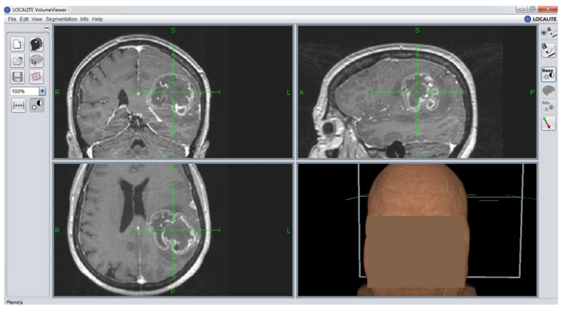


Fig. 2 - Importation of the segmented brain tumor from the planning software interface of the company Localite and visualization as contours.

DISCUSSION AND CONCLUSION

Next step in this project is the development of further tools to segment additional risk structures like the blood vessels and the ventricles to generate a complete patient model.

PROJECT TEAM

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PROJECT PARTNERS

Dipl.-Ing. Sven Arnold, Localite GmbH

FUNDING

German Federal Ministry for Economic Affairs and Energy (BMWi)

National Council on Science and Technology (CONACyT) of Mexico

AUDITORY FEEDBACK SYSTEM FOR INTRAOPERATIVE NAVIGATION DURING CRANIOTOMY IN NEUROSURGERY

INTRODUCTION

Digital intraoperative navigation systems are crucial devices to support neurosurgical interventions nowadays, especially for the intraoperative planning of the craniotomy. Besides the technical improvements in radiological imaging, there is also space for developing new assisted guidance systems. The use of auditory display as a complementary feedback system beneath the traditional only-visual monitor of the navigation system would create opportunities to improve ergonomic, concentration and self-assured working of the surgeon.

MATERIAL AND METHODS

Because the auditory feedback system needs additional parameters regarding the traditional navigation system, a new tool is implemented using MeVisLab from the Fraunhofer MeVis to fulfill the specified requirements. Beneath the measurement of the distance of the surgical instruments to the given target structure, for example the tumor, it provides the functionality to project the contour of tumors or other segmented intracranial structures to an outer surface like the cranium or skin depending on the current position of the pointer. The projected contour is intended to be used as a section line and therefor as reference for the audio feedback system (Fig. 1). The goal is to indicate to the surgeon using an audio signal the distance of the pointer to the reference projected contour.

RESULTS

A prepared head phantom is used to evaluate the system during the intraoperative planning of the section line, the simulated cut of skin and bone, and finally the navigation towards the target tissue (Fig. 2).

DISCUSSION AND CONCLUSION

Due to the current state of development no evaluation is done yet, but taking previous research into account, the surgeon will benefit from better ergonomics and self-confidence regarding the additional auditory feedback. The

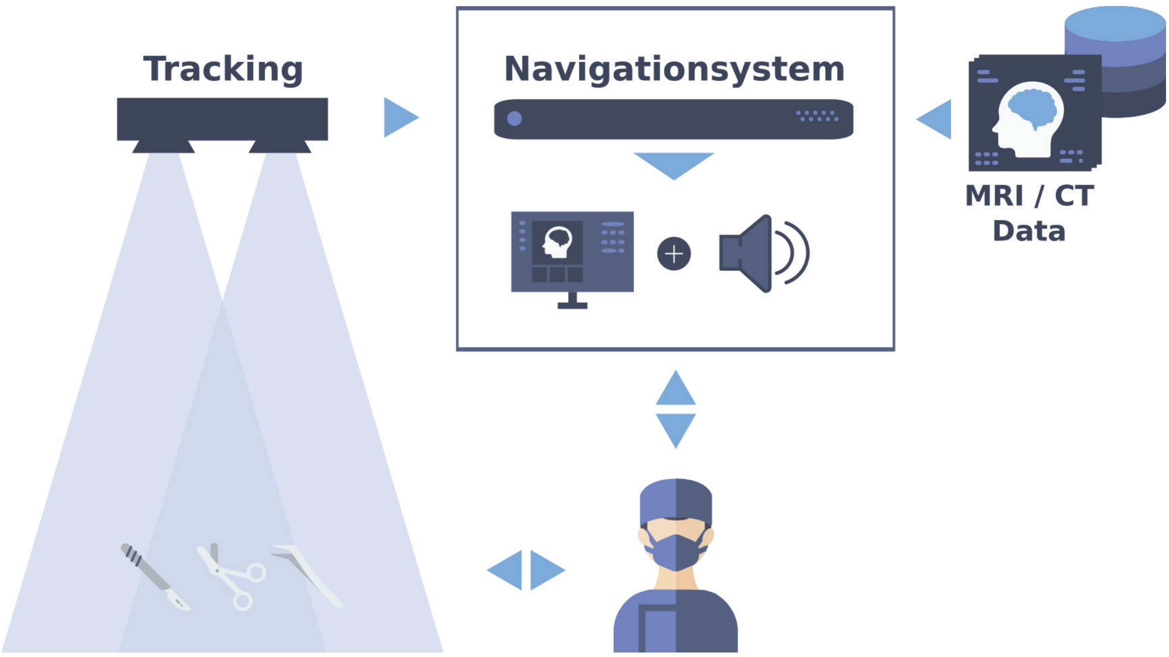

Fig. 1 - Description of the hardware components of the system: (1) the navigation system enables to track the instruments (left); (2) the developed software (middle) includes a tool for suggesting a position for the craniotomy section line based on the preoperative MR data (right) and a sonification tool to support the surgeon in the execution of the craniotomy.

development of the auditory display is based on the sparse field of previous research done regarding sonification in the medical context. So it could serve for another steps towards multiple perceptualization in intraoperative navigation.

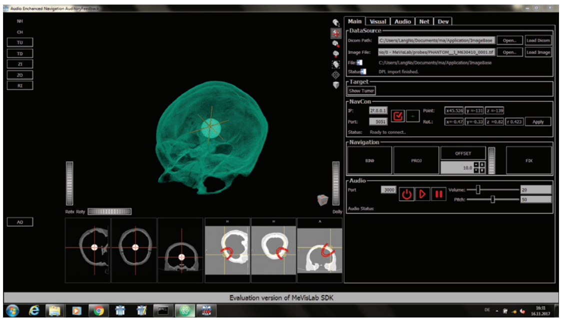

Fig. 2 - Screenshot of the planning step performed by the developed software tool. A model of skull and brain tumor is depicted in green. The surgeon indicates with the pointer (yellow cross) the optimal angle to reach the tumor. Then, the tumor is projected on the skull (small images on the lowest part of the screen). The projection is used to suggest a position for the craniotomy section line.

PROJECT TEAM

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IMAGE BASED CONNECTOR FOR THE AUTOMATIC CONFIGURATION OF 3D ULTRASOUND DATA ACQUISITION

INTRODUCTION

The use of intraoperative ultrasound (iUS) imaging supports the neurosurgeon in the identification of tumor tissue during brain tumor operations. Especially 3D image data provides a complete overview of the surgical field. The commercial SonoNavigator product (Localite GmbH) includes a navigation system connected to an ultrasound device and performs the reconstruction of 3D iUS data based on 2D iUS images. The reconstruction step requires the manual selection of the corresponding calibration files which depend on US parameters. The goal of this project is the automatic identification of the parameter values in the US image data for the automatic selection of the calibration data file.

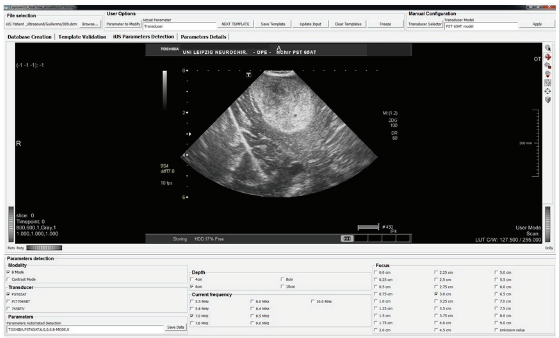

Fig. 1 - MeVisLab tool for the automatic recognition of US parameters in intraoperative US images.

MATERIAL AND METHODS

An image based connector was implemented with MeVisLab on a laptop connected through a grabber to the US device. The tool performs a matching between the life iUS image and a data base of image templates including the different US parameters that have to be automatically recognized. The template with the highest correlation score is returned to the user as the identified US parameter. Moreover, the tool is able to identify non appropriate configuration of US parameters. Finally, the known parameters are sent to the navigation system for the future selection of the corresponding calibration data.

RESULTS

The image base connector identifies the following US parameters: US device model, transducer name, image depth and focus, modality, current used frequency, image shape and orientation (Fig. 1). The tool was tested on 47 US images with different configurations acquired during 43 brain tumor operations of patients. The different recognition scores were obtained: US device model, transducer, frequency and modality 100%; depth 71.42%, focus 67.34%.

DISCUSSION AND CONCLUSION

The main limitation of the tool is the need to create new database of templates for each different US device. However, since the US parameters are not directly provided by the vendors, this method showed to be robust. Such automatic tool is needed to reduce the user machine interaction and increase the safety of the use of US imaging in neurosurgery.

PROJECT TEAM

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Dipl.-Ing Sven Arnold

FUNDING

National Council on Science and Technology (CONACyT) of Mexico

PATIENT SPECIFIC MODEL BASED SEGMENTATION OF BRAIN TUMORS IN 3D INTRAOPERATIVE ULTRASOUND IMAGES

INTRODUCTION

Intraoperative ultrasound (iUS) imaging is commonly used to support brain tumor operation. The success of automatic methods to extract the tumor in the iUS image is limited due to high noise sensibility. Therefore, an alternative brain tumor segmentation method in 3D-iUS data using a tumor model obtained from magnetic resonance (MR) data for local MR-iUS registration is presented in this paper. The aim is to enhance the visualization of the brain tumor contours in iUS.

MATERIAL AND METHODS

A multi-step approach is proposed (Fig. 1). First, a region of interest (ROI) based on the specific patient tumor model is defined. Second, hyperechogenic structures, mainly tumor tissues, are extracted from the ROI of both modalities by using automatic thresholding techniques. Third, the registration is performed over the extracted binary sub-volumes using similarity measure involving gradient values and rigid and affine transformations. Finally, the tumor model is aligned with the 3D-iUS data and its contours are represented.

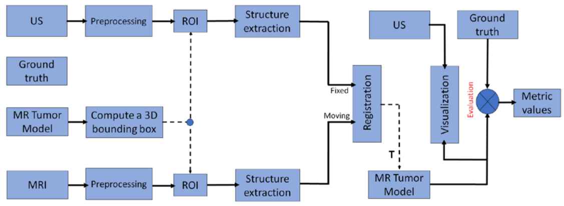

Fig. 1 - Automatic tumor segmentation approach in iUS. A preprocessing step including image filtering and histogram stretching are performed to improve the image quality. The segmentation method consists of using a tumor model obtained by semi-automatic segmentation of brain tumor in the preoperative MR data. A region of interest is automatically defined based on the tumor model and is applied on the MR and 3D-iUS data to extract sub-volumes. A registration process is then performed between binary structures extracted from the MR and iUS sub-volumes using the Otsu multilevel thresholding technique. Finally, the obtained transformation matrix T is applied on the tumor model to align it with the tumor in the 3D-iUS data.

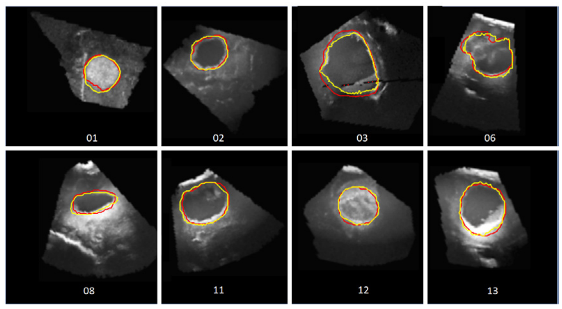

Fig. 2 - Automatic segmentation of brain tumor metastasis in eight 3D-iUS patient data. The ground truth is depicted in yellow and the obtained result in red. The tumor models are well aligned with the ground truths. Hence the tumor borders in iUS are enhanced. Moreover, in case of artifacts at the bottom of the tumor (patients 08 and 13) the registered model is able to suggest a plausible position to the real tumor boundary.

RESULTS

Experiments were conducted on 3D-iUS datasets (B-mode) of 33 patients with metastasis (Fig. 2) and glioblastomas. The method was evaluated by comparing the automatic segmentation with manual delineations using the contour mean distance (CMD) and Dice (D) index. The mean D values were measured before and after registration. The results for the metastasis were Dbefore = 0.6767±0.129, Dafter,rigid = 0.8051±0.071, Dafter,affine = 0.8189±0.066 and for the glioblastomas Dbefore = 0.6466±0.156, Dafter,rigid = 0.7659±0.094, Dafter,affine = 0.7602±0.140. The CMD mean values after rigid registration was 1.7±0.7 mm for the metastasis and 2.3±1.4 mm for the glioblastomas.

DISCUSSION AND CONCLUSION

The method is consistent with the use in the operating room regarding the limited interaction. The benefit of the affine transform in the registration method is only local and the process is more time consuming. The main advantage of the tumor model is the ability to locally supplement missing boundary information especially in the presence of image artifacts or in the case of glioblastomas whose margins can be unclearly represented in B-mode.

PROJECT TEAM

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SELECTED PUBLICATIONS

Chalopin C, Ilunga Mbuyamba E, Cabal Aragón JG, Camacho Rodriguez JC, Arlt F, Avina Cervantes JG, Meixensberger J, Lindner D. Application of Image Processing Functions for Brain Tumor Enhancement in Intraoperative Ultrasound Image Data. Eurographics Workshop on Visual Computing for Biology and Medicine (2017), pp. 1-9, S. Bruckner, A. Hennemuth, and B. Kainz (Editors).

