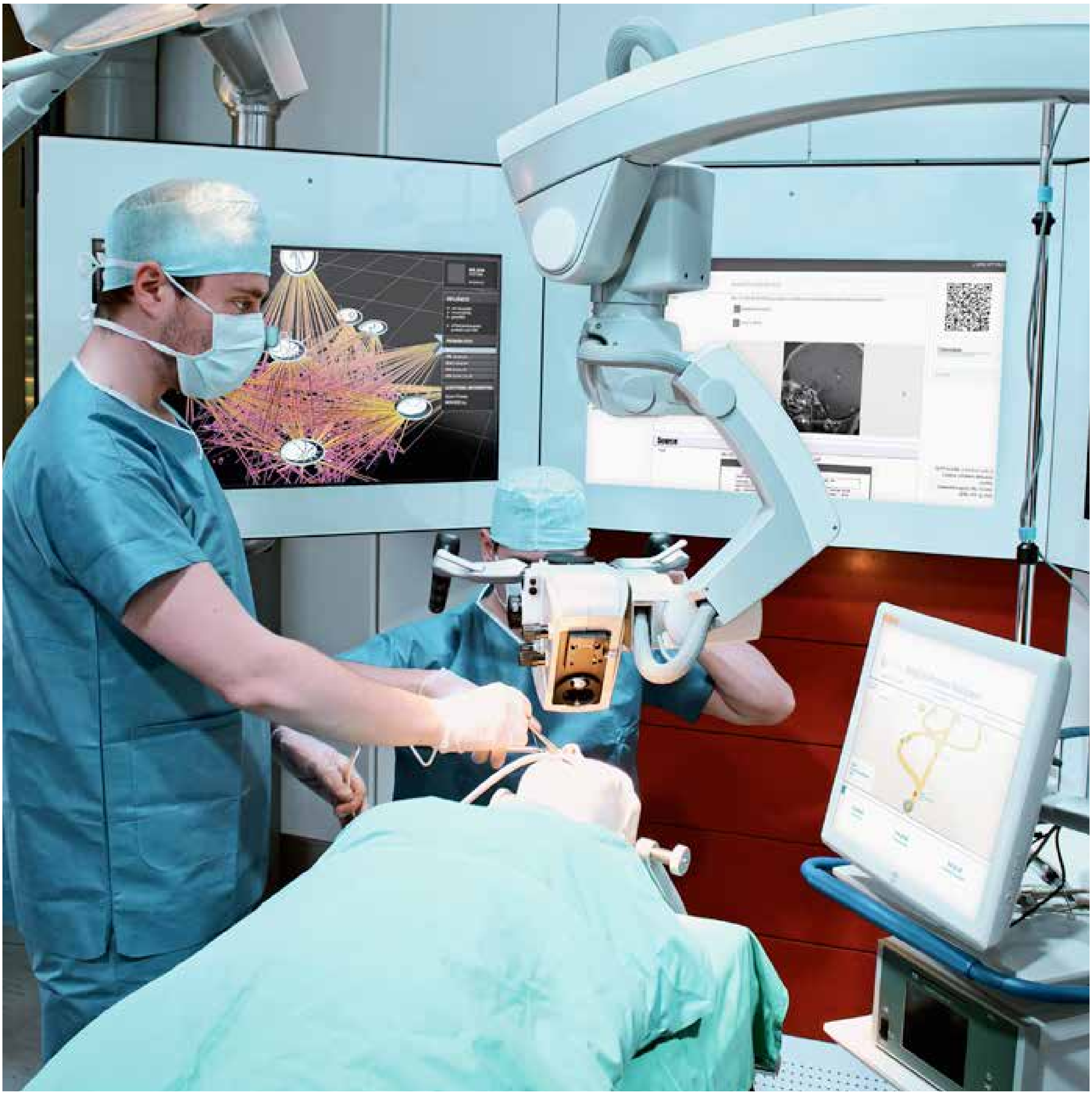
UNIVERSITÄT LEIPZIG

Medizinische Fakultät

2014
ANNUAL REPORT



iccas

IMPRINT

Editor

Innovation Center Computer Assisted Surgery (ICCAS)
Medizinische Fakultät
Universität Leipzig
Semmelweisstraße 14
04103 Leipzig
Germany

E-Mail: info@iccas.de

Executive Director
Prof. Dr. Andreas Melzer

Layout
Kathrin Scholz
Alexander Oeser
Christoph Zeumer

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PREFACE

Continuing its endeavors towards the surgical cockpit, in 2014 ICCAS focussed on additional aspects of patient modelling, process automation, supporting decision-making, and standardizing information exchange. Its main fields of work can be described as follows:

Digital Patient and Process Model: Digital patient records consist of a large number of isolated data entries provided by various health information systems and medical devices. The vision of the Digital Patient Modeling project group is to make this data and the relevant clinical knowledge available in a clear, concise manner before, during and after surgery.

Model-based Automation and Integration: The vision of this research group is an interlinked technical infrastructure in which all the elements work smoothly together. The resulting surgical workplace will have the potential to qualitatively and quantitatively improve surgical treatment. The goal is to develop prototypical workflow management systems as well as control and monitoring systems for the technical infrastructure in the digital operating room.

Standards: The digital operating room comprises several IT systems. In order to benefit from all their functions, data exchange is vital. The aim of the Standards group is to provide interoperability on various levels of integration for the international community. This should lead to more robust systems with a wider range of functionality.

To tackle these challenges, we are working on new solutions in the following areas:
» Digital patient modeling using probabilistic graphs
» Information modeling employing openEHR and other standards
» Surgical decision-making support through information aggregation and visualization
» Training of health professionals
» Workflow automation

All these areas are addressed in the projects described in ICCAS's annual report by the researchers carrying them out. If you are interested in any of these projects, feel free to contact us regarding joint projects and partnerships. Alternatively, why not join ICCAS as a Ph.D. student or senior researcher in order to work on the foremost questions of computer-assisted surgery today and tomorrow?

In 2014, ICCAS successfully hosted the first Digital Operating Room Summer School, where participants from Germany and abroad were given insights into cutting-edge information technology for the digital operating theater.

In September 2014, Prof. Dr. Andreas Melzer joined ICCAS as its director. He was simultaneously appointed professor of computer-assisted surgery at the Faculty of Medicine at Universität Leipzig. Thanks to his research background in medical engineering and robotics, ICCAS has gained a very experienced scientist and director. His arrival will strengthen ICCAS and its various fields of research. Everyone at ICCAS would like to extend a very warm welcome to him.

Prof. Dr. med. Jürgen Meixensberger
Board ICCAS

PREFACE

by the new Director of ICCAS

First of all, I'd like to sincerely congratulate the ICCAS team members on their outstanding achievements over the past ten years since ICCAS was founded. Under the careful guidance of the ICCAS Board (consisting of Professors Andreas Dietz, Gero Strauß, Heinz U. Lemke and Friedrich W. Mohr, and chaired by Professor Jürgen Meixensberger), exceptional, internationally recognized research has been established in digital patient and process modeling as well as model-based automation and integration. Moreover, crucial first steps have been taken towards standardization in tomorrow's digital operating room. This exciting work and related activities are outlined in this 2014 annual report.

It's both a privilege and an honor to join the outstanding ICCAS team and I'm delighted to accept the position of director. My primary goal will be to support the researchers and scientists in their efforts to secure long-term research in the area of computer-assisted surgery.

My background includes pioneering work in the development of endoscopic and laparoscopic surgery in Professor Gerhard Buess's group in Mainz and Tübingen (1986–93), early work on MRI-compatible devices and the development of MRI-guided clinical procedures (1994–2001), and introducing one of the first bachelor's and master's programs in applied medical technology at University of Applied Sciences Gelsenkirchen (1998–2006). Since 2006 I'm holding the Chair of Medical Technology and the position as founding director of the Institute for Medical Science and Technology (IMSaT), a joint venture of the Universities of Dundee and St Andrews (UK) initiated by Sir Alfred Cuschieri. Based on my previous work and my experience in image-guided therapy, my main goal will be to extend ICCAS's current objectives into the areas of computer-assisted diagnosis and therapy by involving additional medical disciplines such as interventional radiology, nuclear medicine, gynecology, urology, gastroenterology and general surgery. I also intend to foster national and international collaboration with for example Fraunhofer and Max Plank institutes and to expand the ICCAS network to other leading centers in Europe, the United States and Asia.

I am indebted to the Faculty of Medicine of the University of Leipzig for providing such generous funding for our forthcoming research on MRI-guided focused ultrasound. MRg-FUS, which has already been performed on more than 12,000 patients worldwide, is the first completely computerized non-invasive »theranostic« technology involving a true closed-loop control of tissue ablation – and is hence a logical extension of ICCAS's existing research.

Finally, I'd like to emphasize how much I'm looking forward to working at the University of Leipzig!

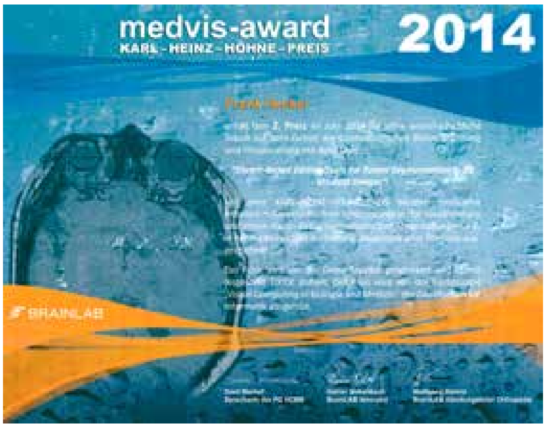
Prof. Dr. med. Andreas Melzer
Executive Director ICCAS

Awards for innovation at ICCAS

In March 2014, the IT Innovation Awards were presented by Initiative Mittelstand, a key platform representing medium-sized businesses. The »Best of 2014« title in the e-health category went to the oncoflow IT system – a novel information system which for some time has been supporting doctors treating cancer patients with tumors in the head and neck at Leipzig University Hospital. This makes oncoflow one of this year's most outstanding IT products in the German-speaking countries. oncoflow was developed by Jens Meier from the Model-based Automation and Integration (MAI) research group together with ENT specialists from Leipzig University Hospital.