FUNDING

National Council on Science and Technology (CONACyT) of Mexico

INFRARED THERMOGRAPHY SYSTEM FOR AUTOMATIC DETECTION OF SKIN PERFORATORS

INTRODUCTION

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

MATERIAL AND METHODS

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

RESULTS

Seven skin regions, typically used for transplants, of 20 participants were statically acquired in a pilot study conducted by our clinical partners. The algorithms were tested on the thermal images using different parameter values and compared with manual annotations. Preliminary results show a median true positive

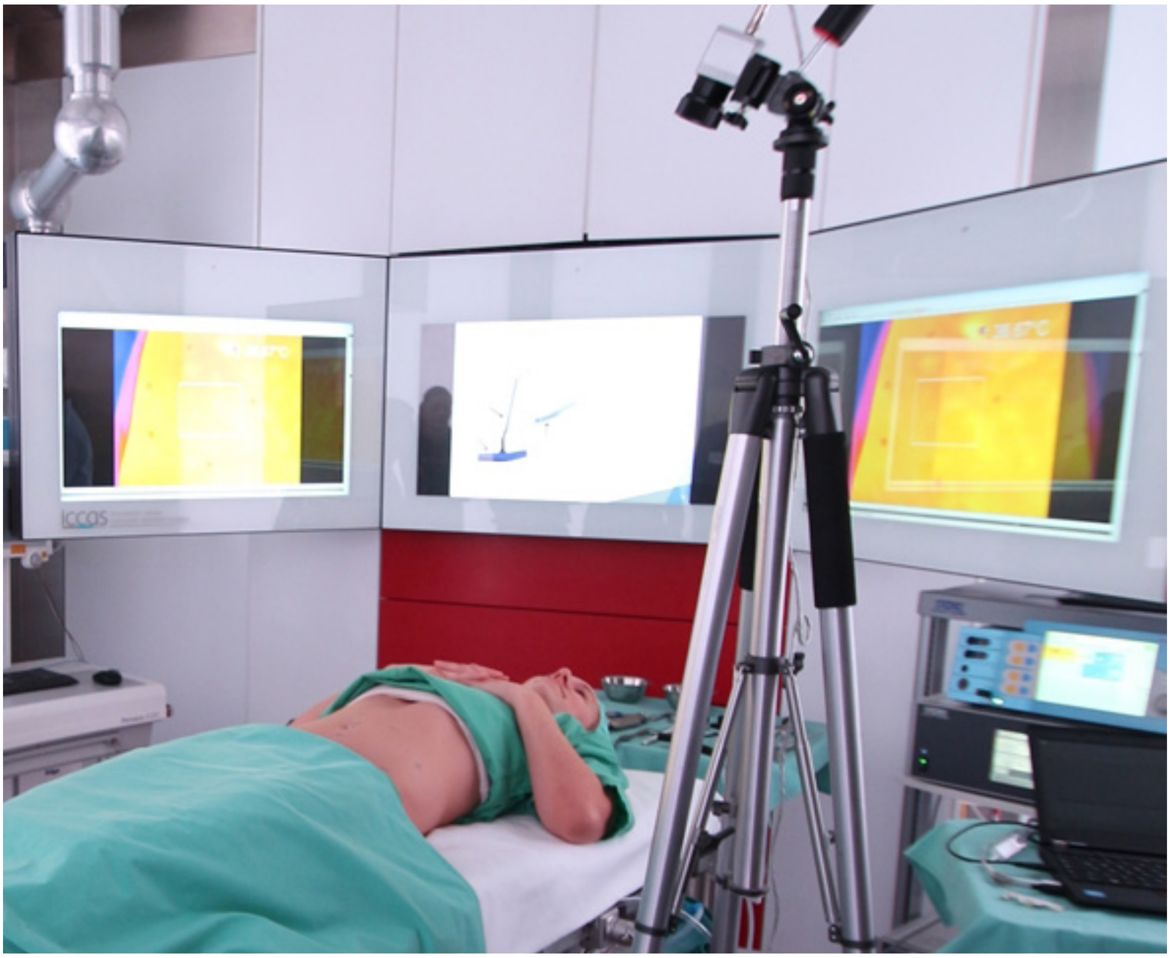

Fig. 1 - Experimental setup in the OR.

rate of 89 percent and a median F1 score of 91 percent.

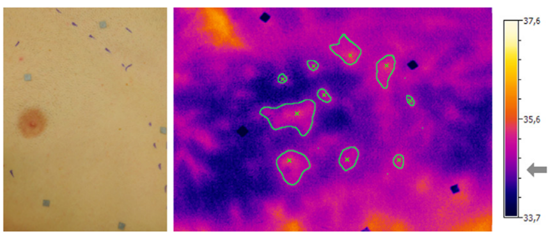

Fig. 2 - Detected perforator centers (cross) and the corresponding regions (contour) of the pectoralis flap.

DISCUSSION AND CONCLUSION

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

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FUNDING

German Federal Ministry for Economic Affairs and Energy (BMWi)

DYNAMIC INFRARED THERMOGRAPHY (DIRT) FOR ASSESSMENT OF SKIN BLOOD PERFUSION IN CRANIOPLASTY:

A Proof of Concept for Qualitative Comparison with the Standard Indocyanine Green Video Angiography (ICGA)

INTRODUCTION

Complications in wound healing after neurosurgical operations occur often due to scarred dehiscence with skin blood perfusion disturbance. The standard imaging method for intraoperative skin perfusion assessment is the invasive indocyanine green video angiography (ICGA). The noninvasive dynamic infrared thermography (DIRT) is a promising alternative modality that was evaluated by comparison with ICGA.

MATERIAL AND METHODS

DIRT data sets were acquired at the end of cranioplasty surgery of nine patients for which ICGA examination was planned. The skin was cooled using a glove filled with water. Visual and quantitative comparisons of both modalities were performed. For that, time-temperature curves (TTCs) in DIRT and time-intensity curves (TICs) in ICGA for defined regions of interest of the images (ROIS) (scare, regions near the scare, reference region) were analyzed. New perfusion parameters were defined in DIRT and compared with the usual perfusion parameters in ICGA (Fig. 1).

RESULTS

The visual observation of the image data in DIRT and ICGA showed that operation material, anatomical structures and skin perfusion are represented similarly in both modalities (Fig. 2). The visual observation of the TTCs and the analysis of the perfusion parameters in DIRT showed differences according to the ROIs and the patients although no complications were observed clinically. Especially the perfusion in the scare is lower than in the regions near to the scare and in the reference region. These variations could be explained by the use of suture material, the position of the ROI in the image, inhomogeneous skin cooling and the use of skull implant of different material. However, these differences were represented in DIRT and ICGA equivalently.

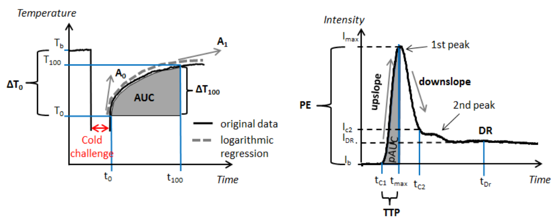

Fig. 1 - Left: time-temperature curve (TTC) in DIRT with perfusion parameters. Right: corrected time-intensity curve (cTIC) in ICGA and perfusion parameters.

DISCUSSION AND CONCLUSION

DIRT has shown a great potential for intraoperative use, with several advantages over ICGA. The technique is passive, contactless and non-invasive. The practicability of the intraoperative recording of the same operation field section

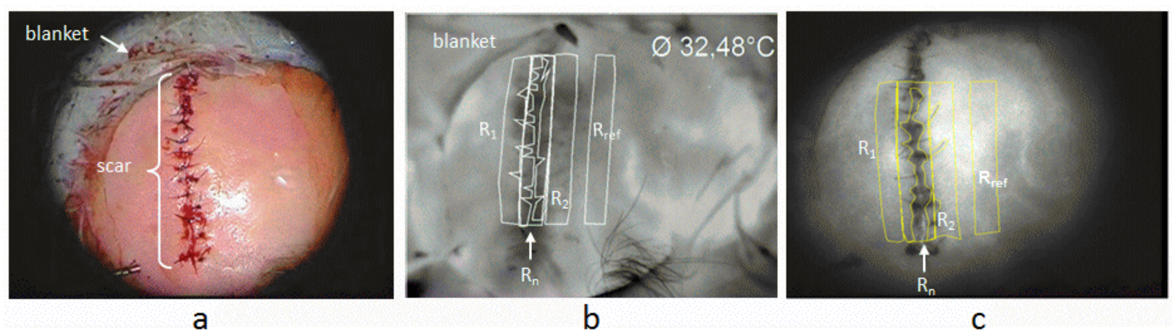

Fig. 2 - Operation field section in video (a), DIRT (b) and ICGA (c). Video: view of the skin in the operation field with the scar. DIRT and ICGA: grayscale images with ROIs.

with ICGA and DIRT has been demonstrated. The promising results of this proof of concept provide a basis for a trial with a larger number of patients.

PROJECT TEAM

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SELECTED PUBLICATIONS

Rathmann P, Chalopin C, Halama D, Giri P, Meixensberger J, Lindner D. Dynamic infrared thermography (DIRT) for assessment of skin blood perfusion in cranioplasty: a proof of concept for qualitative comparison to the standard indocyanine green video angiography (ICGA). Int J Comput Assist Radiol Surg.

MEASUREMENT OF MOISTURE AT SKIN SURFACE BASED ON HYPERSPECTRAL TECHNOLOGY

INTRODUCTION

Hyperspectral imaging (HSI) technology provides new opportunities to measure essential patient information to monitor patient state. Perfusion parameters like oxygen saturation and tissue haemoglobin concentration can be currently recorded. New parameters like tissue water index could provide additional information.

MATERIAL AND METHODS

In this work, the measurement of moisture at skin surface, for example at patient hand, using an HSI camera is considered. The system includes a spectrometer measuring light spectrum from 500 to 1000 nm (resolution: 5 nm) and a CMOS camera unit with a spatial resolution of 640 × 480 pixels per image. The illumination unit contains eight halogen lamps of 20W. In a small experiment, we measured the moisture volume of the forehead of one subject before and after five minutes of sport activity. The sweating was not visible but palpable.

RESULTS

Figure 1 left shows the mean absorbance spectra in a region of the forehead. The largest absorbance during sport activity can be explained by an increase of tissue perfusion especially well depicted by the double peak of hemoglobin in the range 500 to 600 nm (black arrow). The representation of the second derivative (right) shows the increase of water content at 960 nm in the near infrared range of the spectrum during sport activity (black arrow). Thus, a water index using information in the near infrared range could be calculated.

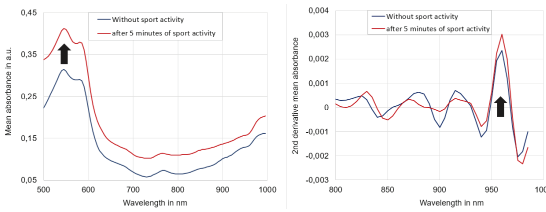

Fig. 1 - Mean absorbance spectra in visual and near infrared range measured on one subject before and during sport activity (left). The largest absorbance during sport activity can be explained by an increase of tissue perfusion. The representation of the second derivative (right) shows increase of water content at 960 nm during sport activity.

DISCUSSION AND CONCLUSION

Our results showed that sweating is measurable in the near infrared area before it is external visible. The quantitative monitoring of gustatory sweating patients could be a clinical application.

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SELECTED PUBLICATIONS

Maktabi M, Chalopin C, Wahl P, Neumuth T. Measurement of Moisture at Skin Surface based on Hyperspectral Technology. 51th Annual conference of the German Society for Biomedical Engineering (DGBMT); Biomed Tech (Berl). September 10-13 2017; Dresden, Germany, 62(1): 71-74.

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FUNDING

German Federal Ministry for Economic Affairs and Energy (BMWi)

HYPERSPECTRAL IMAGING OF GASTROINTESTINAL ANASTOMOSIS

INTRODUCTION

Anastomosis insufficiency (AI) remains a most feared surgical complication in gastrointestinal surgery, closely associated with a prolonged in-patient hospital stay and specific postoperative mortality. Hyperspectral imaging (HSI) is a relatively new medical imaging procedure that has proven itself promising in tissue identification, as well as in the analysis of tissue oxygenation and water content. Until now, no data exists on the in vivo hyperspectral analysis of gastrointestinal Anastomosis.

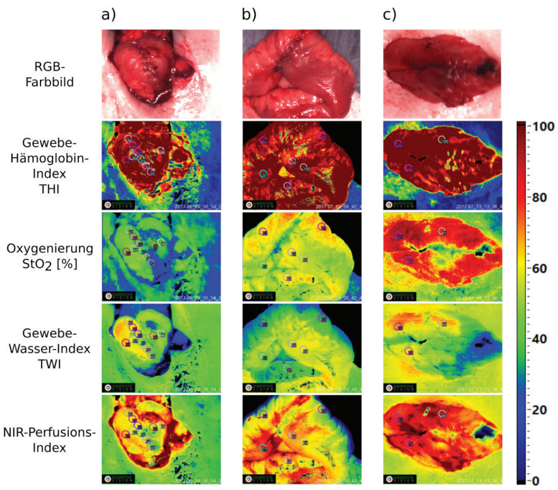

Fig. 1 - Parameters computed from the light spectra measured with hyperspectral imaging (HSI): tissue oxygenation (StO2), tissue water index (TWI), tissue hemoglobin index (THI) and near infrared (NIR) perfusion. Their values are coded and represented with colors.

MATERIAL AND METHODS

Intraoperative images were obtained using the TIVITA™ Tissue System hyperspectral imaging camera of Diaspective Vision GmbH (Pepelow, Germany). In 17 Patients who underwent gastrointestinal surgery with esophageal, gastric, or intestinal anastomosis, 92 images were generated. The parameters obtained at the site of anastomosis included tissue-oxygenation (StO2), tissue hemoglobin index (THI), Near-infrared (NIR) perfusion, and Tissue-Water-Index (TWI) (Figure 1).

RESULTS

Obtaining and analyzing intraoperative images with this non-invasive imaging system, proved practicable and delivered good results on a consistent basis. For example, the visualization of the images of HSI indexes showed different values, especially for tissue oxygenation, between patients with and without postoperative anastomosis insufficient (Figure 2).

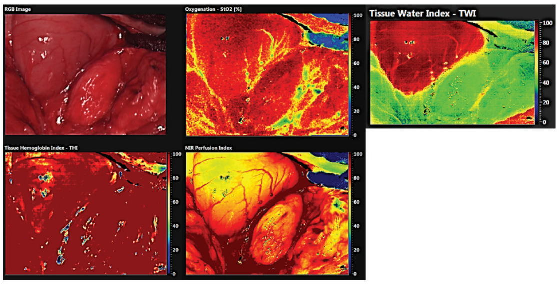

Fig. 2 - Images of HSI indexes for three patients with (a) and without (b and c) postoperative anastomosis insufficient. Values of tissue oxygenation index are especially lower in a than in b and c.

DISCUSSION AND CONCLUSION

HSI provides, without the use of a contrast medium, a non-contact, non-invasive, intraoperative imaging procedure, which allows a real-time analysis of physiological anastomosis parameters that may contribute to determining the “ideal” anastomosis region. In light of this, the establishment of this methodology in the field of visceral surgery, enabling the generation of norms or “Cut off” values for different gastrointestinal anastomosis types, is an obvious necessity.

PROJECT TEAM

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PROJECT PARTNER

Dr. Axel Kulcke | Diaspective Vision GmbH

TISSUE CHARACTERIZATION USING HYPERSPECTRAL IMAGING

INTRODUCTION

During thyroid surgery, it is sometimes difficult to identify anatomical structures especially the recurrent laryngeal nerve or the parathyroid glands. New imaging technologies capable of providing additional information for the surgeon, beyond the abilities of the human eye, are being developed. Hyperspectral imaging (HSI) is a relatively new modality, which combines spectroscopy with camera imaging. It enables a non-invasive tissue differentiation through a contact free chemical analysis. The goal of this work was to evaluate HSI for the identification of organs and structures in thyroid surgery.

MATERIAL AND METHODS

The HSI system developed by the company Diaspective Vision GmbH (Pepelow, Germany) was used to acquire datasets of 12 patients during open thyroidectomies and parathyroidectomies. In vivo anatomical structures, i.e. thyroid and parathyroid, nerve, muscle and fat were manually annotated as region of interest (ROI). The averaged absorbance spectra of all annotated structures were computed and plotted (Figure 1).

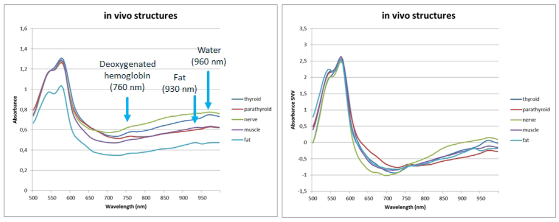

Fig. 1 - Averaged absorbance (left) and absorbance SNV transformed (right) spectra of in vivo structures acquired during thyroidectomy and parathyroidectomy operations.

RESULTS

The observation of the absorbance spectra showed that: (1) The known spectroscopic peaks (deoxygenated hemoglobin at 760 nm, fat at 930 nm, water at 960 nm) were clearly detected in the absorbance spectra; (2) The absorbance spectra of the nerve presented a lower absorbance in the range 600 to 700 nm and a larger absorbance in the range 800 to 1000 nm than the spectra of muscle and fat, indicating a larger oxygenation of nerves; (3) The absorbance spectra of the in vivo thyroids and parathyroids showed different oxygenation states,

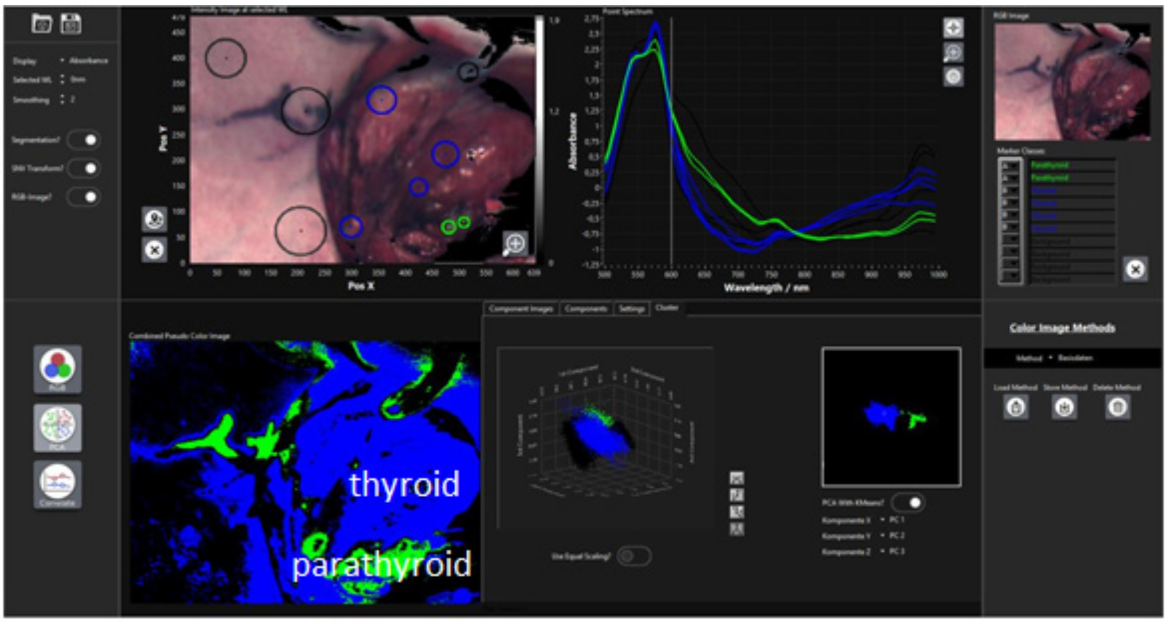

Fig. 2 - Principal Component Analysis performed on the light spectra of one patient. Thyroid and parathyroid tissue could be correctly differentiated.

allowing a clear differentiation between those two structures. These differences were used to perform a classification of both structures in the images (Figure 2).

DISCUSSION AND CONCLUSION

Our observations match the results published in the literature. Future works will consist in the measurement of further organs and structure and in the development of computer assisted algorithms (for example machine learning classification algorithms) to discriminate these structures during operations.

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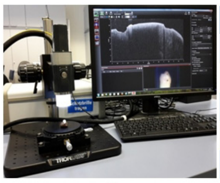
DETECTION AND ASSESSMENT OF UNCAVITATED CARIOUS ENAMEL LESIONS BY OPTICAL COHERENCE TOMOGRAPHY

INTRODUCTION

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

MATERIAL AND METHODS

28 extracted human teeth with 47 approximal carious lesions and sound surfaces were used. Approximal surfaces were sectioned visually by means of ICDAS-II codes 0 to 2. One region of interest (ROI) was marked by 2 drill-holes each according to maximum lateral lesion extent. Imaging these lesions was performed with SD-OCT developing a 2D- and 3D-Scan. Using µCT imaging 150 – 250 µm tooth sections were scanned through the ROI. As reference method we used TMR, scanning electron microscopy (5 kV) and wide-field confocal laser microscopy (WFC). These imaging methods facilitate lesion depth measurements (µm). According to lesion extent OCT and µCT signals were categorized (Fig. 1b).



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

a b

Fig. 1 - Spectral domain OCT: Telesto II of Thorlabs GmbH, λc=1310 nm, b) categorization of lesion extent.

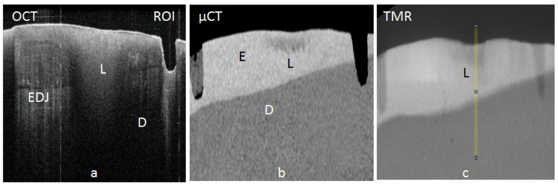


Fig. 2 - A carious enamel lesion of ICDAS-II code 1 (category 2) imaged using OCT, µCT and TMR. L: carious lesion, E: enamel, D: dentin, EDJ: enamel dentin junction.

RESULTS

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

DISCUSSION AND CONCLUSION

All used methods detected the extension of carious lesions in enamel. While µCT is invasive, as X-rays are applied, the OCT is a noninvasive method with a potential in dental diagnosis, especially for detection and assessment of carious lesions. OCT applies near-infrared light for cross-sectional object imaging scanning to produce two-dimensional cross sections and tomograms. The high correspondence of it with reference methods indicated the reliability of the OCT. OCT seems to be more suitable to assess carious enamel lesions, limited to the first quarter of the enamel than µCT.

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SELECTED PUBLICATIONS

Schneider H, Park KJ, Häfer M, Rüger C, Schmalz G, Krause F, Schmidt J, Ziebolz D, HaakR. Dental Applications of Optical Coherence Tomography (OCT) in Cariology. J Appl Sci. 2017; 7(5): 472.

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FUNDING

German Federal Ministry for Economic Affairs and Energy (BMWi)

OPTICAL COHERENCE TOMOGRAPHY (OCT) FOR INTRAOPERATIVE EXAMINATION OF TISSUE SAMPLES

INTRODUCTION

In surgical tumor resections, it is common practice to secure a R0 resection by means of intraoperative frozen sections. This requires the surgeon to recognize the tumor margins as accurately as possible. Optical coherence tomography (OCT) is an imaging technique that enables non-invasive and non-contact examination of tissue in a high resolution. This application and feasibility study examined whether OCT can help the surgeon to distinguish tumor tissue from tumor-free tissue.

MATERIAL AND METHODS

Four tissue samples of patients were analyzed using OCT. One patient underwent endolaryngeal laser-resection with intraoperative frozen sections and three patients incisional surgical biopsy from the larynx or tongue as part of a microlaryngoscopy or panendoscopy. A total of 20 histological samples were examined immediately after excision in the operating room with a Thorlabs Telesto OCT (center wavelength of 1325 nm and bandwidth of 150 nm). The axial and lateral resolutions of the image data are 6.5 µm and 15 µm and the maximum imaging depth 2.5 mm. The raw data was converted into DICOM format, smoothed using a Gaussian filter and visualized with the software MeVisLab.

RESULTS

Pathological work-up revealed squamous cell carcinoma in three patients and leukoplakia with inflammatory alteration in one patient. In OCT squamous cell carcinomas were characterized by an increase in the thickness of the epithelial cell layer compared to tumor-free tissue (Figure 1). In addition, architectural changes of the epithelium were visible in OCT (Figure 2). The leukoplakia also had a thickened layer of epithelial cells and was therefore not safely distinguished from squamous cell carcinoma.

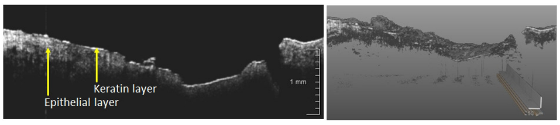

Fig. 1 - OCT image data of tumor-free tissue sample (left: 2D slice, right: 3D representation). The keratin and epithelial layers are represented. Due to the limited imaging depth the basement membrane is not depicted.

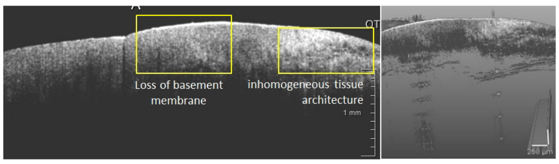

Fig. 2 - OCT image data of tumor tissue sample (left: 2D slice, right: 3D representation). Cell carcinomas are characterized by an increase in the thickness of the epithelial cell layer and by architectural changes.

DISCUSSION AND CONCLUSION

The OCT has the potential to support the surgeon to recognize margins of lesions. For intraoperative use, however, it is necessary to develop an easy-to-use OCT system for real-time in vivo measurement.

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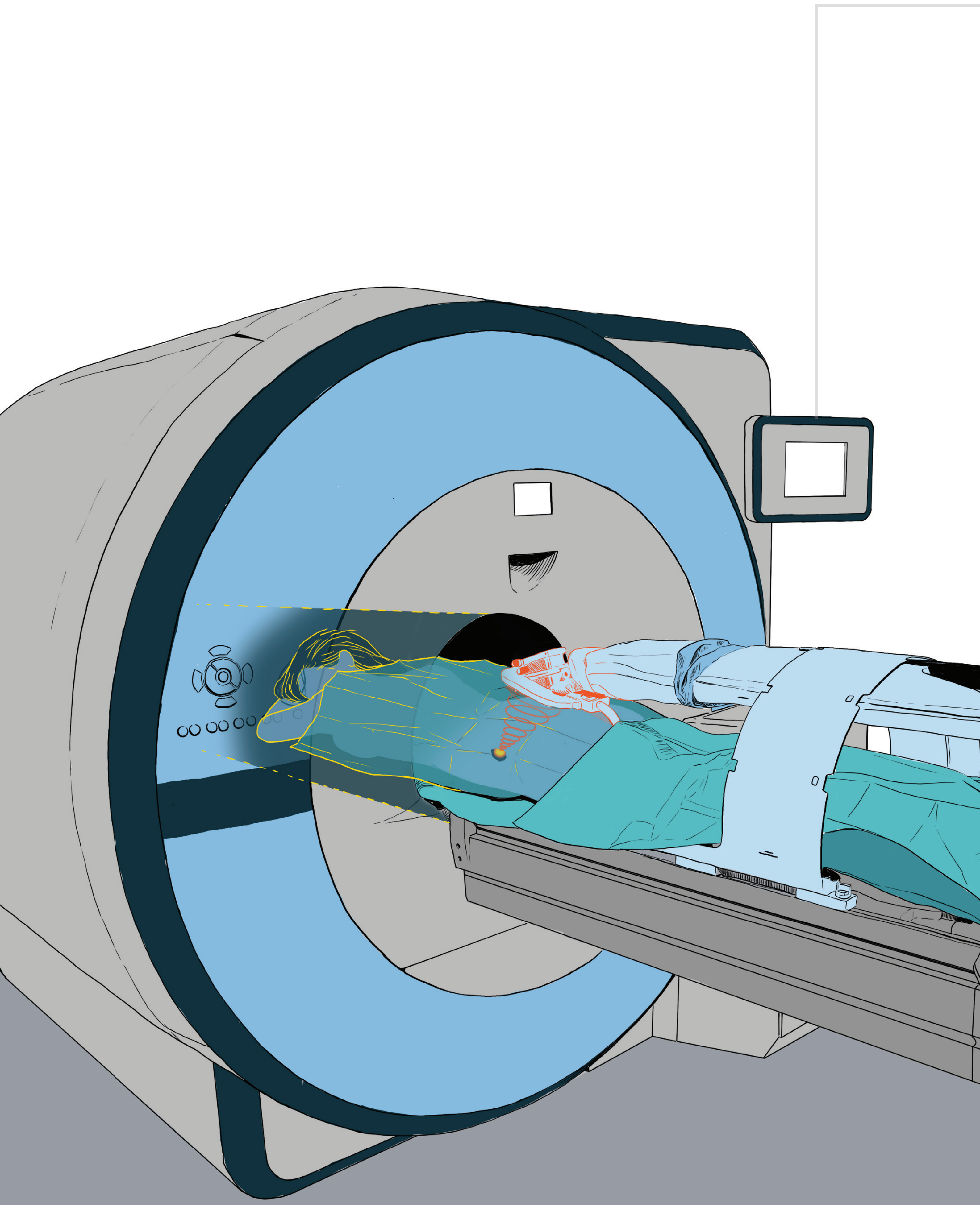
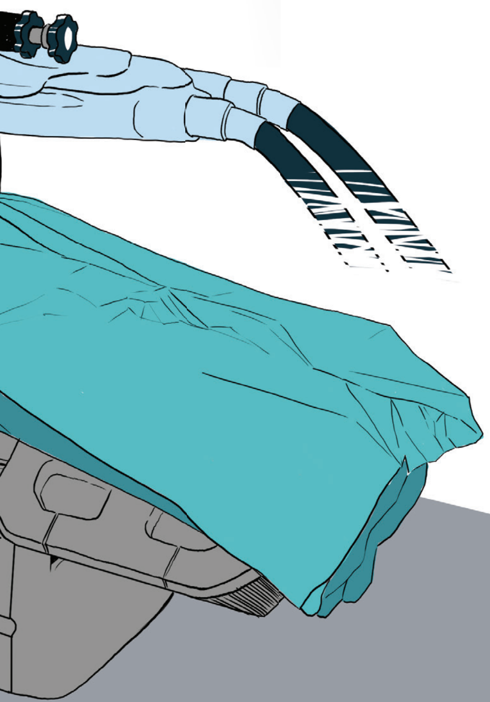


COMPUTER-ASSISTED IMAGE-GUIDED INTERVENTIONS

'ICCAS researches on new technologies for image guided procedures and therapeutic assistance systems in the field of MRI-guided and non-invasive interventions – novel application of focused ultrasound (FUS) under the guidance of magnetic resonance therapy (MRgFUS) – robotic assisted MRgFUS and interventional techniques under PET-MRI guidance – combined FUS and radiation therapy to support the treatment of cancer (SONO-RAY, BMBF project).'