The three authors of the winning poster at the MMVR in California (from left to right Mario Cypko, Prof. H.U. Lemke, Dr. Dr. med. Dave Warner).

Meanwhile, Mario Cypko from the Digital Patient and Process Model (DPM) group received awards for his poster presentations at the 12th Leipzig Research Festival and the NextMed/MMVR21 Conference 2014 in Manhattan Beach, California (USA). His award-winning work involved the development of multi-entity Bayesian networks (MEBNs) enabling the modeling of treatment decisions and the visualization of patient data to make therapy management more transparent and comprehensible. The development of expert-based support systems for interdisciplinary oncological decision-making is another worldwide unique selling point for the DPM research group.



In September 2014, the Karl-Heinz Höhne Prize was awarded to Frank Heckel, a visiting scientist on secondment to ICCAS from MEVIS (Fraunhofer Institute for Medical Image Computing). After Silvia Born in 2012, this was the second time that the legendary MedVis Award for junior scientists making outstanding contributions to diagnosis, planning and intervention in medicine on the basis of imaging techniques had gone to ICCAS. The German Informatics Society's Visual Computing for Biology and Medicine group praised Heckel's work on the interactive post-correction of automatically generated segmentation results in oncology.

Together at the 28th CARS Congress in Japan

In June 2014, the scientific community of developers and users of computer-assisted medical systems met up in the Japanese city of Fukuoka for the 28th International Congress of Computer Assisted Radiology and Surgery (CARS). This congress is always an important platform for project presentations and discussions for ICCAS. This year, the Standards research group presented existing solutions as well as DICOM and IHE surgical data objects and profiles which are currently under development. The Digital Patient and Process Model research group explained the progress made in developing a system to model medical treatment decisions as well as the results of a tumor board analysis from a doctor's viewpoint.

Long-standing workshop at MICCAI 2014

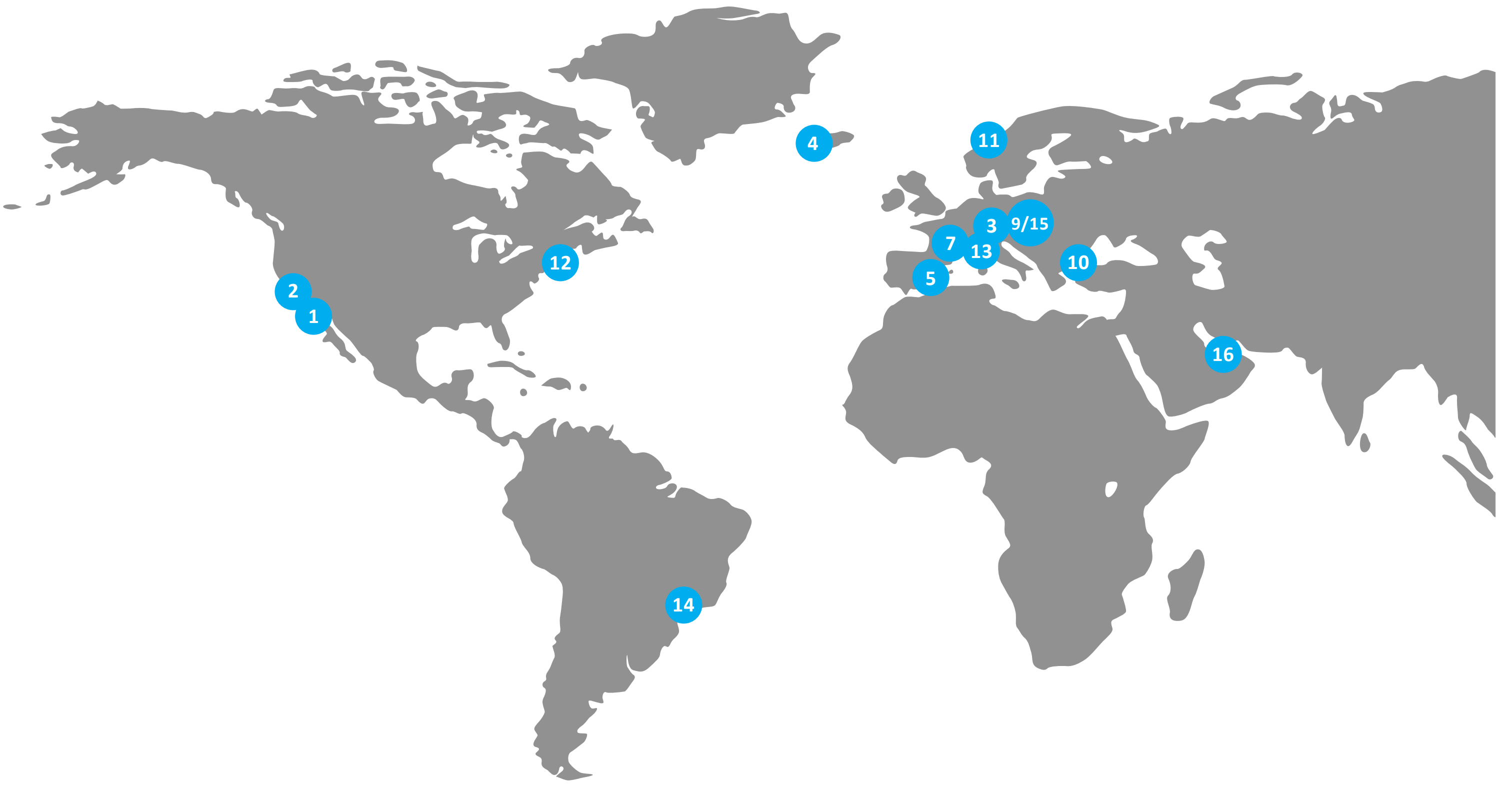
For several years, conference papers have been regularly presented by the Model-based Automation and Integration group at M2CAI – the Workshop on Modeling and Monitoring of Computer Assisted Interventions. The workshop (which is part of the extensive program at the annual MICCAI International Conference on Medical Image and Computer Assisted Intervention) once again featured a wide range of papers on the analysis, modeling and application of surgical workflows.
Selected project presentations on ICCAS's latest findings were given by Bernhard Glaser (»Eye-Tracking Analysis of Scrub Nurse Viewing«) and Stefan Franke (»Online Generation of Multi-Perspective Surgical Situation Descriptions«).

Successful launch for the ICCAS Digital Operating Room Summer School

Participants of DORS 2014 with Prof. Dr. Thomas Neumuth (left).

The first ICCAS Digital Operating Room Summer School, which was held at the Augusteum and Bibliotheca Albertina in Leipzig from September 22 to 26, 2014, was an enormous success. Renowned experts from the worlds of medicine, engineering and clinical practice explained the latest techniques to international participants. The summer school addressed developments and challenges in IT for the digital operating room and included demonstrations of practical applications. And in addition to an introduction to human physiology and anatomy, it gave insights into modern procedures and technologies at the International Reference and Development Centre for Surgical Technology and the ENT Department at Leipzig University Hospital. Finally, participants were even able to try out the latest developments for themselves during workshops staged at ICCAS. Afterwards, they were full of praise for the insightful lectures and discussions with specialists as well as the hands-on opportunities.

CONFERENCES WITH ICCAS CONTRIBUTIONS ABROAD IN 2014



1 SPIE Medical Imaging 2014 | San Diego, CA, USA | 15-20 February 2014

2 NEXTMED / MMVR21- Medicine Meets Virtual Reality- Conference 2014 | Manhattan Beach, CA, USA 19-22 February 2014

3 2nd eHealth Summit Austria 2014 | Vienna, Austria | 21-25 May 2014

4 LREC 2014- 9th International Conference on Language Resources and Evaluation | Reykjavik, Island 26-31 May 2014

5 BHI 2014- 2nd International Conference on Biomedical and Health Informatics |Valencia, Spain | 01-04 June 2014

6 CARS 2014- 28th International Congress of Computer Assisted Radiology and Surgery | Fukuoko, Japan 25-28 June 2014

7 Deutsch-Französischer HNO-Kongress 2014 | Lyon, France | 26-28 June 2014

8 37th Annual International ACM SIGIR Conference | Gold Coast, Australia | 06-11 July 2014

9 ICBES 2014- International Conference on Biomedical Engineering and Systems | Prague, Czech Republic 14-15 August 2014

10 MIE 2014- 25th European Medical Informatics Conference | Istanbul, Turkey | 31 August- 03 September 2014

11 VPH 2014- Virtual Physiological Human Conference | Trondheim, Norway | 09-12 September 2014

12 MICCAI 2014- 17th International Conference on Medical Image Computing and Computer Assisted Intervention | Boston, MA, USA | 14-18 September 2014

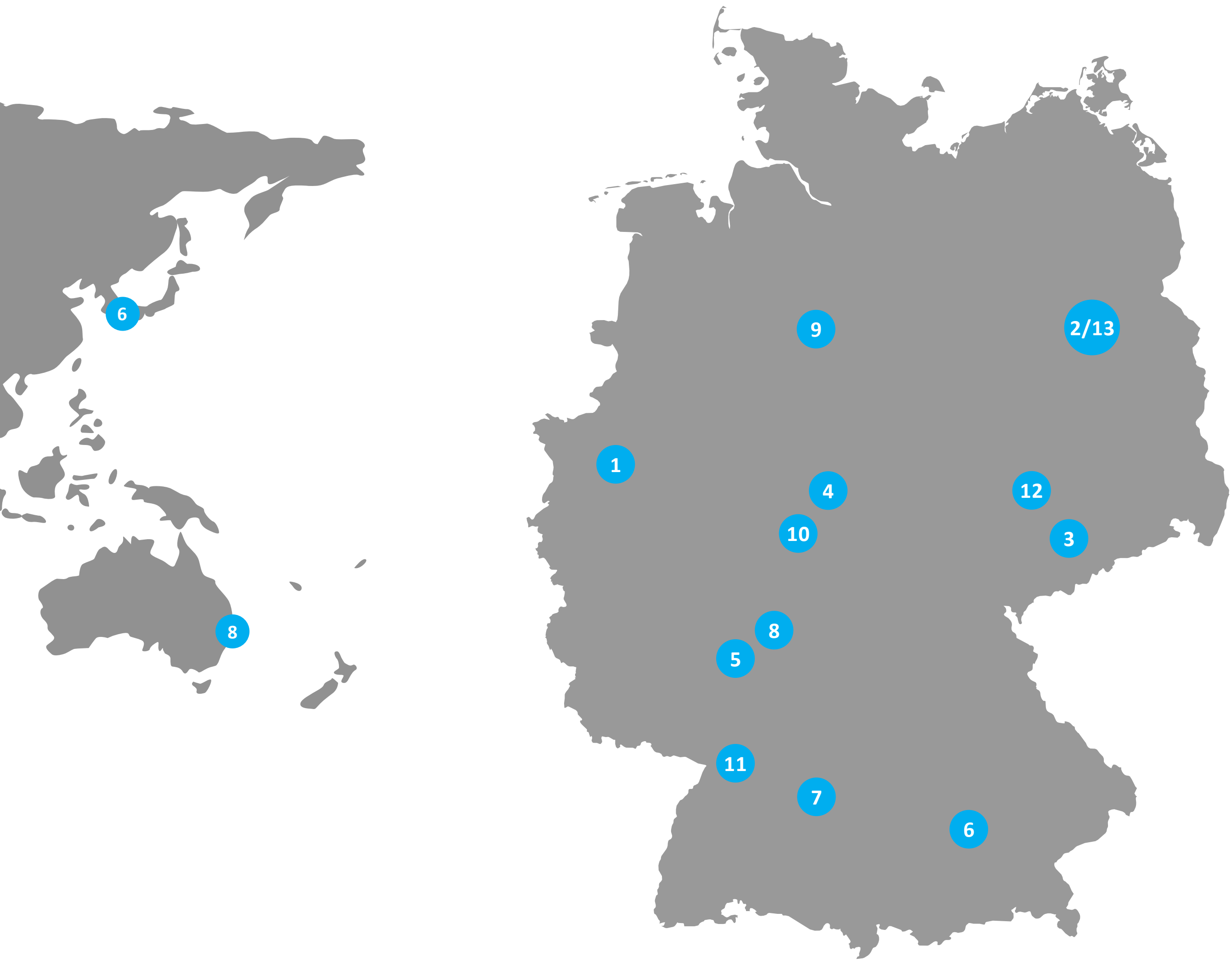
13 EACTS 2014- 28th Annual Meeting of the European Association for Cardio-Thoracic Surgery | Milan, Italy 11-15 October 2014

14 V. Joint Meeting of the Brasilian and German Society of Neurosurgery | Sao Paulo, Brasilia 21-23 February 2014

15 15th European Congress of Neurosurgery (EANS 2014) | Prague, Czech Republic | 12-17 October 2014

16 Rhinology Unites (ISIAN-IRS-PARS 2014) | Dubai, UAE | 22-24 November 2014

CONFERENCES WITH ICCAS CONTRIBUTIONS IN GERMANY IN 2014



1 85th Annual Meeting of the German Society of Oto-Rhino-Laryngology, Head and Neck Surgery | Dortmund 28 May- 1 June 2014

2 conhIT 2014- Connecting Healthcare IT | Berlin | 06-08 May 2014

3 23th Annual Meeting Vereinigung Mitteldeutscher Hals-Nasen-Ohrenärzte 2014 | Chemnitz | 5-6 September 2014

4 GMDS 2014 - 59th Annual Conference German Association for Medical Informatics, Biometry and Epidemiology Göttingen | 07-10 September 2014

5 KIS-RIS-PACS and DICOM Meeting 2014 | Mainz | 18-20 June 2014

6 CURAC 2014- 13th Annual Conference of the German Society for Computer and Roboter-Assisted Surgery Munich | 11-13 September 2014

7 INFORMATIK 2014- 44. Jahrestagung der Gesellschaft für Informatik | Stuttgart | 22-26 September 2014

8 InSim 2014 – Interdisziplinäres Symposium zur Simulation in der Medizin | Frankfurt a. M. | 25-27 September 2014

9 DGBMT 2014- 48th Annual Conference of the German Society for Biomedical Engineering | Hannover 08-10 October 2014

10 HL7 IHE Annual Meeting 2014 | Kassel | 22 October 2014

11 data2day 2014 | Karlsruhe | 26-28 November 2014

12 Deutscher Anästhesiekongress 2014 | Leipzig | 08-10 May 2014

13 131. Kongress der Deutschen Gesellschaft für Chirurgie | Berlin | 25-28 March 2014

MAI

MODEL-BASED AUTOMATION AND INTEGRATION

RESEARCH VISION

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

Model-based Automation and Integration

Group leader

Prof. Dr. Thomas Neumuth

thomas.neumuth@medizin.uni-leipzig.de

The development of new technical and organizational concepts is crucial for improved surgical therapies in the operating room. Research by »Model-based Automation and Integration« (MAI) revolves around the development of advanced surgical assist systems to provide optimal support for surgery. Research focusses on the integration and presentation of pre- and intraoperative information to support surgical management within the overall patient treatment process.

The group's main developments address advanced technologies such as surgical workflow recognition systems, situation monitoring and the storage infrastructure, workflow management systems, treatment planning and integration systems.

Its findings have been presented at industry expos such as CeBIT and conhIT, and discussed in dedicated workshops at the CARS and MICCAI conferences. Its projects are currently funded by the BMBF German Ministry of Education and Research, the BMWi German Ministry for Economic Affairs and Energy, the European Social Fund, and Siemens Healthcare.

Selected Publications

Glaser B, Daenzer S, Neumuth T. Intra-operative surgical instrument usage detection on a multi-sensor table, Int J Comput Assist Radiol Surg. 2014. [in print]

Meier J, Boehm A, Kielhorn A, Dietz A, Bohn S, Neumuth T. Design and evaluation of a multimedia electronic patient record »oncoflow« with clinical workflow assistance for head and neck tumor therapy. Int J Comput Assist Radiol Surg. 2014. [in print]

Unger M, Chalopin C, Neumuth T. Vision-based online recognition of surgical activities. Int J Comput Assist Radiol Surg. 2014. [in print]

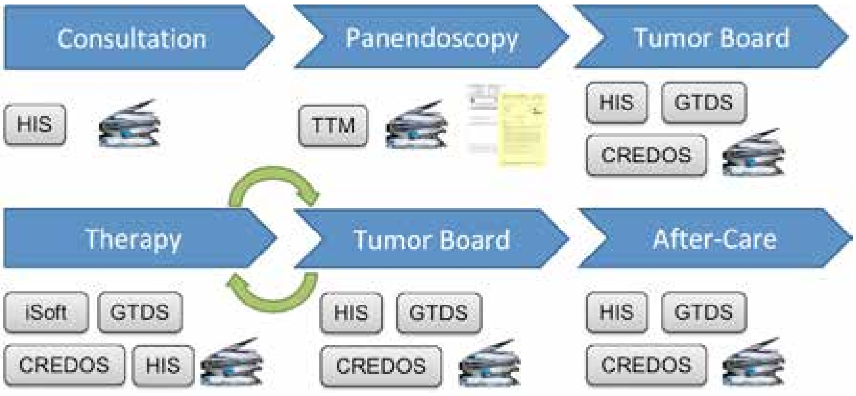


Fig. 1 - Treatment process and clinical information systems used for patients with head and neck cancer.

CLINICAL WORKFLOW ASSISTANCE IN HEAD AND NECK TUMOR THERAPY

The oncoflow information system was developed in close cooperation with physicians and surgeons from ENT surgery. It integrates patient-specific information on tumor patients into a central database in order to provide efficient workflow support throughout the patient's entire treatment process and to facilitate clinical studies.

Information management in tumor therapy is a challenging process for physicians and surgeons because the documentation of clinical results is primarily driven by economic rather than clinical considerations. Numerous assistance and decision support systems are used in daily clinical routine to relieve physicians and surgeons from repetitive, time-consuming tasks as well as to provide support for complex therapy planning scenarios (see Fig. 1). However, these systems do not integrate smoothly into the clinical workflow and are poorly integrated into the clinical IT landscape. Moreover, their possibilities for sharing patient-specific information with each other are limited, as is access to the raw data in the database. This leads to inefficient, time-consuming clinical workflows, error-prone copy and paste procedures, and internal department databases for clinical studies or quality management even though all the information is already available in digital form.

We developed a sophisticated, web-based clinical information system known as *oncoflow* which is intended to support the physician and clinical staff throughout the entire therapy process. Relevant patient-specific information is automatically imported from leading clinical information systems such as the Hospital Information System (HIS) and the Tumor Therapy Manager (TTM) into a central database, restructured according to clinical needs, and presented within a structured web interface. The *oncoflow* system supports the entire oncological treatment process from

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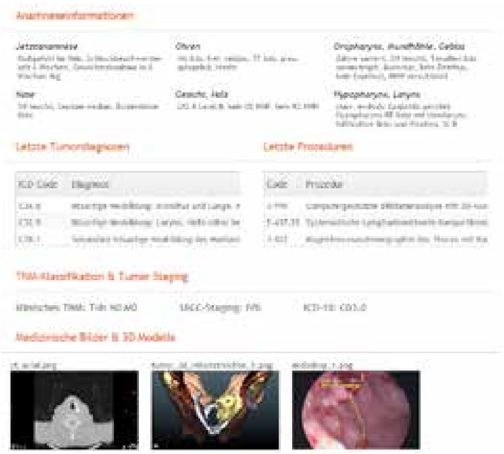


Fig. 2 - The treatment summary gives a brief overview of the patient's current medical status.

the initial consultation until follow-up documentation. Additional information is gathered within each process step to efficiently support clinical studies, quality management and cancer center certification processes.