Prof. Dr. Andreas Melzer
(group leader)



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SELECTED PUBLICATIONS

Xiao X, Huang Z, Rube MA, Melzer A. Investigation of active tracking for robotic arm assisted magnetic resonance guided focused ultrasound ablation. Int J Med Robot. 2017; 13(3): 1768.

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Xu D, Landgraf L, Melzer A. Tumor therapy combining image-guided focused ultrasound and radiation therapy – introducing of SONO-RAY project. 4th Symposium on Focused Ultrasound Therapy (EUFUS). Leipzig, Germany; 2017.

1 META CENTER FOR INNOVATION COMPETENCE (ZIK) BETWEEN ICCAS (LEIPZIG) AND ONCORAY (DRESDEN):
SONO-RAY - Combination Therapy of MR-Guided Focused Ultrasound-Hyperthermia (FUS-HT) and Radiation Therapy (RT) for the Treatment of Cancer | project part ICCAS

INTRODUCTION
Focused ultrasound (FUS) is rapidly gaining clinical acceptance as non-invasive and non-ionizing technique which allows treatment of patients as day cases, thus reducing hospital in-patient costs. FUS therapy underlies the generation of heat in tissue for a wide range of applications whereby Magnetic Resonance (MR) imaging is mostly used for treatment planning and real-time thermometry. Over the last 10 years, FUS treatment for ablation of benign and malignant tumors including breast, liver, pancreas, thyroid, brain and bone is investigated in clinical trials. At this time, systems for treatment of benign uterine fibroids, prostate cancer, Parkinson's disease and MRgFUS as an alternative modality for pain palliation are approved by the Food and Drug Administration (FDA).
In contrast to ablative procedures where high-energy ultrasound beams lead to coagulative necrosis in the target tissue the use of ultrasound to support drug delivery as well radiotherapy is ongoing. Regarding this research area, full team of the Sono-Ray project (funded by BMBF) starts at ICCAS to investigate effects of FUS-hyperthermia (HT) combined with radiation therapy in vitro. Activities in 2017 included the development of a high-throughput 96 well sonicator together with Frauenhofer IBMT (St. Ingbert) and determination of most effective time intervals for combination of HT plus radiation to treat cancer cells derived from prostate, glioblastoma and head and neck tumors. In collaboration with OncoRay (Dresden) planning of in vivo studies started and simulations of ultrasound propagation and cell models are underway. For translation of the combined therapy robotic system which can hold mobile transducer was installed in PET-MR in University Hospital Leipzig. The Sonalleve ultrasound system which was funded by ICCAS and installed in 2016 have been used for experimental set up investigation for in vitro treatment of cancer cells and the first treatment of fibroids of two patients was done.

Combination of ultrasound and radiation therapy for cancer treatment in an in vitro 96-well plate format.

1.1 EFFECTS OF ULTRASOUND HYPERTHERMIA COMBINED WITH RADIATION THERAPY IN VITRO

INTRODUCTION

Many literatures report about synergistic effects of hyperthermia combined with radiation therapy (RT) due to radio-sensitizing events in tumor cells. In this context, focused ultrasound (FUS) has the potential to generate mild hyperthermia (40-45°C) in tumor tissue in a non-invasive and precise way. Pre-clinical studies demonstrated that hyperthermia leads to increased perfusion, thus reduce hypoxia in tumor tissue. Moreover, hyperthermia is able to confer direct cell death, inhibits DNA repair mechanisms and appears to induce immune response (Peeken et al., 2017). Recent heating techniques using e.g. electrodes, radiative or infrared based systems rarely allow solely heating of tumor tissue alone and lack of precise temperature control in real-time while MRgFUS provide the benefit of the temperature monitoring to control the treatment in a comfortable way for the patient. The goal of the biological work in Sono-Ray is to investigate in detail the thermal as well as mechanical effects of FUS at the cellular level on glioblastoma, prostate and head and neck cancer cell lines. Furthermore, treatment procedures with optimal temperature and time regime for FUS-HT + RT need to be clarified.

MATERIALS AND METHODS

Cancer cells were cultured in the desired cell culture medium in an incubator at 37°C and 5% CO_2. To investigate effects of FUS-HT and combination therapy different cell lines were used (glioblastoma: LN405, T98G, U87MG; head and neck: FaDu, UT-SCC-5, UT-SCC-8; prostate: PC-3). For ultrasound treatment and for the radiation therapy cells grew in 96-well µclear bottomed plates. To analyze effects of the treatment on cell viability relative cellular NAD(P)H levels using WST-1 assay and proliferation with BrdU assay were measured. Both assay systems were carried out according to the manufactures instructions.

Impact on cancer cells of two different in vitro sonication systems was investigated. A self-made cell sonication system (Gerold et al., 2012; IMSaT, Dundee) (Fig. 1) possess a single focused transducer in a water tank with operating frequency at 1 MHz. Cells were exposed to acoustic intensities of 35W/cm². Together with Frauenhofer IBMT a high throughput cell applicator (Fig. 2) with 96 single elements deliver homogenous ultrasound waves to cells operation at a frequency of 1 MHz and max. intensities of ~1.5 W/cm². US induced hyperthermia (40 -47°C) was performed for a duration of 30 min. Infrared thermal camera with imaging software (PI connect version 2.10) was used to monitor real-time temperature in the wells during sonication. A 150 kV X-ray machine (DARPAC 150-MC) was employed for irradiation at doses of 0-20 Gy (Fig. 2).

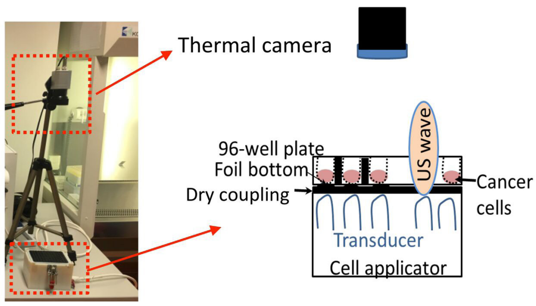

Fig. 1 - Photography and schematic drawing of the *in vitro* sonication system for treatment of cancer cells in 96 well plate format. High throughput cell applicator with 96 elements and thermal camera for temperature control in real-time.

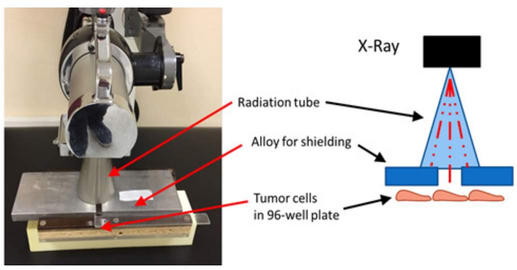

Fig. 2 - Photography and schemata of radiation system for irradiation of cells in 96 well plates.

To get first insight on best treatment regime for combined therapy cancer cells were treated in suspension in waterbath or thermoblock (41°C

- 43°C, 10 min - 60 min) whereby temperature was monitored with thermocouples.
Additionally to the in vitro sonication systems test phase of hyperthermia treatment of cancer cells using the clinical HIFU device Sonalleve (Profound Medical) integrated into 3T Philips achieva MR scanner started (Fig. 3). The system was configured to operate with a power of 60 Watts at 1.1 MHz. MR thermometry was used to monitor the sample temperature.

RESULTS

Radiation dose curves of the three cancer types showed dose dependent loss in cellular NAD(P)H levels with increasing radiation dose. A high resistance against DNA damaging ionizing radiation was detected for glioblastoma cell line U87MG and all head and neck cancer cell lines. The highest impact of RT was detected during analysis of DNA synthesis (BrdU) which nearly stopped at dosages above 5 Gy for all tested cell lines.
Comparison of US-HT to waterbath-HT revealed higher impact on cell viability of the US treatment group.

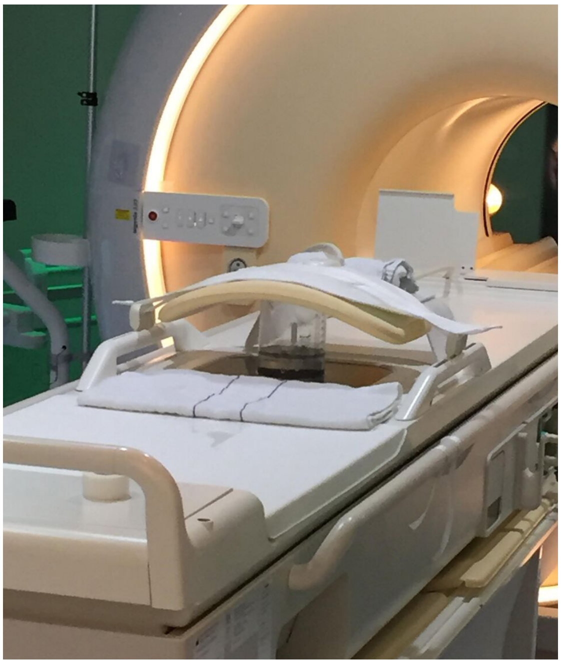

Fig. 3 - Clinical HIFU system (Profound medical) with transducer installed in the tabletop integrated into 3T achieva MR scanner (PHILIPS) at University Hospital Leipzig. Beaker with tubes for hyperthermia treatment stands on the transducer window.

Performance of first combination experiments of water bath-hyperthermia and radiation revealed highest efficiency of a short gap between heating and irradiation of cancer cells. Relative NAD(P)H levels of glioblastoma cell line T98G decreased to the lowest level of 43% when RT was carried out within 15 min after hyperthermia. Furthermore, short time interval between the two treatment modalities was also obvious in head and neck cancer cell line FaDu.

DISCUSSION AND CONCLUSION

In this work preliminary results of the effects of ultrasound hyperthermia showed a higher impact on cell viability of ultrasound-HT compared to waterbath-HT indicating the occurrence of additional biochemical events at cells. Investigation of the optimal treatment regime by using waterbath-HT plus radiation demonstrated the best therapy outcome when a short interval between thermotherapy and irradiation was conducted. This could imply that the cells are only in a desired window more radio sensitive against RT. In the future, the in vitro setup and sonication device need to be optimized to guarantee that experimental situation is comparable to the in vivo situation and to present a practicable workflow for the experimenter. Further methods need to be established in the lab for analysis of DNA double strand break repair, apoptosis events and the production of reactive oxygen species.

1.2 SIMULATIONS OF ULTRASOUND PROPAGATION AND IN SILICO CELL MODELS

INTRODUCTION

Since the application of ultrasound is a well-established technique in various fields of the medical treatment of patients, plenty of helpful methods to simulate the effects and propagation of ultrasonic waves in a given tissue have been introduced already. Such simulations provide a very good overview of how given intensities influence a specific medium. Not only the macroscopic, but also the microscopic domain can be examined as well, by looking into the cell behavior and growth under given circumstances and modeling the different proliferation states for example in cellular automata. As mentioned beforehand, the accumulation of hyper-thermal temperatures through focused ultrasound poses a main aspect for investigations. Mathematical models were already presented in the past, to examine effects of heat on tumor cells. The most commonly used approach for this may be the Arrhenius model (Dewey, 1994) in combination with the calculation of t_43 equivalent minutes (Sapareto et al., 1984). Additionally to this the Linear-Quadratic model provides good results in calculating surviving fractions of cell cultures under given radiation doses (Fowler, 1989). Yet, the research of combined therapies for ultrasound and radiation is still situated in an early stage of progress. Due to the sparse knowledge of the effects of such a combined treatment on the many different tumor cell types, only few attempts could be made to combine both properties in an in silico model. Only very recently an approach was presented, to combine the two models for heat and radiation into a single one (Brüningk et al., 2017). To furthermore investigate in the mechanical effects of cell interactions like adhesion under ultrasound influence, the Johnson-Kendall-Roberts (JKR) model may pose promising results (Johnson et al., 1971). The goal therefore is to build up on these works and work out a simulation on the cellular level that accounts for cell properties in specific ultrasound and radiation fields, including absorption characteristics and mechanical effects as well. Since another main goal is the transition from in vitro results to in vivo setups the simulation, though running on cellular levels, shall still provide a large enough scale for further analysis.

MATERIAL AND METHODS

In a first step the overall framework for the simulation approaches, consisting of two main steps was defined. In the first step the ultrasound propagation and resulting temperature diffusion for given setups and mediums are calculated with the MATLAB Toolkit k-Wave (Treeby et al., 2010), using the k-space approach and Pennes' Bioheat equation (Pennes, 1948). Using the HDF5 file suite for large data formats (The HDF Group, 2017), the resulting grid data containing pressures, intensities, etc. can be saved for further use. The second step consists of a particle based simulation approach. For this the overall calculation procedure given in Fig. 1, will be used. The simulations will be performed on a 3D spatiotemporal grid derived from the HDF5 files from beforehand calculations. Given a set of cells, two main loops are to be computed. In a loop for tumor growth, the proliferation cycle for each given cell is calculated similar to known cellular automata approaches resulting in an updated set of proliferated cells. A loop for therapy calculations utilizes named given models for thermal and radiation dose and mechanical ultrasound effects. Depending on performance outcome, each particle will be calculated as a cell or a subset of cells respectively in an agent based approach. The simulation is performed over predetermined time steps, depending on which of the two loops is running. First implementations were done in C++ using the Fluidix (MacDonald, 2014) for particle systems and NVIDIA CUDA framework for parallelization and OpenGL for visualization.

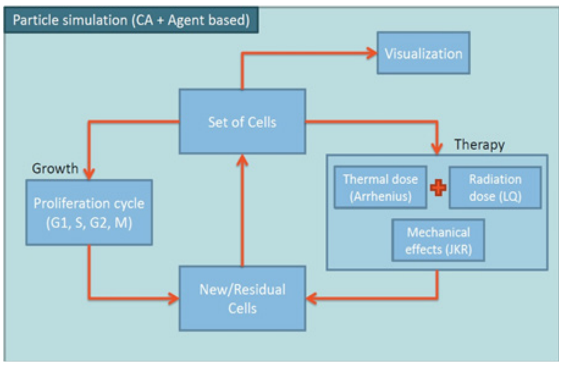

Fig. 1 - Calculation procedure for the particle simulation consisting of the growth and therapy loops.