Three major assistance functions should be mentioned in more detail. The first consultation consisting of an anamnesis and clinical examination of the patient has been improved significantly with *oncoflow*. All questions to the patient have been standardized throughout the clinic and implemented as a structured form in the web browser. A subsequent clinical study indicated an improved workflow which was 71% more structured than before.

Secondly, tumor board management including patient scheduling, invitation mailings, results documentation and protocol mailings has been implemented in *oncoflow*. It improves the clinical workflow and relieves the physicians and surgeons from the time-consuming handling of numerous Word documents each week.

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

Jens Meier
Dipl.-Ing.

j.meier@medizin.uni-leipzig.de

Stefan Bohn
Dr.-Ing.

stefan.bohn@iccas.de

Thomas Neumuth
Prof. Dr.

thomas.neumuth@medizin.uni-leipzig.de

CONTRIBUTORS

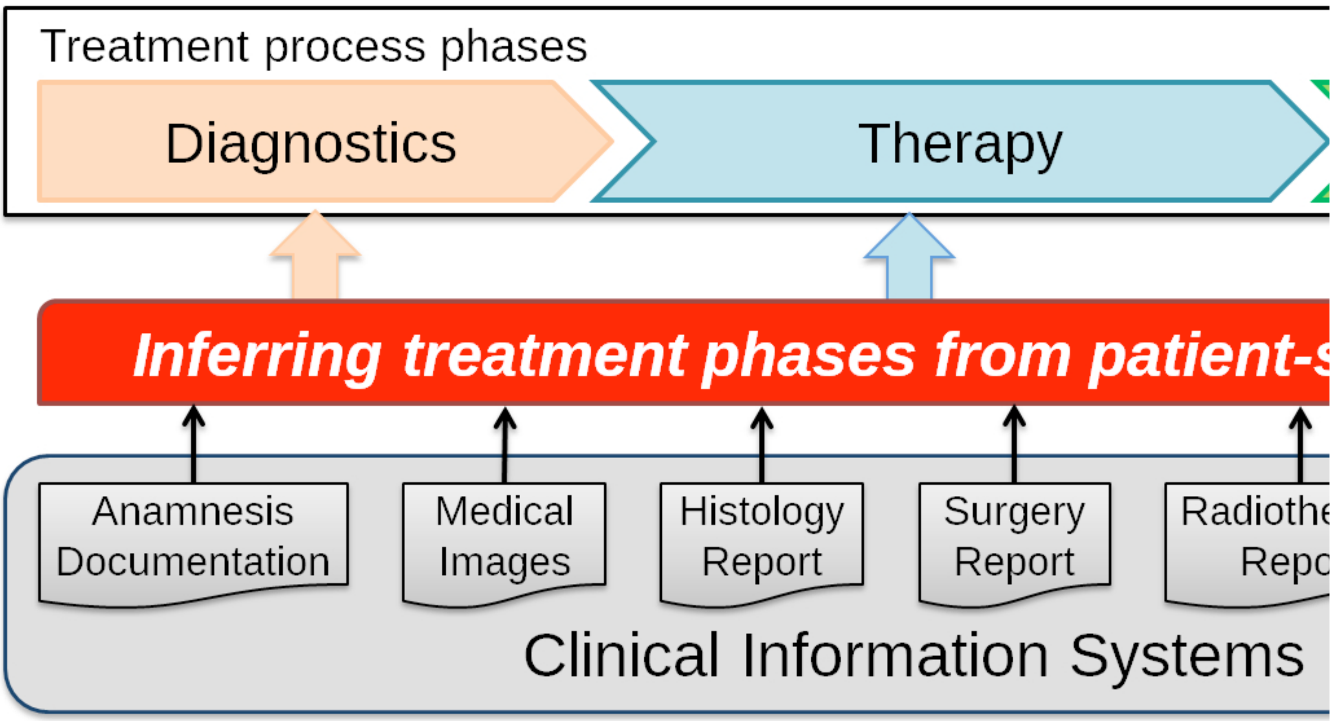
Oliver Krauß (M. Sc.)

PARTNERS

Leipzig University Hospital
Department of ENT-Surgery
Dr. med. Andreas Boehm

Dornheim Medical Images GmbH Magdeburg

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung
ZENTREN FÜR INNOVATIONSKOMPETENZ
UNTERNEHMEN REGION
Die BMBF-Innovationsinitiative Neue Länder



RECOGNITION OF CLINICAL WORKFLOW STEPS FROM PATIENT-SPECIFIC INFORMATION

Patient-specific information in clinical information systems frequently lacks information about the clinical workflow. The aim of this project was to automatically predict workflow steps based on patient-specific information using Hidden Markov Models. The resulting recognition rates were as high as 90%.

Knowledge about the clinical context is crucial for the development of sophisticated clinical workflow assistance and decision support systems. This clinical context may include information about the patient, disease patterns, attending physicians, and the current working step in the overall treatment process. Unfortunately, this information is hardly available in an appropriate manner in well-established clinical information systems.

This research project focusses on recognizing the patient's progress in the overall treatment process based on the information entities available in clinical information systems (see Fig. 1). Therefore, we used anonymized Electronic Patient Records (EPRs) from the oncoflow information system and created stochastic models

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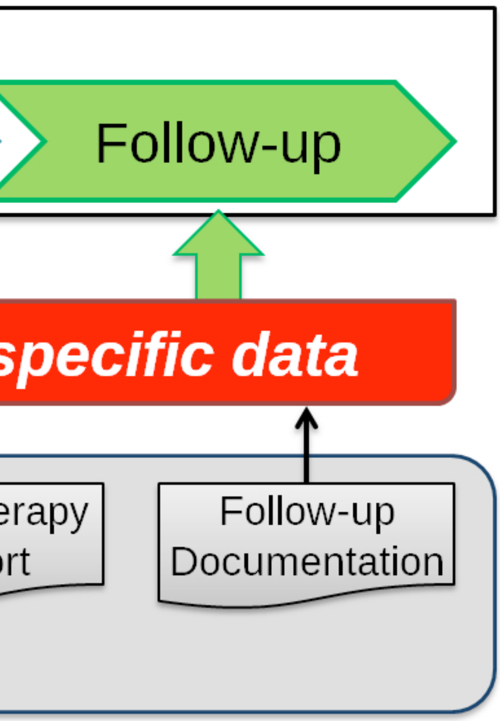

Fig. 1 - Inference of clinical workflow steps from patient-specific information.

based on Hidden Markov Models (HMMs). These models represent average clinical workflows for the treatment of tumor patients in head and neck surgery consisting of first consultation, panendoscopy, tumor board, surgical interventions, radiochemotherapy and follow-up meetings. In each of these workflow steps, information entities such as ICD10 or ICPM codes, radiological reports, histopathological findings, OR reports or follow-up documentation was created and served as observations during model creation and evaluation. These patient-specific information entities were then manually tagged with the correct workflow step and afterwards used for model training. Subsequently, these models were used for the classification of untagged patient-specific information within a controlled leave-one-out cross validation study. Forty EPRs were included in the study.

The study was performed for each EPR as follows. An HMM was created from all previously tagged EPRs except the EPR under consideration in the current cycle. Afterwards, untagged information entities from the omitted EPR were transferred to the model in chronological order and the model was able to predict the treatment step for each information entity. Finally, the correctness of the predicted workflow steps was confirmed for this EPR. This study was repeated for each of the 40 EPRs.

The results of the study are very promising. We achieved recognition rates of up to 90%, indicating that the clinical workflow can be accurately deduced from patient-specific information. Further research should focus on model creation with a much higher number of EPRs in order to improve the recognition results. Finally, this basic research paves the way for the development of intelligent clinical workflow support systems which improve the efficiency and safety of the patient treatment process.

Jens Meier
Dipl.-Ing.

j.meier@medizin.uni-leipzig.de

Thomas Neumuth
Prof. Dr.

thomas.neumuth@medizin.uni-leipzig.de

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung
ZENTREN FÜR INNOVATIONSKOMPETENZ
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Die BMBF-Innovationsinitiative Neue Länder

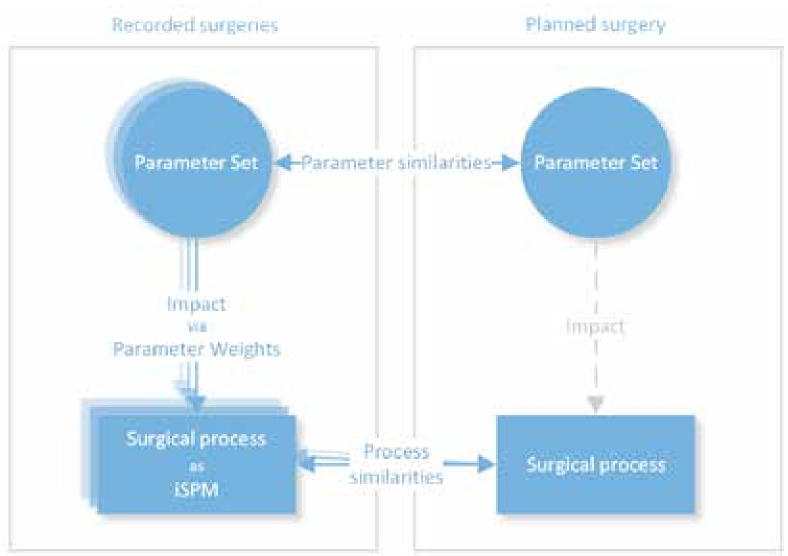

Fig. 1 - Simplified generation of a gSPM from two iSPMs.

GENERIC ESTIMATION OF PREDICTORS AND THEIR IMPACT ON SURGICAL PROCESSES

The SWAP module for oncoflow enables the impact of factors such as patient age, the surgeon, and tumor location on the workflow of a surgical procedure to be measured. Knowing about the effect of these factors allows the workflow of upcoming surgery to be estimated by comparing factor values of the patient with values from the database. Furthermore, it provides a method to select surgical workflows from the database which are likely to be similar to the impending surgery.