RESULTS

The presented procedure provides a first approach to combine ultrasound and radiation ef-

fects with cell simulations in a particle system, that includes proliferation properties, as well as mechanical, thermal and radiation effects. First simulations with k-Wave were conducted for an experimental setup sonicating a TPX Tube contained in water. A screenshot can be seen in Fig. 2.
Furthermore smaller simulations in homogeneous medium were used to transfer grid data by HDF5 and run first particle simulation tests. Fig. 3 shows the propagation of pressure in a cubical grid randomly filled with particles.

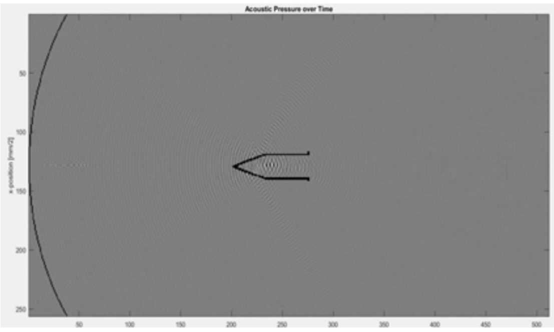

Fig. 2 - k-Wave Simulation of a TPX tube in water with a grid size of 256x256x512 elements and a spacing of 1/2 mm.

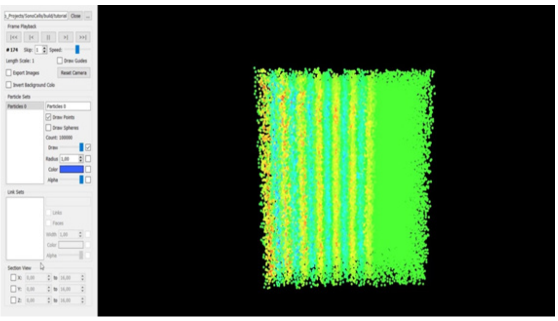

Fig. 3 - Fluidix simulation of the propagation of pressure through randomly placed particles in a cuboid grid.

DISCUSSION AND CONCLUSION

The suggested approach poses questions on the performance feasibility that have to be examined in more detail. Furthermore, there is no sufficient information about up to which scale such a simulation can provide useful results. Nevertheless it may be a good way to show cell behavior in ultrasound and radiation on a semi-large scale, depending on the quantity and quality of single cell visualization. Further work has to be done to implement the two simulation loops and combine the mathematical models to calculate effects on tumor cells.

1.3 INTEGRATION OF ROBOTIC ASSISTED FUS SYSTEM INTO THE CLINIC

INTRODUCTION

Robotic systems become more and more important in medicine, because they provide precise and reproducible positioning of surgical tools and equipment. In this context, robotic systems are used in clinics to assist for example during biopsies and ablation treatment. Regarding the non-invasive therapy applying FUS/HIFU for treatment of tumors at various locations or moving organs a precise positioning of the ultrasound transducer is crucial for the efficacy and safety of the treatment. Integrated HIFU systems like Profound Sonalleve only allow the treatment in very specific regions. Hence, a robotic arm positioning the FUS system according to the treatment planning is more versatile. For further studies on combined FUS-RT treatment, the robotic arm system needed to be integrated into the existing clinical infrastructure in the PET-MR at the hospital in Leipzig.

MATERIAL AND METHODS

The MR-compatibility of our robotic arm system InnoMotion by InnoMedic GmbH is crucial for the FUS treatment under MR-guidance and is indispensable for thermometry during the heating process. The robotic arm system was not compatible with the Biograph mMR MR-PET system (Siemens Healthineers) in the Department of Nuclear Medicine of the University Medical Center Leipzig. Therefore, the C-arm holding the robotic arm was modified to fit onto the patient table (Fig. 1).

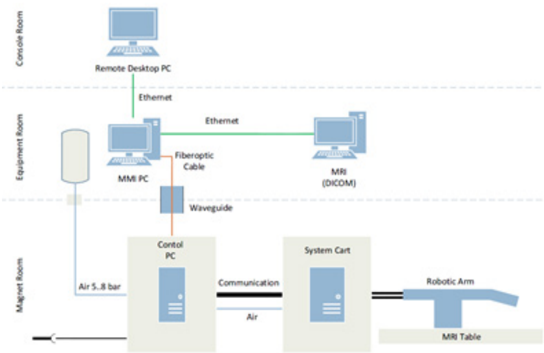

Fig. 1 - Integration concept for the Innomotion robotic arm. The treatment is planned and carried out using a MMI PC which is connected to the MR-PET system (Siemens Biograph mMR) to acquire DICOM data.

A 3D-printer (Makerbot Z18) was used to manufacture a modified foot for the C-arm. A concept to integrate the system into the clinical infrastructure was developed (Fig. 1). The MR system acts as a DICOM server which provides the imaging data to the robotic arm system. To enable operation alongside the common diagnostic use, the robotic arm system should be attached to the secondary network interface of the MR-PET system.

Fig. 2 - Setup of the robotic arm system in the MR-PET system in the Department of Nuclear Medicine of the University Medical Center Leipzig. The robotic arm (left) positions the US transducer according to the planned treatment. The MR-PET system monitors the position of the transducer, the temperature and the efficacy of the treatment.

RESULTS

The robotic arm system was successfully modified to fit the Biograph mMR MR-PET system in the Department of Nuclear Medicine of the University Medical Center Leipzig (Fig. 2) and the robotic arm system was integrated into the clinical IT infrastructure.

DISCUSSION AND CONCLUSION

Using MR-PET imaging technique improves the evaluation of the efficacy of a combined FUS-RT treatment. Due to the early stage of these combined therapies, MR-capable robotic systems are hardly available. Therefore, these systems lack standard for clinical integration. Studies evaluating the impact of the robotic arm on the PET-MR system will be conducted.

1.4 SCORPIUS – ROBOT ASSISTED NEEDLE GUIDANCE AND ULTRASOUND MONITORING

INTRODUCTION

Image guided assistance became a common technique in minimal invasive interventions over the past years to guide the surgeon in his or her task. In spite of using these techniques, inaccuracies of the imaging system and the complex coordination effort of the surgeon still can lead to missing the target. It is therefore not unusual that the insertion trajectory e.g. of a biopsy needle needs to be corrected to reach a desired target. This leads to repetitive insertion of the instrument and entails increased physical stress for the patient as well as the surgeon. A robot guided system for needle placement in combination with ultrasound monitoring may overcome these downsides.

MATERIALS AND METHODS

We attached a wireless ultrasound probe (Clarius L7) to a Kuka iiwa lightweight robotic arm. A retainer for the probe was constructed in 3D printing, supplemented with a mechanical needle guide and fixed to the flange of the robotic arm. The system was tested using a neck phantom with an ultrasound visible structure inside, representing a defect in the lymph node. To precisely position the tools on the phantom a tracking system, consisting of an NDI optical camera and a Microsoft KINECT is used. The position of all relevant tools, the phantom and the user as well are monitored. This allows for treatment planning using an augmented reality based tablet application. Utilizing a reconstructed 3D model from CT-Images, with this application a target trajectory to the defect structure can be defined and the robot be steered. A second application allows for visualization of ultrasound images from the Clarius probe while advancing the needle to control its positioning. The whole setup can be seen in Fig. 1.

Fig. 1 - The Scorpius robotic system. Shown are the KUKA robot arm, the Clarius L7 wireless ultrasound probe, the tracking camera system and the neck phantom.

RESULTS

A study investigating the position accuracy of the needle tip showed a mean position deviation of 2.93 mm. To evaluate the usefulness and acceptance of the system, a questionnaire was administered to participants after performing all given tasks. The participants rated the functions of the system to be useful, but were unsatisfied with the usability of the system at its current implementation.

DISCUSSION AND CONCLUSION

We showed that a robot assisted needle placement in combination with ultrasound monitoring of the needle insertion improves reaching a desired target. In the future, a second robotic arm positioning a focused ultrasound probe shall be used to induce hyperthermia in malignant tissue for a combined FUS-RT treatment. The system shall be further enhanced with more sophisticated interaction possibilities to increase user-friendly handling and reduce treatment time.

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FUNDING

German Federal Ministry of Education and Research (BMBF)

2 MRI-GUIDED FOCUSED ULTRASOUND IN THE TREATMENT OF UTERINE FIBROIDS

INTRODUCTION

The Philips/Profound Sonalleve MR-HIFU System is since January 2017 at the Department of Radiology (Leipzig University Hospital) operational. Our goal was in 2017 to establish a MR-HIFU-Therapy-Center for the treatment of uterine fibroids and in the near future also of bone tumors.

Uterine fibroids are benign tumors in the uterus consisting of smooth muscle fibers and connective tissue. Up to 40% of women of childbearing age have a uterine fibroid and in one third of cases they cause discomfort or more serious problems like bleeding, pain, frequent urination/polallkiuria and miscarriage. For decades surgery has been the only cure for these tumors, but in the meantime, depending on the localization and the configuration of the fibroids, new therapies like embolization and non-invasive MR-HIFU have made their way into clinical routine for the fibroid treatment. Especially for young women MR-HIFU treatment has the advantage of preserved fertility.

Our aim for 2017 was to implement clinical patient care with treatment of uterine fibroids. This was successful with the first treatments performed in October 2017.

MATERIALS AND METHODS

In February 2017 we had our first introduction followed by an extensive training at the Sonalleve console held by a Profound specialist. Despite difficulties in patient acquisition, we were able to treat our first two patients in October 2017.

The first patient was a 28-yo student with a uterine fibroid (Funaki type II) in the anterior wall (measuring 48 ml) with good coverage. The patient was suffering on dysmenorrhea and wished to become pregnant within the next years. Fibroid characteristic were favorable for the HIFU-therapy. The treatment took about 241 minutes with 37 sonications.

The second patient was a 32-yo artist with a uterine fibroid (Funaki type I) in the anterior wall (measuring 55 ml) with good coverage. The patient had already two abortions in the past, possibly due to the fibroid. The fibroid was in a good treatment window. The HIFU-therapy took about 213 minutes including 24 sonications.

In order to establish a MR-center for fibroids, we figured out a workflow in collaboration with the gynecologists including an interdisciplinary outpatient clinic. We also concentrated our efforts on informing assigning physicians and patients through the web, information flyers and press releases.

Setting up a center for FUS/HIFU involves a lot of challenging tasks. Amongst others, installation of the system including an inpatient ward, enough space for preparation and post-interventional treatment, arrangement of a responsible team with interventional radiologists, registered nurses, medical technical radiologic assistants, medical physicists and secretaries are to mention. Satisfying therapy results are only accomplished through strict indication and patient selection, demanding a high number of primary screenings in order to select the best suitable patients.

We are of course also creating a data registry of acquired patients for future clinical evaluation and scientific analysis.

RESULTS

We were able to perform an ablation of 81% in the fibroid of the first patient (Fig. 1). Immediately after therapy the patient felt pain equal to an average menorrhea. The day after treatment and also during the next 30 days the patient was painless.

In the fibroid of second patient, we even were able to perform an ablation of 100% (Fig. 2). Immediately after therapy the patient felt pain 5 / 10 (VAS). The first few days following the treatment the patient reported a slight vaginal bleeding. During the next 30 days the patient was painless and had no further complaints.

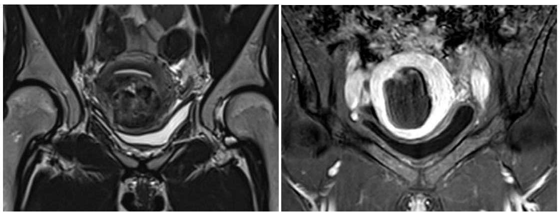

Fig. 1 - MR images of first patient. Left side: Uterine fibroid before therapy (T2w coronal); Right side: post-HIFU-therapy (contrast-enhanced T1w coranal).

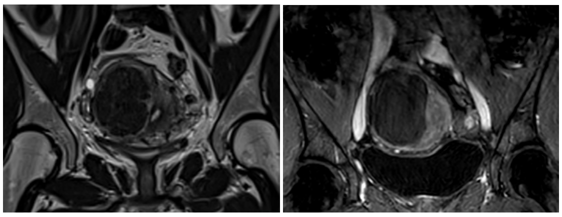

Fig. 2 - MR images of second patient. Left side: Uterine fibroid before therapy (T2w coronal); Right side: post-HIFU-therapy (contrast-enhanced T1w coranal).

DISCUSSION AND CONCLUSION

We were able to establish a center for FUS/HIFU and to treat our first patients with uterine fibroids with excellent results. In the near future we are also going to apply the therapy on benign and malignant bone tumors and focus on the implementation of MR-HIFU as an alternative therapy in the clinical routine of cancer treatment in the University Hospital of Leipzig.

PROJECT TEAM

Prof. Dr. Thomas Kahn
Prof. Dr. Andreas Melzer
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3 MRGLIFUP: NEURO-MODULATION USING MRI-GUIDED LIGHT INTENSITY FOCUSED ULTRASOUND

INTRODUCTION

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

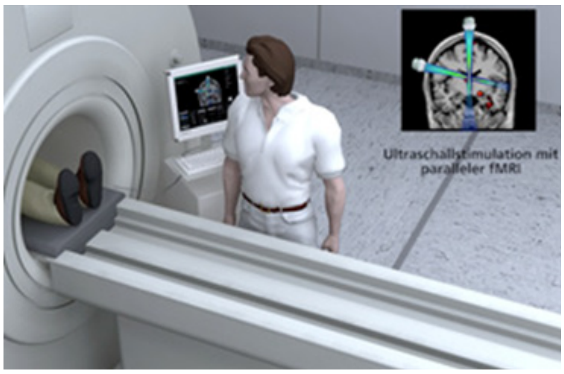

Fig. 1 - Concept of MRgLIFUP

In 2017, a custom-made ultrasound system (Figure 2) was developed and provided by the Fraunhofer IBMT (Tretbar, St. Ingbert), which enables human use neuromodulation using freely programable ultrasound transmission sequences synchronized and in parallel to EEG or MR measurements.

In addition, a 3D ultrasound matrix transducer was realized with an ultrasound transducer matrix of 11x11 elements, an active aperture of 35 mm x 35 mm and a center frequency of 650 kHz.

With this matrix array and a special control software, it is possible to position a focal spot in a given volume with high spatial accuracy. The implementation of a patient-specific modulation algorithm to compensate for the influence of the skull bone on the sound field geometry is work in progress. The system is connected to a highly sensitive EEG system to gain initial evidence of the effects of LIFUP. A first clinical trial at the MPI (Prof. Villringer) is performed with the setup in 2018.

Based on the results, an MR-compatible version of the system will be realized by the Fraunhofer IBMT in the next step and integrated into an MRI / PET-MRI setup at ICCAS (Prof. Melzer / ICCAS, Prof. Sabri / NUK, UKL, Leipzig).

Fig. 2 - LIFUP-System with Matrix-Transducer and UI (Fraunhofer IBMT, St. Ingbert).