Interaction between patients, medical personnel and technical resources means that workflows in medicine are subject to multiple influencing factors. As a result, surgical procedures are very costly and their outcome is highly variable. In fact the operating room is one of the most expensive units in a hospital because many resources are tied up there for a very short time frame on a very small space.

Although some clinical studies have tried to identify and evaluate the factors affecting treatment workflow and predict specific workflow progressions, they mainly focus on very specific treatments and address only a handful of possible factors.

The SWAP module for oncoflow currently being developed at ICCAS provides a method to compute the impact of various factors on a surgical workflow. They include for instance the patient's age, their body mass index, the surgeons, or even the method chosen to reach a target structure during surgery. The preoperative

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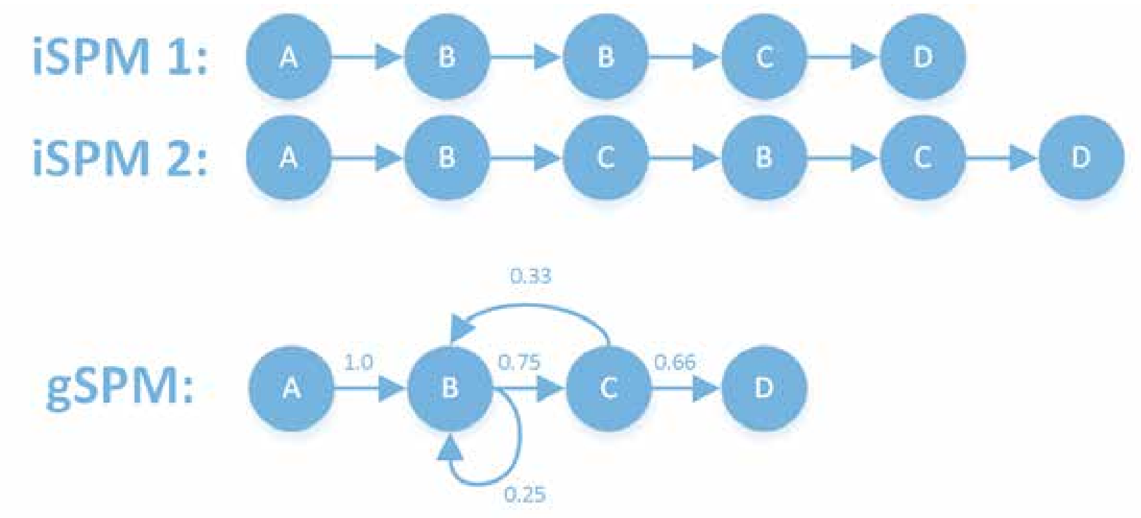

Fig. 2 - Basic idea of the SWAP method.

parameters (the factors to be considered during computation) can be chosen by the user. SWAP then identifies the impact of these preoperative parameters on a given surgery type.

For parameter weight calculation, recorded surgical workflows (iSPMs) are linked to their relevant metadata from the patient data management system oncoflow, which has been developed over the past few years by Jens Meier at ICCAS. Afterwards, parameter weights are estimated using similarity metrics and a system of equations. Each parameter weight indicates its impact on the surgical workflow.

These parameter weights can be used to assess the similarity between any recorded surgical workflow and the workflow of forthcoming surgery. This allows patients to be selected from a database whose treatment workflow can be expected to be very similar to the upcoming workflow and therefore used to predict it.

In recent years, Stefan Franke has developed a method at ICCAS to predict the remaining time of surgery intraoperatively. For this, iSPMs of the same surgery type were merged to create a general model (gSPM) representing a whole surgery type instead of individual surgeries. By using the SWAP module, iSPMs can now be weighted in terms of their similarity to the expected workflow, enabling a personalized gSPM adapted to each patient. This should make intraoperative forecasts of the further progress of a surgical procedure more precise. Moreover, this method is a first step towards a generic analysis tool allowing the effect of preoperative parameters on any type of surgical procedure (e.g. discectomy, brain tumor removal, etc.) to be assessed.

Erik Schreiber
M. Sc.

erik.schreiber@medizin.uni-leipzig.de

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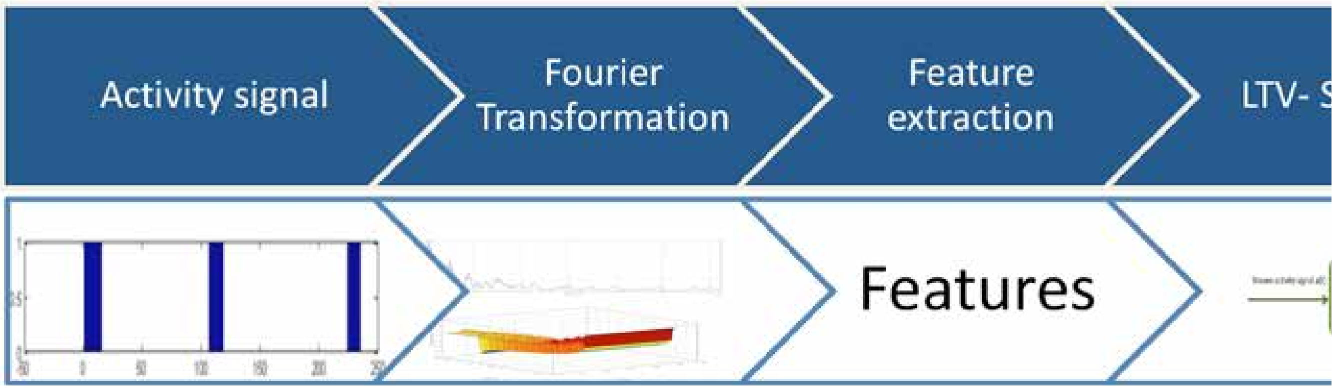

SPECTRAL ANALYSIS OF SURGICAL WORKFLOWS

Given the present demographic trend, optimal clinical workflow automation is crucial. One major step towards automation is an effective, efficient assessment of surgical processes. Work in the project is currently focusing on examining the hypothesis that spectral analysis known from speech recognition and biosignal analysis can be used to predict future steps in surgical processes.

The present demographic trend makes optimal clinical workflow automation all the more essential. One major step towards automation is being able to assess surgical processes effectively and efficiently. Signal analysis, for instance speech recognition, could contribute to an accurate evaluation of surgical processes. Therefore, this project is examining the hypothesis that spectral analysis known from speech recognition and biosignal analysis could be used to predict future steps in surgical processes (see Fig. 1).

When recording surgical workflows, the surgeon's activities were timed. Accordingly, a surgery can be broken down into activity signals that definitely change over time. Therefore we generated activity time signals from the recorded workflows corresponding to anatomical structure, action, surgical instruments, and the hand used. Based on digital signal processing methods, activity signal processing can be performed. First of all, the activity signals are presented as square wave signals: 1 for

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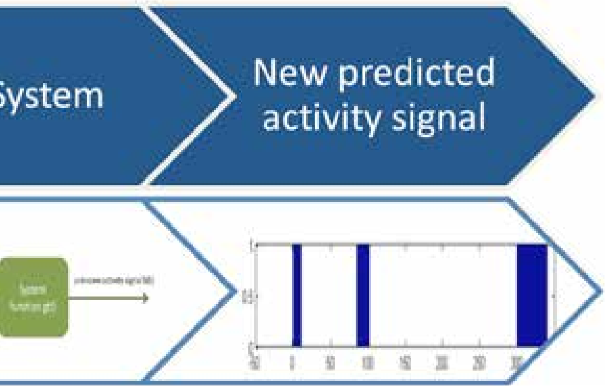

Fig. 1 - In this work we apply signal processing methods to predict future steps in surgical processes. Workflow components of the lumbar discectomy such as anatomical structure, action, instrument and exercised hand can be extracted and processed as a time signal.

active and 0 for inactive. Afterwards, spectral analysis is carried out.

The power spectral density (PSD) of the activity signals is used for information extraction. These spectra can be obtained by means of nonparametric methods such as short time Fourier transformation (STFT) or Welch's power spectral density estimation. Afterwards, differentiability between the various surgical workflows is required. The differentiability can be represented by feature extraction. Parameters of feature extraction can be derived from frequency representation such as peak power frequency. Based on these calculated frequency domain parameters, various surgical workflows can be identified for specific types of intervention. Afterwards, we assume the variability of activities in surgeries, which can be gauged by applying a linear time-variant system (LTV). Based on the convolution integral, a new activity signal can be computed to predict future surgical process activities.

A study was implemented to evaluate the accuracy of our prediction results. The method was applied to a type of neurosurgical intervention, namely lumbar discectomy. The required surgery workflows were recorded in 2007 at ICCAS and broken down into 35 activities as well as three intervention phases: approach to disc, discectomy, and closure. We simulated an ongoing surgery to test the method; the start time of every activity evaluation was 1 minute after the beginning of surgery and the time window was amplified by 1-minute time steps. Based on the evaluation study, the activity prediction of devices in specific time intervals was calculated and showed significant outcomes.

In future work, the activity signals analysis can be carried on other surgical intervention types.

Marianne Maktabi
Dipl.-Ing.

marianne.maktabi@medizin.uni-leipzig.de

Thomas Neumuth
Prof. Dr.

thomas.neumuth@medizin.uni-leipzig.de

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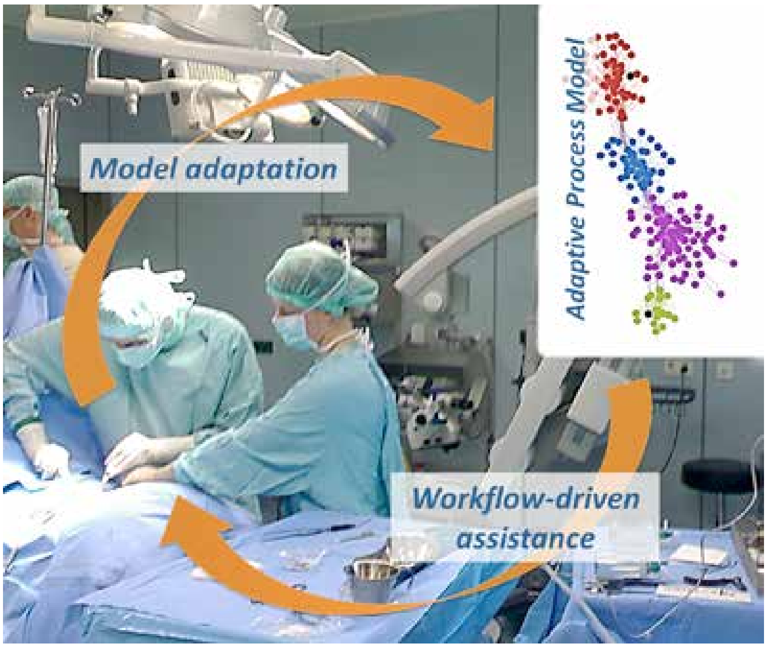

Fig. 1 - The principle of adaptive process models and workflow-driven assistance.