PROJECT TEAM

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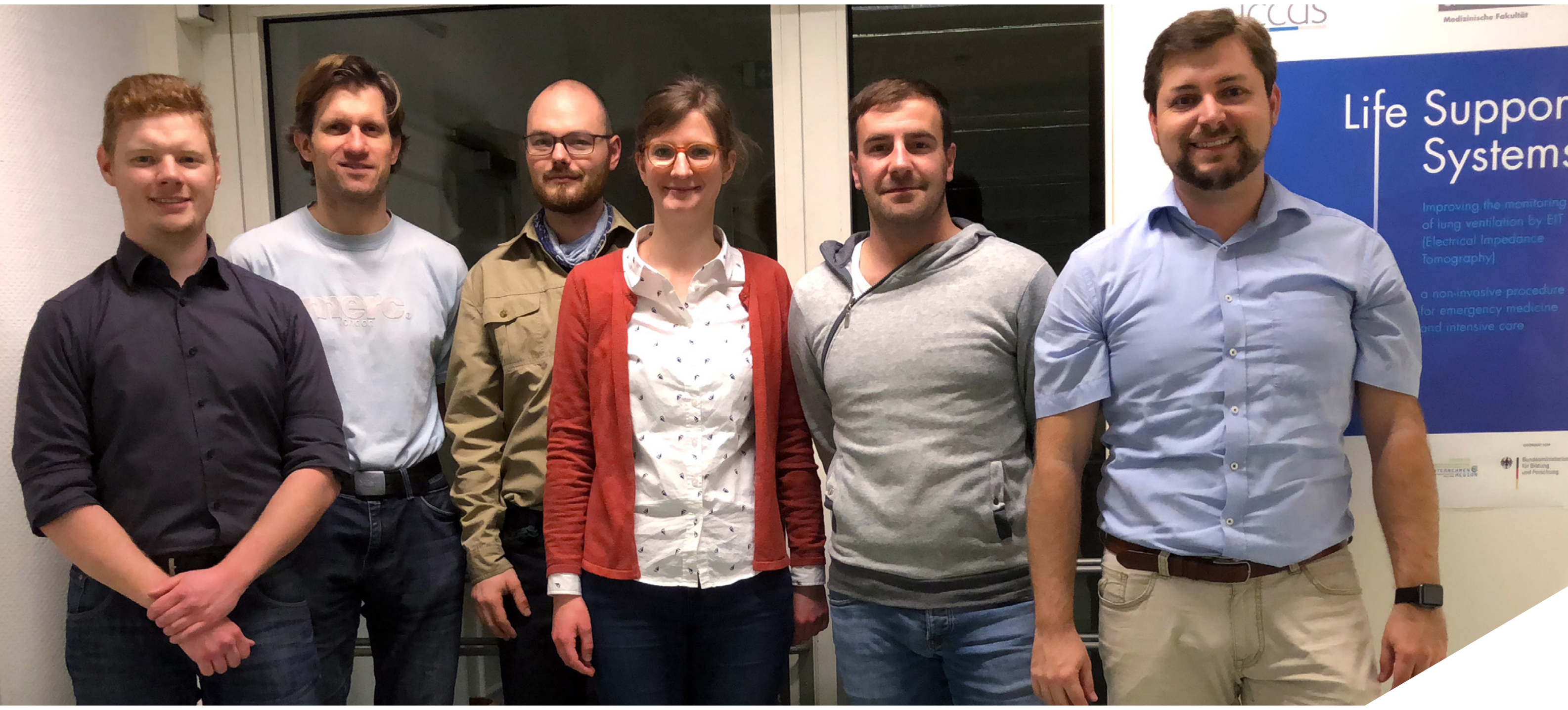
Prof. Dr. Arno Villringer, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig

Dipl.-Ing. Steffen Tretbar, Division of Ultrasound, Fraunhofer IBMT Institute for Biomedical Engineering, St. Ingbert

LIFE SUPPORT SYSTEMS

'The non-invasive and radiation-free Electrical Impedance Tomography has the potential to offer direct insight into the patient's lung condition and lung function for physicians in emergency medicine and intensive care. We develop innovative diagnosis and monitoring algorithms to advance individualized therapy selection and steering for respiration disorders.'

PD Dr. Andreas Reske
(group leader)



SCIENTIFIC STAFF

Reinhard Fuchs, Dominic Schneider, Tobias Landeck, Julia Mrongowius, Martin Ziemann, Peter Salz (f.l.t.r.)

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IMPACT: MOBILE SYSTEM FOR DIAGNOSIS AND MONITORING OF PNEUMOTHORAX IN EMERGENCY MEDICINE

INTRODUCTION

The goal of this project is the development of a mobile system for lung function diagnostics and monitoring in emergency situations. Based on electrical impedance tomography (EIT), changes of electrical properties in the lung are measured using an easily applicable electrode belt. This allows for a three-dimensional imaging and functional analysis to assess ventilation status.
This is the first application of EIT outside of the stationary clinical setting, enabling emergency physicians to determine the need for mechanical ventilation, monitor regional changes of lung function, and detect potentially life-threatening complications like pneumothoraces.

AIMS

In close cooperation with Fritz Stephan GmbH, ITP GmbH, and HTWK Leipzig, we develop a novel EIT device with significantly miniaturized hardware for mobile use. With an innovative textile-based electrode belt that can be quickly attached to the patient, a reliable monitoring of the lung function can be performed even in cramped spaces such as car wrecks with only partial access to the patient. Novel methods for three-dimensional image reconstruction and data analysis developed at ICCAS enable the quantification of one-sided ventilation due to incorrect positioning of the tube as well as the detection and monitoring of pneumothoraces which might require an invasive intervention.

DISCUSSION AND CONCLUSION

The mobile EIT device with novel and innovative developments of textile belts, image processing and analysis methods will enhance the initial treatment of emergency patients and support the physician's decision making in terms of mechanical ventilation, tube positioning and invasive interventions. A better outcome for patients regarding duration of mechanical ventilation and less complications from interventions is expected.

PROJECT TEAM

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PROJECT PARTNERS

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Klaus Richter, ITP GmbH
Wolfgang Braun, Fritz Stephan GmbH

FUNDING

German Federal Ministry of Education and Research (BMBF)

EMU: VENTILATION SYSTEM WITH ELECTRICAL IMPEDANCE TOMOGRAPHY FOR MONITORING AND OPTIMAL VENTILATION OF THE PATIENT

INTRODUCTION

This project is a cooperation with Fritz Stephan GmbH with the goal of combining an advanced ventilaton device with Electrical Impedance Tomography (EIT). By measuring dynamic changes of electrical properties inside the lung which correlate with ventilation, EIT provides an unprecedented, radiation-free, and real-time view of the lung function. Changes in EIT data corresponding to deterioration of lung function can be observed much sooner than by usual means, such as blood oxygenation (SpO_2), chest X-ray or CT scan. The ventilation device EVE provides mechanical ventilation for a large patient range, from premature babies to neonates and adults. Combining a ventilator with EIT enables clinicians to adapt their ventilation strategies and interventions more precisely to the individual patient's needs.

MATERIAL AND METHODS

A multi-modal ventilation system combined with an EIT measurement device will be developed to be used for temporary monitoring and automated ventilation of the patient. Vital parameters such as lung activity and lung volume will be measured. Additionally, a thorax belt integrates EIT-based imaging of the lung. The captured parameters are then mapped to an individual patient model and analyzed. Based on the development of these parameters, conclusions about the patient's condition as well as prognoses are possible. If a critical condition is detected, for example caused by respiratory distress, the ventilation can be optimally adjusted based on ventilation profiles. Combined with the monitoring functionality, this allows for a complete and prompt communication with the physician.

DISCUSSION AND CONCLUSION

Due to the innovative ventilation systems by Fritz Stephan GmbH, it is now possible to respond adaptively to changed lung parameters. The aim is to achieve the shortest possible ventilation periods with a concurrent improvement of the lung function. A lung-protective ventilation or an adapted weaning process support this and reduce the risk of ventilator-induced lung injury.

PROJECT TEAM

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PROJECT PARTNERS

Wolfgang Braun, Fritz Stephan GmbH

FUNDING

German Federal Ministry for Economic Affairs and Energy (BMWi)

PUBLICATIONS

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Neumann J, Wiemuth M, Burgert O, Neumuth T. Application of activity semantics and BPMN 2.0 in the generation and modeling of generic surgical process models. 31st Conference for Computer Assisted Radiology and Surgery (CARS). Barcelona, Spain; 2017.

Neumuth T. Universitäre Einrichtungen als Hersteller – Erfahrungen mit der DIN EN ISO 13485 Zertifizierung - Die Sicht des Wissenschaftlers. 62. Jahrestagung der Deutsche Gesellschaft für medizinische Informatik, Biometrie und Epidemiologie (GMDS). Oldenburg, Germany; 2017.

Neumuth T. The European Modular Field Hospital: Herausforderungen für IT beim Einsatz mobiler Krankenhäuser nach Naturkatastrophen. 62. Jahrestagung der Deutsche Gesellschaft für medizinische Informatik, Biometrie und Epidemiologie (GMDS). Oldenburg, Germany; 2017.

Rockstroh M, Franke S, Hofer M, Will A, Kasparick M, Andersen B, Neumuth T. Multi-perspective qualitative evaluation of an integrated operating room based on IEEE 11073 SDC. 31st Conference for Computer Assisted Radiology and Surgery (CARS). Barcelona, Spain; 2017.

Saleh K, Stucke S, Uciteli A, Faulbrück-Röhr S, Neumann J, Tahar K. Using Fast Healthcare Interoperability Resources (FHIR) for the Integration of Risk Minimization Systems in Hospitals. 16th World Congress on Medical and Health Informatics. Hangzhou, China; 2017.

Schreiber E, Franke S, Neumuth T. Intraoperative Prioritization and Consistent Presentation of Clinical Information. 31st Conference for Computer Assisted Radiology and Surgery (CARS). Barcelona, Spain; 2017.

Stoehr M, Cypko MA, Lemke HU, Dietz A. Integrating clinical viewpoints into the digital patient model for laryngeal cancer. 31st Conference for Computer Assisted Radiology and Surgery (CARS). Barcelona, Spain; 2017.

Unger M, Jochimsen T, Berger J. Set up of PET MR compatible robotics for FUS. 4th Symposium on Focused Ultrasound Therapy (EUFUS). Leipzig, Germany; 2017.

Westphal P, Hilbert S, Unger M, Chalopin C. Development of a tool-kit for the detection of healthy and injured cardiac tissue based on MR imaging. Current Directions in Biomedical Engineering. Dresden, Germany; 2017.

Xu D. Optimization of Tumor Therapy by Combination of Focused Ultrasound and Radiation Guided by MRI and PET-MRI. International Symposium for Therapeutic Ultrasound (ISTU). Nanjing, PRC; 2017.

Xu D. Combination Therapy for Cancer by PET-MR and MR Image Guided Focused Ultrasound and Radiation. International Symposium for Therapeutic Ultrasound (ISTU). Nanjing, PRC; 2017.

Xu D. Optimization of Tumor Therapy by Combination of Focused Ultrasound and Ionizing Radiation guided by (PET-)MRI. Annual Meeting of the European Society for Hyperthermic Oncology (ESHO). Athens, Greece; 2017.

Xu D, Landgraf L, Melzer A. Tumor therapy combining image-guided focused ultrasound and radiation therapy – introducing of SONO-RAY project. 4th Symposium on Focused Ultrasound Therapy (EUFUS). Leipzig, Germany; 2017.

Zhang X, Xu D, Landgraf L. An in vitro study of ultrasound-induced hyperthermia combined with radiation therapy for glioblastoma cells. 4th Symposium on Focused Ultrasound Therapy (EUFUS). Leipzig, Germany; 2017.

EVENTS

ICCAS COLLOQUIUM AND SEMINAR

JANUARY 25, 2017 | COLLOQUIUM

Speaker: Prof. Dr. Rebecca Fahrig | Head of Innovation at Advanced Therapies, Siemens Healthineers

Topic: Integrated Multi-Modality Solutions for Interventional and Minimally Invasive Surgery Procedures

MARCH 29, 2017 | COLLOQUIUM

Speaker: Dr. Björn Gerold | IMSaT, University of Dundee

Topic: Bubble-Enhanced Heating During Focused Ultrasound Surgery

MAY 15, 2017 | COLLOQUIUM

Speaker: Prof. Dr. Holger Grüll | Department of Radiology, University of Cologne

Topic: Thermal Combination Therapies Using MR-HIFU

AUGUST 9, 2017 | COLLOQUIUM

Speakers: Prof. Dr. Michael Uecker | Diagnostic and Interventional Radiology, Georg-August-Universität Göttingen and Prof. Dr. Christina Unterberg-Buchwald | Cardiac MRI, Georg-August-Universität Göttingen

Topic: Real-Time MRI: Basics and Implementation, Focused Myocard Biopsy

AUGUST 16, 2017 | COLLOQUIUM

Speaker: Prof. Dr. Volkmar Falk | Medical Director of Department of Cardiothoracic and Vascular Surgery, German Heart Center Berlin

Topic: Translation in Cardiology, Heart Medicine

NOVEMBER 1, 2017 | SEMINAR

Speaker: Dr. Renata Raidou | Technische Universität Wien

Topic: Visual Analytics for Digital Radiotherapy: Aiding the Development of a Tumor-Specific Pipeline

NOVEMBER 21, 2017 | COLLOQUIUM

Speaker: Dr. Heiko Enderling | MOFFITT Cancer Center Florida

Topic: Quantitative Models to Personalize Oncology

UNIVERSITY COURSES

LEIPZIG UNIVERSITY

Surgical Navigation, Mechatronics and Robotics
(lecture)

Computer Assisted Surgery
(practical course)

Medical Planning and Simulation Systems
(lecture)

Introduction to Computer Assisted Surgery
(lecture)

LEIPZIG UNIVERSITY OF APPLIED SCIENCES

System Innovation in Medicine
(lecture and seminar)

Developing Medical Products
(lecture and seminar)

Project Management for Engineers
(lecture)

System Engineering
(lecture)

CONFERENCES, SYMPOSIA, WORKSHOPS

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

FUTURE TECHNOLOGIES SCIENCE MATCH

January 26, 2017 | Dresden, Germany

Prof. Dr. Andreas Melzer | lecture: 'Computer-assistierte Chirurgie – ein Blick in die Zukunft'

EUROPEAN ASSOCIATION FOR ENDOSCOPIC SURGERY AND OTHER INTERVENTIONAL TECHNIQUES (EAES) – TECHNOLOGY WINTER MEETING 2017

February 3, 2017 | Frankfurt am Main, Germany

Prof. Dr. Andreas Melzer | director symposium

Prof. Dr. Thomas Neumuth | invited lecture: 'AI to Improve the Workflow in the OR. Fully Integrated OR – the German OR Network'

SPIE MEDICAL IMAGING CONFERENCE 2017

February 11 – 16, 2017 | Orlando, FL, USA

Erik Schreiber | invited lecture: 'Consistent and Prioritized Presentation of Surgical Information'

Prof. Dr. Heinz U. Lemke | invited lecture: 'Surgical PACS and the Digital Operating Room'; session chair: SPIE/CARS Workshop on the DOR

EUROPEAN MODULAR FIELD HOSPITAL (EUMFH) – FIRST STEERING COMMITTEE MEETING

February 13 – 14, 2017 | Rome, Italy

Prof. Dr. Neumuth | member: steering committee

SYMPOSIUM INTENSIVMEDIZIN + INTENSIVPFLEGE

February 15 – 17, 2017 | Bremen, Germany

PD Dr. Andreas Reske | invited lecture: 'Zwischen Wunsch und Realität: Wie weit sind wir beim klinischen Einsatz der elektrischen Impedanztomographie?'