ADAPTIVE PROCESS MODELS FOR WORKFLOW-DRIVEN SURGICAL ASSISTANCE

The project introduces a novel approach to the intraoperative adaptation of surgical process models. Instead of relying on static process descriptions, a process model is proposed that is generated on the fly. The tests demonstrated a significantly improved ability to anticipate the next work steps.

Surgical workflows have proven their usefulness to describe, quantify and analyze surgical procedures. Although the operating theater is one of the most complex and expensive working environments in a hospital, process management has not yet been established there. Although process management has been used in various branches of industry to improve safety, effectiveness and efficiency, active process management in the operating room requires process models that are able to handle a level of interprocess variability which is normally much higher than in industry. Surgical procedures can neither be normalized nor predicted for each patient. Process management in the operating room therefore needs to be as flexible as possible and yet still be able to accurately assess upcoming situations to be beneficial for the autonomous preconfiguration of medical devices and a cooperative working environment.

In this project, we introduce a novel approach to the intraoperative adaptation of surgical process models. The work focusses on surgical process modeling for intraoperative workflow-driven assistance. Instead of relying on static process descrip-

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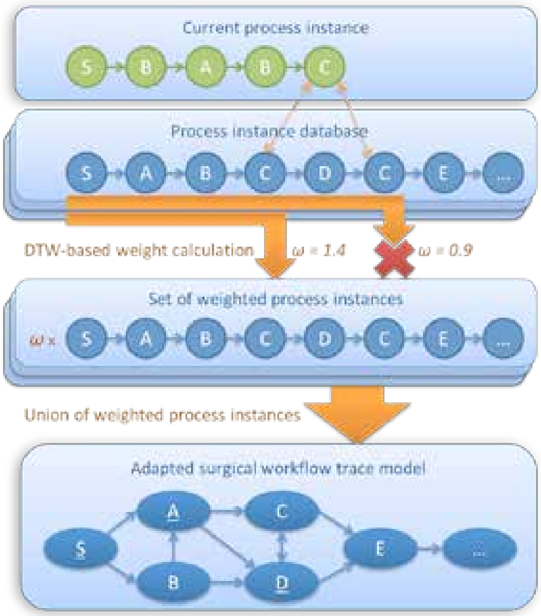

Fig. 2 - The three-level approach for on-the-fly generation of continuously adapted surgical process models.

tions, a process model is proposed that is generated on the fly. The novel Adaptive Surgical Process Model is a union of process instances implementing the common bottom-up modeling approach. However, the instances are continuously weighted according to their similarity to the course of the ongoing and yet not fully known process instance. The transition probabilities as well as time and frequency information included in the model are hence continuously adapted. The adaptation procedure repeatedly applied consists of three mayor steps: the calculation of similarities, the calculation of weights, and the generation of adaptive process model instance.

We evaluated the model's feasibility for intraoperative application by analyzing the mean transition probabilities during the course of surgery. The probabilities of the assumed transitions are an indicator for the quality of representation of the course of the intervention within the given model as well as the ability to anticipate the forthcoming surgical work steps.

The mean transition probabilities of static and continuously adapted surgical process models were compared in a study. Data from 60 recorded cases of brain tumor removal were used to analyze the performance. The results demonstrate the significantly improved ability to anticipate the next work step for adaptive process models.

The implementation of the workflow-driven autonomous adaptation of medical systems and smart system behavior in the operating room requires flexible yet reliable assessments of upcoming surgical situations. The integration of methods for process model flexibility will be a significant prerequisite for reliable, smart system behavior. It will hence contribute to a cooperative OR environment that increases patient safety and reduces costs.

Stefan Franke

Dipl.-Inf.

stefan.franke@medizin.uni-leipzig.de

Thomas Neumuth

Prof. Dr.

thomas.neumuth@medizin.uni-leipzig.de

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung
ZENTREN FÜR INNOVATIONSKOMPETENZ
UNTERNEHMEN REGION
Die BMBF-Innovationsinitiative Neue Länder

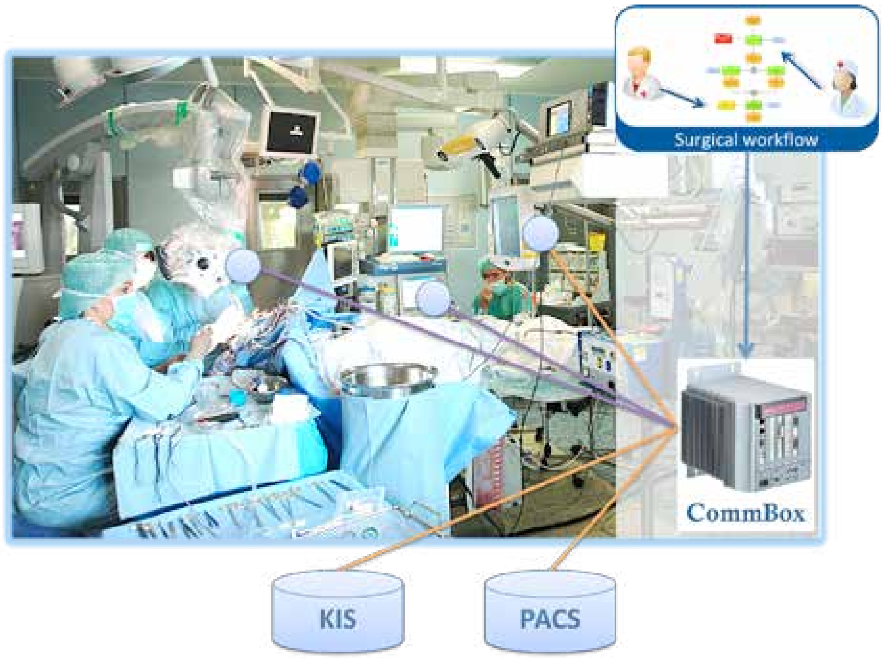

Fig. 1 - Schematic representation of the EVENTOR concept with the CommBox as centralized workflow-processing unit interconnected with various medical devices.

EVENTOR – EVENT-BASED NETWORKING IN THE OPERATING ROOM

The aim behind EVENTOR is to enable the workflow-driven interconnection of medical devices which do not share a common interface.
A centralized unit integrates process logic and communication frameworks to enable semiautomatic device adaptation.

New technologies introduced into the operating room (OR) have exacerbated surgeons' workload due to very time-consuming system configuration and information-seeking tasks. In recent years, concepts and technical solutions for integrated operating rooms have emerged. Modern surgical assistance systems share their information and control functions via various OR bus implementations which allow the integration of information and centralized control. However, these changes have only partly reduced surgeons' workload.

EVENTOR is being conducted in cooperation with SWAN – Scientific Workflow Analysis GmbH. The project aims to enable the workflow-driven interconnection of medical devices. A centralized unit known as the CommBox implements various communication protocols and integrates process logic and communication frameworks. The interfacing of medical devices is to be controlled by process logic based on surgical process models. As a result, the CommBox will be able to automatically

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set up communication pathways between components of the overall OR system depending on the surgical situation. Surgical process models represent specific types of surgery by breaking them down into work steps. A workflow engine, the core component of the CommBox, processes these models to follow the surgical process. Each medical device can be attached to the process logic using connector modules. The process logic's open interface enables application-specific connector modules to be developed for medical devices of any kind. Each connector module provides two main functions: protocol transformation and situation adaptation. Workflow-driven adaptation for each medical device type is implemented by processing a rule set. It derives the communication pathways that need to be established from the surgical situation provided by the workflow engine. The actual data transport medium depends on the specific circumstances. Videos for instance are handled by a dedicated video bus with a control unit connected to the CommBox via a connector module.

The integration of process logic and communication frameworks facilitates assistance functions such as the situation-aware configuration of devices, the import of data from external systems, and integrated information visualization. We will develop prototypes for selected clinical use cases (e.g. brain tumor removals) to demonstrate the feasibility of this approach. A set of surgical process models for a type of surgery has been compiled. Brain tumor removals tend to be lengthy and complicated, and require many different technical systems such as navigation, intraoperative ultrasound and electrophysiology, calling for workflow-driven configuration and communication. The prototype will be evaluated under laboratory conditions using data from real intervention recordings.