SMART CYBER OPERATING THEATRE (SCOT) WORKSHOP

February 17 – 22, 2017 | Tokyo, Japan

Prof. Dr. Thomas Neumuth, Erik Schreiber, Stefan Franke | presentation: OR.Net at the Tokyo Women's Medical University

ECR LUNCH SYMPOSIUM ON FOCUSED ULTRASOUND

March 1, 2017 | Vienna, Austria

Prof. Dr. Andreas Melzer | lecture: 'State of the art of MRgFUS'

VISUAL COMPUTING IN BIOLOGY AND MEDICINE – ANNUAL WORKSHOP 2017

March 16, 2017 | Magdeburg, Germany

PD Dr.-Ing. Steffen Oeltze-Jafra | invited lecture: ‚Digital Patient Models'

INSTITUTE FOR TRANSLATIONAL MEDICINE & THERAPEUTICS (ITMAT) MEETING

March 16 – 17, 2017 | Edinburgh, Scotland, UK

Jan Gaebel | poster presentation: 'Therapy Decision Support System using Bayesian Networks with an example of Laryngeal Cancer'

134. KONGRESS DER DEUTSCHEN GESELLSCHAFT FÜR CHIRURGIE (DGCH)

March 21 – 24, 2017 | Munich, Germany

Prof. Dr. Thomas Neumuth | invited lecture: ‚Modellierung von chirurgischen Eingriffen'

EUROPEAN SCHOOL OF ONCOLOGY (ESO) MASTERCLASS

March 30, 2017 | Berlin, Germany

Prof. Dr. Andreas Dietz | invited lecture: 'Head and Neck Surgery'

13. DGBMT/FRAUNHOFER/SMIT SYMPOSIUM 'KRANKENHAUS DER ZUKUNFT' AT 47. KONGRESS DER DEUTSCHEN GESELLSCHAFT FÜR ENDOSKOPIE UND BILDGEBENDE VERFAHREN E.V. (DGE-BV)

April 06 – 08, 2017 | Berlin, Germany

Prof. Dr. Andreas Melzer, Dr. Thomas Wittenberg | organizing committee members; session chairs: Endo-Innovation CTAC/DGBMT Arzt meets Ingenieur I, DGBMT I

Prof. Dr. Andreas Melzer| lectures: 'Erfahrungen aus der Digital Operating Room Summer School', 'Computer

Assistierte Interventionen, Vision oder Realität?'
Juliane Neumann | invited lecture: 'Workflow Analyse im OP'

RADIOONKOLOGISCHES KOLLOQUIUM
April 12, 2017 | Leipzig, Germany
Prof. Dr. Andreas Melzer |invited lecture: 'Hochintensiver fokussierter Ultraschall (HiFU) und Radiotherapie. Vorstellung eines neuen Prinzips und gemeinsamen Projektes'

INFORMATICS FOR HEALTH 2017
April 24 – 28, 2017 | Manchester, UK
PD Dr.-Ing. Steffen Oeltze-Jafra, Dr.-Ing. Mario A. Cypko | Tutorial: 'Model-Based Therapeutic Decision Support - from a Probabilistic and a Physiological Perspective'
Dr.-Ing. Mario A. Cypko | lecture: 'Probabilistic Models for Therapeutic Decision Support'

38TH ANNUAL CONFERENCE OF THE EUROPEAN ASSOCIATION FOR COMPUTER GRAPHICS (EUROGRAPHICS 2017)
April 24 – 28, 2017 | Lyon, France
PD Dr.-Ing. Steffen Oeltze-Jafra | talk: 'Sketching and Annotating Vascular Structures to Support Medical Teaching, Treatment Planning and Patient Education'

CONHIT 2017
April 25 – 27, 2017 | Berlin, Germany
Prof. Dr. Thomas Neumuth, Dr.-Ing. Stefan Franke, Max Rockstroh | presentation: OR.Net activities on the Intelligent Operating Room

INTERNATIONAL IMAGINE SURGERY WORKSHOP AT CHARITÉ BERLIN
April 28 – 29, 2017 | Berlin, Germany
Prof. Dr. Thomas Neumuth | lecture: 'Model-Based Computer-Assisted Therapy: Requirements, Use Cases, Benefits'

MRT COLLOQUIUM
May 3, 2017 | Göttingen, Germany
Prof. Dr. Andreas Melzer | invited talk: 'Instrumente und Systeme für MR geführte Interventionen und Fokussierten Ultraschall'

RADIOONKOLOGISCHES KOLLOQUIUM
May 17, 2017 | Leipzig, Germany
Dr. Lisa Landgraf | project presentation: 'Radiosensibilisierung durch Fokussierten Ultraschall'

PARLAMENTARISCHER ABEND 'PHYSIK ALS MEDIZIN'
May 17, 2017 | Berlin, Germany
Prof. Dr. Andreas Melzer | invited presentation: Computer-Assisted Surgery and Intervention; talk: 'Krankheiten behandeln II (Operationen, Plasmamedizin)'

17TH INTERNATIONAL SYMPOSIUM FOR THERAPEUTIC ULTRASOUND (ISTU)
May 31 – June 02, 2017 | Nanjing, China
Prof. Dr. Andreas Melzer, Dr. Doudou Xu | posters: 'Optimization of Tumor Therapy by Combination of Focused Ultrasound and Radiation Guided by MRI and PET-MRI', 'Combination for Cancer by PET-MR and MR Image Guided Focused Ultrasound and Radiation Therapy'; scientific exhibition: SONO-RAY project

EURORV³ AT EUROVIS
June 12 – 13, 2017 | Barcelona, Spain
PD Dr.-Ing. Steffen Oeltze-Jafra | session chair: 'Perceptual Experiments and Insights'

19TH EG/VGTC CONFERENCE ON VISUALIZATION (EUROVIS)
June 12 – 16, 2017 | Barcelona, Spain
Dr.-Ing. Mario A. Cypko | lecture: 'Visual Verification of Cancer Staging for Therapy Decision Support'
PD Dr.-Ing. Steffen Oeltze-Jafra | member: program committee

11. DIGITAL-GIPFEL

June 12, 2017 | Ludwigshafen, Germany

Prof. Dr. Andreas Melzer, Prof. Dr. Thomas Neumuth, Dr.-Ing. Stefan Franke, Jan Gaebel | exclusive presentation: Intelligent Operating Room and Digital Patient Model

UK RADIOLOGICAL AND RADIATION ONCOLOGY CONGRESS (UKRC)

June 12 – 14, 2017 | Manchester, UK

Prof. Dr. Heinz U. Lemke | invited lecture: 'The Evolution of the Digital Operating Theatre for the Next 5 - 10 Years'; session chair: 'CARS Workshop'

17TH ANNUAL MEETING OF THE INTERNATIONAL SOCIETY FOR COMPUTER ASSISTED ORTHOPAEDIC SURGERY (CAOS)

June 14 – 17, 2017 | Aachen, Germany

Prof. Dr. Thomas Neumuth | invited lecture: 'Technical Approaches and Benefits of OR.NET Based Workflow Management'; session chair: 'OR.NET – Interoperability and Modular Dynamic Device-IT Interaction in OR and Clinic'

25TH INTERNATIONAL CONGRESS OF EUROPEAN ASSOCIATION OF ENDOSCOPIC SURGERY AND OTHER INTERVENTIONAL TECHNIQUES (EAES)

June 14 – 17, 2017 | Frankfurt am Main, Germany

Prof. Dr. Andreas Melzer | lecture: 'Focused Ultrasound for Surgical Diseases – an Overview'

Prof. Dr. Thomas Neumuth | session chair: OR.NET Satellite Symposium – OR.NET Goes Europe – State of the Art and Future Tasks of Device Integration in the Operating Room; lecture: 'Medical Device Integration in the OR – The German Flagship Project OR.Net'

SILICON SAXONY'S SCIENCE PITCH AT 12TH SILICON SAXONY DAY 'LOOKING BEYOND HORIZONS'

June 20, 2017 | Dresden, Germany

Dr. Lisa Landgraf | invited lecture: 'MR Guided FUS and HiFU – A New Way of Non-Invasive Precision Medicine'

ANNUAL CONFERENCE OF THE INTERNATIONAL SOCIETY FOR COMPUTER AIDED SURGERY (CARS)

June 20 – 24, 2017 | Barcelona, Spain

Prof. Dr. Andreas Melzer | invited lecture: 'Synergism of Ultrasound and MRI in Interventional Radiology'; session chair: 'Magnetic Resonance Imaging'; panel discussion: 'Moving into the Future of Radiology and Surgery'

Prof. Dr. Thomas Neumuth | session chair: 18th IFCARS/SPIE/ISCAS Joint Workshop on the Digital Operating Room

Erik Schreiber | lecture: 'Intraoperative Prioritization and Consistent Presentation of Clinical Information'

Max Rockstroh | lecture: 'Multi-Perspective Qualitative Evaluation of an Integrated Operating Room Based on IEEE 11073 SDC'

Juliane Neumann | lecture: 'Application of Activity Semantics and BPMN 2.0 in the Generation and Modeling of Generic Surgical Process Models'

Dr.-Ing. Mario A. Cypko | lecture: 'Quality Management of Therapy Decision Models Based on Multi-Entity Bayesian Networks'

Prof. Dr. Andreas Dietz | invited lecture: 'Computerized Clinical Decision Support for the Tumor Board'

PD Dr.-Ing. Steffen Oeltze-Jafra | session chair: '9th EPMA/IFCARS Workshop on Clinical Decision and Support Systems'

Prof. Dr. Heinz U. Lemke | invited lecture: 'Towards the Vision and Spirit of CARS with Innovative Clinical Investigations'; session chair: 'CARS Clinical Day'

Erik Schreiber | technical committee: IHE Surgery Meeting; invited lecture: 'IHE Work Items at ICCAS'

Dr.-Ing. Mario A. Cypko | organization committee: Young Investigators Networking Session (YINS) of the International Society for Computer Aided Surgery (ISCAS)

RESEARCH SEMINAR

June 21, 2017| Universitat politècnica de Catalunya (UPC), Barcelona, Spain

PD Dr.-Ing. Steffen Oeltze-Jafra | invited lecture: 'Visual Analytics of Medical and Biological Data'

MEDTECH SUMMIT

June 21 – 22, 2017 | Nuremberg, Germany

Prof. Dr. Thomas Neumuth | invited lecture: 'Medical Device Interoperability and Workflow Management in the Operating Room'

HAMLYN SYMPOSIUM

June 25 – 28, 2017 | London, UK

Prof. Dr. Andreas Melzer | member: organization committee; invited talk: 'Ultrasound and MR Guided Focused Ultrasound Therapy: SONO-RAY'

3RD FUTURE CONGRESS OF THE FEDERAL MINISTRY OF EDUCATION AND RESEARCH (BMBF)

June 26 – 27, 2017 | Bonn, Germany

Richard Bieck| presentation: BIOPASS project

COMPUTATIONAL HEALTH INFORMATICS

July 12, 2017 | Institute of Distributed Systems, Faculty of Electrical Engineering and Computer Science, Leibniz University Hannover, Hannover, Germany

Dr.-Ing. Mario A. Cypko | invited lecture: 'Therapy Decision Support System Using Bayesian Networks for Multidisciplinary Treatment Decisions in Oncology'

16TH WORLD CONGRESS ON MEDICAL AND HEALTH MEDINFO

August 21, 2017 | Hangzhou, China

Dr.-Ing. Mario A. Cypko | lecture: 'Therapy Decision Support System Using Bayesian Networks for Multidisciplinary Treatment Decisions in Oncology'; poster: 'Guided Expert Modeling for Clinical Bayesian Network Decision Graphs'

Jan Gaebel | poster: 'Towards the Consideration of Diagnostic Delay in Model-Based Clinical Decision Support'

PD Dr.-Ing. habil. Steffen Oeltze-Jafra, Dr.-Ing. Mario A. Cypko, Jan Gaebel | Tutorial: 'Model-Based Therapeutic Decision Support'

8TH SUMMER SCHOOL ON SURGICAL ROBOTICS

September 6 – 13, 2017 | Montpellier, France

Prof. Dr. Andreas Melzer | co-organizer; tutor: Image Guided Therapies (IGT)-Workshop

EUROGRAPHICS WORKSHOP ON VISUAL COMPUTING FOR BIOLOGY AND MEDICINE (EG VCBM)

September 7 – 8, 2017 | Bremen, Germany

Dr. Claire Chalopin | presentation: 'Application of Image Processing Functions for Brain Tumor Enhancement in Intraoperative Ultrasound Image Data'

JAHRESTAGUNG DER BIOMEDIZINISCHEN TECHNIK UND DREILÄNDERTAGUNG DER MEDIZINISCHEN PHYSIK DGBMT

September 10 – 13, 2017 | Dresden, Germany

Prof. Dr. Andreas Melzer | member: scientific board

Prof. Dr. Thomas Neumuth | member: scientific board; session chair: 'Special Session on Model-based Therapy'; lecture: 'Model-Based Therapy'

PD Dr.-Ing. Steffen Oeltze-Jafra | member: scientific board; session chair: 'Special Session on Model-based Therapy', lecture: 'Visualization for Model-Based Therapy Decision Support'

Marianne Maktabi | lecture: 'Measurement of Moisture at Skin Surface Based on Hyperspectral Technology'

Richard Bieck | lecture: 'Towards Standardized Surgical Robotics Interoperability for Intraoperative Assistance Systems'

Dr.-Ing. Mario A. Cypko | lecture: 'Therapy Decision Support System Using Bayesian Networks'

Dr.-Ing. Stefan Franke | lecture: 'Framework for Context-aware Assistance in Integrated Operating Rooms'

Max Rockstroh | lecture: 'Optimizing Procedures – Value Added Services Based on OR Integration'

Dr. Lisa Landgraf | poster: 'Combined PET-MR Guided Focused Ultrasound and Radiation Therapy to Improve Treatment of Cancer'