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

Stefan Franke
Dipl.-Inf.

stefan.franke@medizin.uni-leipzig.de

Marianne Maktabi
Dipl.-Ing.

marianne.maktabi@medizin.uni-leipzig.de

Thomas Neumuth
Prof. Dr.

thomas.neumuth@medizin.uni-leipzig.de

PARTNERS

SWAN - Scientific Workflow Analysis GmbH, Leipzig
Frank Eckhardt

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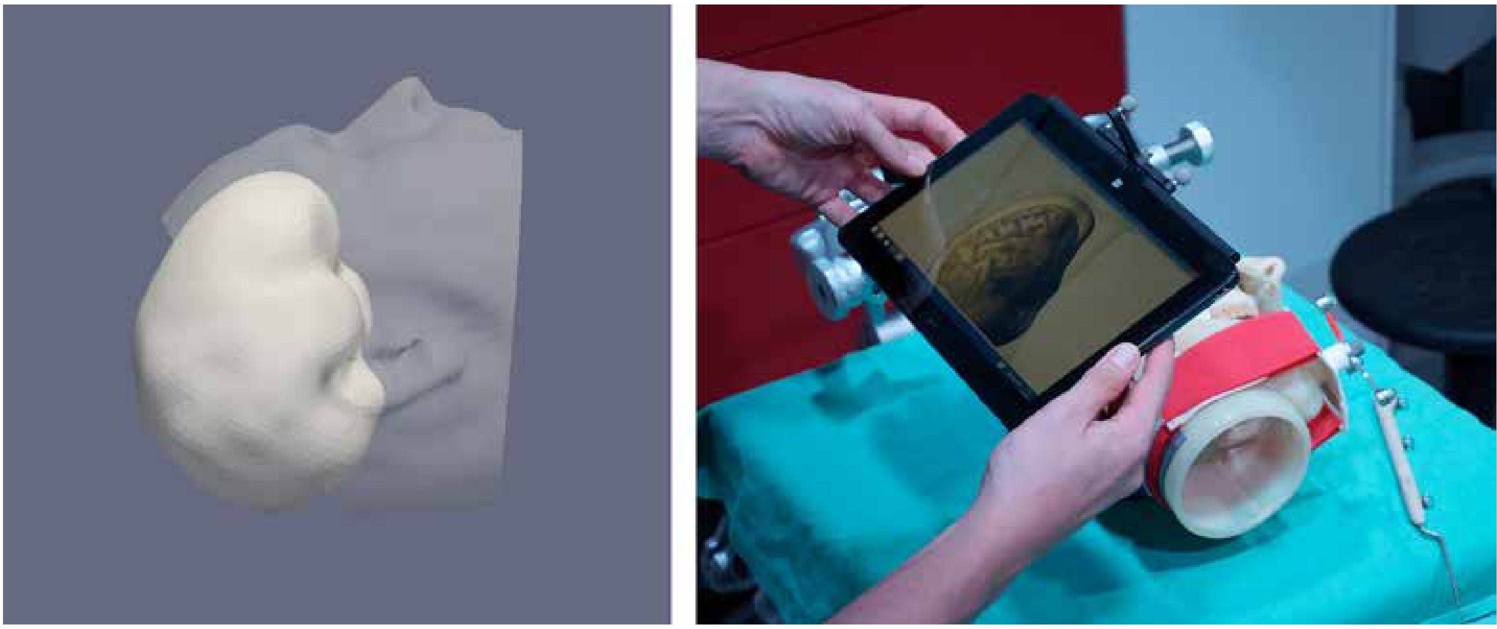

Fig. 1 - 3D visualization of segmented brain and skin (left) and display on a tracked tablet (right).

MAGIC LENS ADVANCEMENT FOR MINIMAL INVASIVE NEUROSURGERY

The Magic Lens is an augmented reality system for minimal invasive surgery to visualize patients' internal anatomical structures. In a prototype application for cardiac surgery, preoperative patient data was interactively integrated into surgical treatment. The Magic Lens system will now also be employed in neurological surgery.

A surgical assistance system was implemented to support challenging identification tasks in minimal invasive surgery. Based on augmented reality, the Magic Lens concept was initially adapted for minimal invasive cardiac surgery in a prototype system. A Magic Lens is a mobile device (e.g. a tablet computer) that displays additional information depending on its position and the position of the user, and which can be employed to visualize subcutaneous anatomical structures. In addition, the Magic Lens system is now to be employed in neurological surgery.

The first implementation consisted of preoperative and intraoperative working steps. For visualization, routinely acquired preoperative images were used to generate segmentations of anatomical structures. Intra-operatively, the system combined two sensors: optical tracking and a time-of-flight (TOF) camera. In optical tracking, the lens position was accurately measured, whereas the TOF camera tracked the surgeon. With both sensor systems registered to each other, the system was able to track the surgeon and the Magic Lens simultaneously. In an addition-

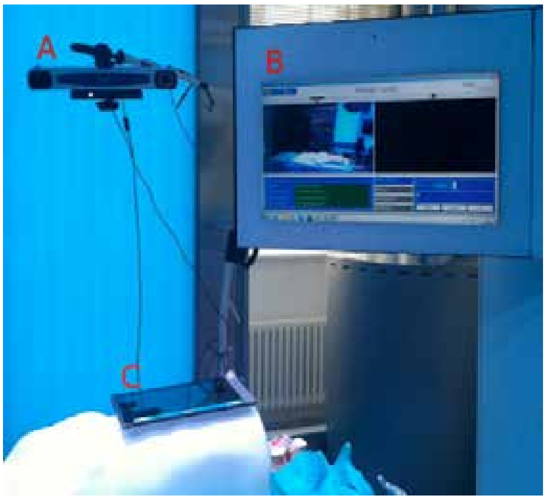

Fig. 2 - The technical setup of the magic lens with tracking system (A), workstation (B) and lens (C).

al step, the system was registered to the patient via surface registration techniques. Based on this setup, 3D surface models of relevant anatomical structures were displayed corresponding to the surgeon's angle of view. 3D visualization was updated in real time to show any movements and displayed reconstructed internal anatomical structures in the patient. Several visualization scenarios were identified based on surgical use cases. Various system presets enabled the depiction of anatomical structures to be altered. Additionally, an easy-to-use interaction concept allowed presets to be selected directly at the lens. The prototype system provided the surgeon with context- and focus-dependent anatomical information, and therefore met the two basic requirements of the Magic Lens concept.

A preliminary user study involving seventeen cardiac surgeons was conducted to evaluate the interaction concept and the potential acceptance of such a system. The study findings indicated the strong potential of the proposed concept and provided important information for further development. As a result, the system will now be trialled in neurological surgery, primarily for navigated interventions. Detailed information on the internal cerebral tissue and vascular structure is expected to support surgeons treating tumors and aneurysms. Subsequently, treatment-dependent visualization presets will be adopted from the cardiac surgery implementation in order to make the depiction of the patient's situation more intuitive. Additionally, depending on the surgical procedure, interactive context-relevant information could be shown on the tablet screen.

Richard Bieck
M.Sc.

richard.bieck@medizin.uni-leipzig.de

Stefan Franke
Dipl.-Inf.

stefan.franke@medizin.uni-leipzig.de

Thomas Neumuth
Prof. Dr.

thomas.neumuth@medizin.uni-leipzig.de

PARTNERS

Leipzig University Hospital
Department of Neurosurgery
Dr. med. Dirk Lindner

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung
ZENTREN FÜR INNOVATIONSKOMPETENZ
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Fig. 1 - Prefilled view of the patient demographics and history on a tablet and resulting PDF documents.

WEB-BASED ANESTHESIA DOCUMENTATION

A web-based system has been developed to support anesthetists' working procedures. It enables anesthesiologists to monitor the vital data of patients in multiple operating rooms and to document the course of anesthesia by using a mobile application.

Anesthesiology, a central discipline in modern hospitals, is under increasing personnel and time pressure. During surgery, sometimes only one anesthetist supported by technical assistants or junior doctors is available for a number of operating rooms. One way of providing a better, faster response in the OR and enabling situations to be assessed remotely would be to set up a mobile solution which allows anesthesia data from multiple operating rooms to be visualized. A solution like this could also enable the patient's documentation to be updated with information on, say, the drugs administered.

To this end, a Web-based solution based on the Vaadin Framework and an interface for Dräger anesthesia systems is being developed. The application enables the anesthesiologist to observe the patient's vital signs from any location in real time. In addition, patients' demographic data and their medical history can be documented, as can the medication used during surgery. To assist permanent medical documentation, a solution for data storage in a PDF document has been developed based on a currently used anesthesia protocol. In a future step, the documentation of the medication doses is to be simplified and algo-

Fig. 2 - Visualization of vital signs.

rithms for the detection of measurement errors will be developed and evaluated. In addition, authentication concepts need to be developed and tested in order to enable simultaneous use of the system on different devices by different user groups.

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

Max Rockstroh
Dipl.-Inf.

max.rockstroh@medizin.uni-leipzig.de

Bernhard Glaser
Dipl.-Inf.

bernhard.glaser@medizin.uni-leipzig.de

Thomas Neumuth
Prof. Dr.

thomas.neumuth@medizin.uni-leipzig.de

PARTNERS
ACQUA Clinic Leipzig
IRDC Leipzig

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung
ZENTREN FÜR INNOVATIONSKOMPETENZ
UNTERNEHMEN REGION
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OR.NET – SECURE AND DYNAMIC NETWORKING IN THE OPERATING ROOM

SUBPROJECT: INFORMATION QUALITY ASSURANCE IN THE NETWORKED OPERATING ROOM

For networked devices, providing reliable and complete information is of essential importance. Ensuring proper data quality is just as important as device networking itself. The goal of this project is to automatically assess individual patient data with respect to the requirements specified for certain use cases. An Automatic Image Quality Assessment (AQUA) component permanently monitors the (image) data streams in order to review their validity for specific tasks.

In recent years, the networking of medical devices has become increasingly important. Particularly image-guided procedures have significantly extended the possibilities for surgeons, allowing for example minimally invasive surgery. It is essential that the information provided by networked devices is reliable and complete. However, the mere technical availability of data does not necessarily ensure that the required information is provided. For example, modern software tools for image-guided surgery define specific requirements regarding the quality of image data in both the planning and the intervention stage. For subsequent systems, insufficient data could be just as fatal as the failure of the data source. Therefore, safeguarding proper data quality is just as important as device networking itself. Given the growing integration of medical devices, automatically assessing the quality of data streams is becoming more and more important. In order to guarantee the safe functionality of individual processing modules, the patient's individual data needs to be compared to the requirements specified for a specific task. Measuring the quality of image data streams on a semantic level is very difficult and no established monitoring components exist yet.