Dr. Claire Chalopin | poster: 'Development of a Tool-kit for the Detection of Healthy and Injured Cardiac Tissue Based on MR Imaging'

EXCELLENCE IN ONCOLOGY – KOPF-HALS-TUMOREN

September 16, 2017 | Frankfurt am Main, Germany

Prof. Dr. Andreas Dietz | invited lecture: 'Head and Neck Cancer'

62ND ANNUAL MEETING OF THE GERMAN ASSOCIATION FOR MEDICAL INFORMATICS, BIOMETRY AND EPIDEMIOLOGY (GMDS)

September 17 – 21, 2017 | Oldenburg, Germany

Jan Gaebel | lecture: 'Considering Information Up-To-Dateness to Increase the Accuracy of Therapy Decision Support Systems'

DRESDEN TALKS ON INTERACTION & VISUALIZATION

September 20, 2017 | Dresden, Germany

PD Dr.-Ing. Steffen Oeltze-Jafra | invited lecture: 'Visual Analytics of Medical Data'

INTERNATIONAL COOPERATION EDUCATION PROGRAM AT CANCER CENTER (NCC) IN SOUTH KOREA

September 22, 2017 | Goyang-si, South Korea

Prof. Dr. Andreas Melzer | lecture: 'The Future of Surgical Oncology by Non-Invasive MR Guided Focused Ultrasound'

XXVI. HUNGARIAN EXPERIMENTAL SURGICAL CONGRESS

September 28 – 30, 2017 | Budapest, Hungary

Prof. Dr. Andreas Melzer | invited lecture: 'Non-Invasive Ultrasound Surgery'

VISUAL ANALYTICS IN HEALTHCARE (VAHC)

October 1 – 2, 2017 | Phoenix, AZ, USA

PD Dr.-Ing. Steffen Oeltze-Jafra | tutorial: 'Visual Analytics of Cohort Study Data – From Individuals to Populations'

Juliane Neumann | poster: ‚Interactive Visualization of Functional Aspects in Head and Neck Cancer Aftercare'

BIOTECHNOLOGIE SYMPOSIUM

October 5, 2017 | Leipzig, Germany

Dr. Lisa Landgraf | poster: 'Translation of a Combination Therapy of MR-Guided Focused Ultrasound Hyperthermia (FUS-HT) and Radiation Therapy (RT) for Cancer Treatment into the Clinic'

16. JAHRESTAGUNG DER DEUTSCHEN GESELLSCHAFT FÜR COMPUTER- UND ROBOTERASSISTIERTE CHIRURGIE (CURAC)

October 5 – 7, 2017, Hannover, Deutschland

Prof. Dr. Thomas Neumuth | organization committee; session chair

Prof. Dr. Jürgen Meixensberger |program committee; session chair: Keynote 'Robotic Technologies and Micro-Technologies for Targeted Therapy: Challenges and Opportunities'

Juliane Müller | poster: 'Weiterentwicklung von Onco-Function – Tumornachsorge 2.0'

Dr. Claire Chalopin | poster: ‚Hyperspektrale Untersuchungen von koagulierten tierischen Gewebeproben'

BMBF-INNOVATIONSFORUM, KRANKENHAUS 4.0'

October 13 – 14, 2017 | Lübeck, Germany

Prof. Dr. Thomas Neumuth | lecture: 'Vernetzung von Medizingeräten im OP'; session chair: 'Clinical Unified Collaboration'

Max Rockstroh | lecture: ‚Prozesse im Operationssaal – Der Weg zum Intelligenten Operationssaal'

KINDERUNIVERSITÄT LEIPZIG

October 20, 2017 | Leipzig, Germany

Prof. Dr. Thomas Neumuth | lecture: 'Wie lernt ein Roboter operieren?'

EUFUS 2017 PRE-CONFERENCE WORKSHOP 'EXPERIMENTAL FUS AND HIFU'

October 25, 2017 | Leipzig, Germany

Dr. Lisa Landgraf | session chair: 'Phantoms and Cell Treatment'; lecture: 'Comparison of Experimental Setups for In Vitro Studies Using a Clinical HIFU Device'; hands-on-tutorial: 'Cell Culture Sonication'

Prof. Dr. Andreas Melzer | lecture: ‚Introduction to SONO-RAY'

Steffen Tretbar | lecture: 'Medical Ultrasound: from Imaging to FUS/HIFU'; session chair 'Bubbles, Cavitation and Simulations'

Johann Berger | lecture: 'Approaches for a Particle Based in Silico Simulation Model for Combined Effects of Ultrasound and Radiation on Tumor Cells'

Dr. Ina Patties | lecture: 'FUS/HIFU Supporting Radiation Therapy'

4TH SYMPOSIUM ON FOCUSED ULTRASOUND THERAPY – EUFUS 2017

October 26 – 27, 2017 | Leipzig, Germany

Prof. Dr. Andreas Melzer | general secretary; lecture: 'Translation of Research for MR Guided Focused Ultrasound Application for Moving Target Tumor Ablation in Abdominal Area: Coil Selection Criteria'

Michael Unger | lecture: 'Set up of PET MR Compatible Robotics for FUS'

Xinrui Zhang | lecture and poster: 'An In Vitro Study of Ultrasound-Induced Hyperthermia Combined with Radiation Therapy for Glioblastoma Cells';

Leonard Leifels | lecture: 'Germany: MR HIFU'

DGBMT AND VDE - WORKSHOP 'MR SAFETY AND COMPATIBILITY'

November 7, 2017 | Frankfurt am Main, Germany

Prof. Dr. Andreas Melzer | lecture: 'MR Safety and Compatibility: Clinical Application'

FUTURE MEDICINE SCIENCE MATCH

November 7, 2017 | Berlin, Germany

Prof. Dr. Thomas Neumuth | invited lecture: 'Model-Based Computer-Assisted Therapy'

MEDICA 2017 – THE WORLD FORUM FOR MEDICINE

November 13 – 16, 2017 | Düsseldorf, Germany

Johann Berger, Riechard Bieck, Juliane Müller | presentation: 'RoboDirect – 3D Model-Based, Ultrasound-Guided Directing Assistant for Needle Advancement'

COMPAMED 2017

November 13 – 16, 2017 | Düsseldorf, Germany

Prof. Dr. Andreas Melzer | invited lecture: 'MR-taugliche Instrumente'

2ND CONGRESS OF THE INTERNATIONAL GUILD OF ROBOTIC AND ENDOSCOPIC HEAD AND NECK SURGERY (IGR-EHNS)

November 30 – December 2, 2017 | Lausanne, Switzerland

Prof. Dr. Andreas Dietz | invited lecture: 'Transoral Robotic Surgery'

29TH CONFERENCE OF THE SOCIETY FOR MEDICAL INNOVATION AND TECHNOLOGY (SMIT)

November 9 – 10, 2017 | Torino, Italy

Prof. Dr. Andreas Melzer | session chair: 'Artificial Intelligence Technology & Surgery'
Prof. Dr. Thomas Neumuth | lectures: 'AI to Improve the Workflow in the OR – Fully Integrated OR – the German OR Network', 'The Role of Multitasking Platforms'

9. BESCHAFFUNGSKONGRESS DER KRANKENHÄUSER

December 6, 2017 | Berlin, Germany

Prof. Dr. Thomas Neumuth | moderator at expert forum: 'Medizintechnik 4.0: Prozessunterstützung und Standards in digitalen Prozessen'

INNOPLAN-SYMPOSIUM

December 8, 2017 | Heidelberg, Germany

Prof. Dr. Thomas Neumuth | invited lecture: 'Der integrierte Operationstrakt der Zukunft – Translation von der Wissenschaft in die klinische Routine.'

ICCAS GRADUATIONS IN 2017

DOCTORATE DEGREES

Mario A. Cypko

'Therapy Decision Support System Using Bayesian Networks for Multidisciplinary Treatment Decisions'

Leipzig University, Faculty of Mathematics and Computer Science

Elisée Ilunga Mbuyamba

'Brain Tumor Tissue Segmentation in Multimodal Images'

Guanajuato University (Mexico)

Stefan Franke

'Modeling of Surgical Procedures and Context-Aware Assistance in the Operating Room'

Leipzig University, Faculty of Mathematics and Computer Science

MASTER DEGREES

Christine Angrick

'Prozesssimulation und -optimierung im Bereich der orthopädischen Chirurgie hinsichtlich verschiedener OP Setups'

Münster University of Applied Sciences

Philip Westphal

'Development of a Tool-Kit for the Detection of Cardial Scar Tissue Based on Magnetic Resonance Imaging'

University of Glasgow (UK)

Reinhard Fuchs

'Entwicklung und Evaluation einer Instrumentenerkennungsmethode für das intraoperative Aktivitätstracking mittels Multi-Sensor-Armband'

Leipzig University of Applied Sciences

Lisa-Marie Kunz

'Entwicklung eines Ergonomie-Konzeptes für interaktive Assistenz- und Planungssysteme in bildgestützten Interventionen'

Technical University of Munich

Gero Kraus

'Entwicklung eines Robotik-basierten Assistenzsystems für die kollaborative Workflowunterstützung in der Interventionellen Radiologie'

Leipzig University of Applied Sciences

Steffen Pade

'Developing an Application for Bayesian Network Modelling'

Free University of Berlin

BACHELOR DEGREE

Stefanie Schlinke

'FHIR Meets Bayesian Networks: Anpassung eines Kommunikationsstandards für Entscheidungsmodelle'

Leipzig University of Applied Sciences

HONORS AND AWARDS

PD Dr.-Ing. Steffen Oeltze-Jafra:

PD Dr. Steffen Oeltze-Jafra received the Dirk Bartz Prize for Visual Computing in Medicine (2nd place) together with computer scientists and physicians of the Otto-von-Guericke-University Magdeburg. The prize was awarded at the Annual Conference of the European Association for Computer Graphics (Eurographics 2017) for the successful research on interactive sketching and annotation of vascular structures to support the medical training, therapy planning and patient education.

Xinrui Zhang:

At the 4th European Symposium on Focused Ultrasound Therapy Xinrui Zhang was recognized for the presentation on 'An in vitro study of ultrasound-induced hyperthermia combined with radiation therapy for glioblastoma cells' (project SONO-RAY) on 27 October, 2017.

Dr.-Ing. Mario A. Cypko

Dr.-Ing. Mario A. Cypko was elected to the Computer Assisted Radiology and Surgery (CARS) program- and congress organizing committee.

ORGANIZATION

EXECUTIVE DIRECTOR

Melzer, Andreas	Human Medicine & Dentistry

VICE DIRECTOR

Neumuth, Thomas	Computer Science, Electrical Engeneering

STAFF

Athner, Katrin	Business Management
Angrick, Christine	Biomedical Engineering
Bailis, Nikolaos	Chemistry, Human Medicine
Beimler, Maximilian	Human Medicine
Berger, Johann	Computer Science
Bieck, Richard	Computer Science
Chalopin, Claire	Medical Imaging
Cypko, Mario	Computer Science
Fischer, Marcus	Humanities
Fitzner, Anne	Office Communication
Franke, Stefan	Computer Science
Fuchs, Reinhard	Electrical Engineering and Information Technology
Gaebel, Jan	Computer Science
Georgi, Christoph	Computer Science
Girrbach, Felix	Human Medicine
Graebeling, Nico	Computer Science
Hermes, Florian Ganymed	Human Medicine
Heuft, Lara	Human Medicine
Hikal, Aisha	Human Medicine
Kindler, Johannes	Computer Science
Köhler, Conny	Biomedical Engineering
Krabbes, Frederik	Humanities
Kraus, Gero	Computer Science
Kreußel, Dennis	Computer Science
Kunz, Lisa-Marie	Human Factors Engineering
Landeck, Tobias	Human Medicine
Landgraf, Lisa	Biology
Lang, Norbert	Computer Science
Leifels, Leonard	Human Medicine
Lindner, Dirk	Human Medicine
Maktabi, Marianne	Computer Science
Melasch, Juliana Teresa	Human Medicine
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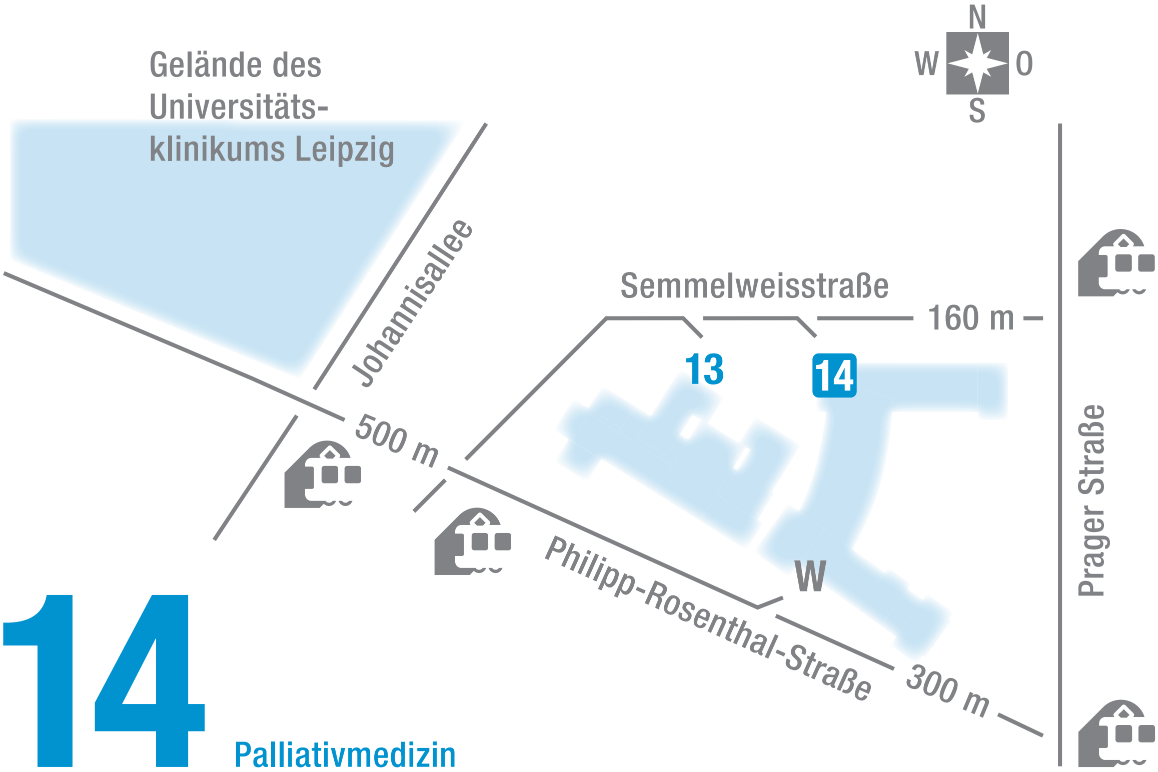

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