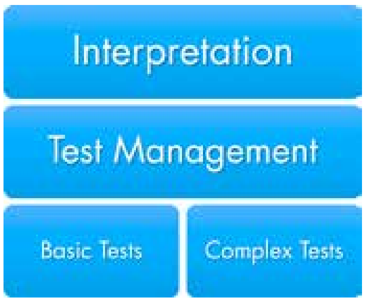

Fig. 1 - Layered architecture of the AQUA framework, which permanently monitors the quality of a patient's individual image data streams in order to review their validity for specific use cases.

This project is investigating general concepts for automatically measuring the quality of medical images. The requirements for specific use cases which form the basis for assessing an image's suitability for answering a certain question are being analyzed. This framework for Automatic Image Quality Assessment (AQUA) will be integrated into OR.NET architecture to create a monitoring component which permanently reviews the validity of

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Fig. 2 - Tool for the manual assessment of medical image data quality. Specific quality aspects can be rated on a predefined scale. In addition, the purpose of the image is captured and the physician is able to mark interesting findings in the image (see the green arrows in the coronal view).

relevant image data streams. The AQUA framework will consist of several layers (see Fig. 1). In this architecture, basic tests refer to both the analysis of the meta-information stored in the DICOM header and fundamental image quality tests, such as signal-to-noise ratio (SNR) and blurring. Complex tests include for example the detection of typical imaging artifacts as well as the detection of structures within the image and whether the structure of interest is completely shown by the image. The test management layer controls which tests have to be performed for a specific use case and how they need to be parameterized. It is also responsible for storing the test results. Finally, these results are analyzed by the interpretation layer, which decides whether the patient-specific measures are acceptable for a certain use case. We are currently conducting two studies on the quality of medical image data. The first study focusses on magnetic resonance imaging (MRI) data of the head as used for brain tumor resection, while the second study is analyzing the quality of computed tomography (CT) images for cochlear implant planning. Both studies use an intuitive, flexible annotation tool that has been developed using MeVisLab (see Fig. 2). The ratings and comments as well as meta information for the specific image are stored in an XML file, which can also handle annotations by additional users. Initial results for the head MRI data are shown in Fig. 3.

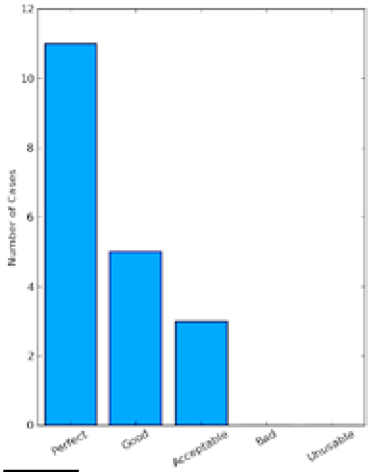

Fig. 3 - Preliminary result plot of an image's suitability with respect to its specific purpose for the MRI data for brain tumor resection (n=19). The images were rated by an experienced neurosurgeon using the tool shown in Fig. 2.

Frank Heckel
Dr.

frank.heckel@medizin.uni-leipzig.de

Max Rockstroh
Dipl.-Inf.

max.rockstroh@medizin.uni-leipzig.de

PARTNERS

Leipzig University Hospital
Department of Neurosurgery
Dr. med. Felix Arlt

Leipzig University Hospital
Department of ENT-Surgery
Dr. med. Mathias Hofer

Fraunhofer MEVIS Bremen
Institute for Medical Image Computing

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OR.NET
SICHERE DYNAMISCHE VERNETZUNG IN OPERATIONSSAAL UND KLINIK

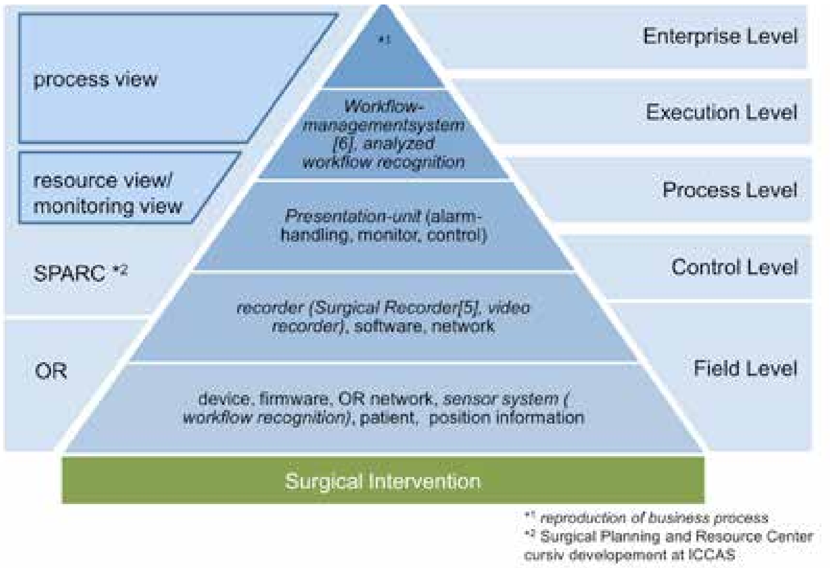

Fig. 1 - SPARC includes several levels of the automation pyramid.

CONCEPTS AND REQUIREMENTS FOR AN ADVANCED CLINIC-WIDE OPERATING ROOM CONTROL CENTER

In recent years, various stakeholders have shown growing interest in the integration and modular networking of medical devices in the OR. Because commercial integrated solutions are based on proprietary interfaces and protocols, several initiatives and projects are now working to develop systems of OR integration based on open standards in order to cut costs and improve patient safety. In this work, the realization of a central workstation to supervise and control integrated OR systems known as a »Surgical Planning and Resource Center« (SPARC) are described.

In recent years, various stakeholders have shown growing interest in the integration and modular networking of medical devices in the OR. Because commercial integrated solutions are based on proprietary interfaces and protocols, several initiatives and projects are now working to develop systems of OR integration based on open standards in order to cut costs and improve patient safety. However, growing budgetary constraints in hospitals require new ways of optimization – such as the proposed concept of process control in the OR with centralized supervisory control. This work demonstrates vertical integration in a hospital to create a Surgical Planning and Resource Center (SPARC). To this end, particular aspects of industrial automation revolving around optimization by integration are to be applied to the medical sector, especially hospitals. Analyzing the relationship between these very different sectors requires comparison regarding specific aspects of automation.

We started by conducting a survey among the different user groups of SPARC at Leipzig University Hospital in order to present the idea of a surgical control cen-

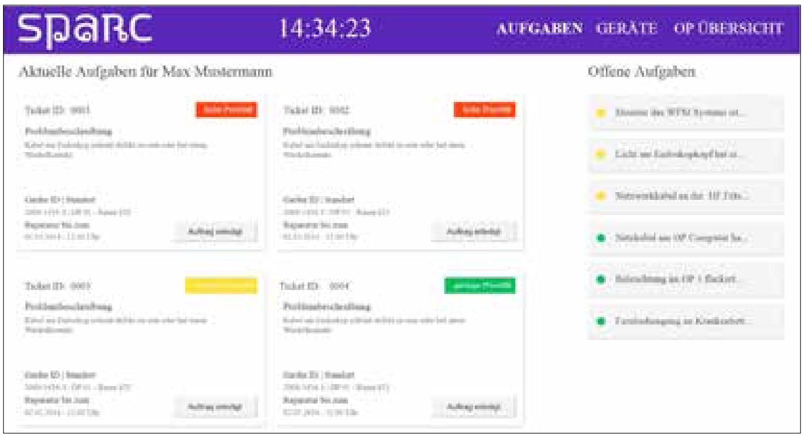

Fig. 2 - We've developed a user interface prototype in close cooperation with the medical engineers; a commonly accepted user interface is the result.

ter to the various stakeholders and ascertain their requirements. The survey found a lack of information. The recorded information and the resulting functions of SPARC can be used by various groups, e.g. hospital technicians, maintenance engineers and OR managers. Furthermore, surgeons, researchers and vendors can use the recorded information for various applications (e.g. clinical studies, surgical training). To design a versatile control room, we considered the control center as a three-unit structure consisting of a representation level, a transmission level, and a processing level. Crucial requirements were identified based on information and function specific analyses of all three levels and used to start developing a supervisor system.

We chose the medical engineers as the first, more closely considered user group whereas the medical engineers represent the first layer after the device landscape layer in an automation pyramid (see Fig. 1). Based on surveys among both the medical engineers and hospital technicians, an initial user interface prototype and the corresponding database scheme were developed (see Fig. 2). The first demonstration of the supervisor control center prototype indicated wide approval of the SPARC concept. Key elements of the implementation of SPARC include aspects of data traffic and data security.

Future work will focus on the implementation of a control center used by medical engineers at ICCAS in cooperation with Leipzig University Hospital. Afterwards, the first version of SPARC can be evaluated by the medical engineers. We will then conduct a comprehensive survey to examine usability.

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ZENTREN FÜR INNOVATIONSKOMPETENZ
UNTERNEHMEN REGION
Die BMBF-Innovationsinitiative Neue Länder

Marianne Maktabi
Dipl.-Ing.

marianne.maktabi@medizin.uni-leipzig.de

Max Rockstroh
Dipl.-Inf.

max.rockstroh@medizin.uni-leipzig.de

Thomas Neumuth
Prof. Dr.

thomas.neumuth@medizin.uni-leipzig.de

CONTRIBUTORS

Alexander Oeser (B.Eng.)

Fig. 1 - System setup at the central sterilization department.

TOWARDS A STRUCTURED SUITABILITY DETERMINATION OF IDENTIFICATION APPROACHES FOR SURGICAL INSTRUMENTS

Automatically detecting the status of a running intervention in the operating room using multiple sensors will allow future support systems to provide situation-based support for the staff during the workflow and contribute to efficiency and patient safety. The aim of this project is to develop the concept of a surgical instrument similarity metric which can be used to generalize the results of a previous study for intra-operative surgical instrument identification, which are limited to ENT surgery.

Automatically detecting the status of a running intervention in the operating room using multiple sensors will allow future support systems to provide situation-based support for the staff during the workflow and contribute to efficiency and patient safety. However, a steady stream of information gathered from all the technical equipment in use is not enough to automatically monitor all the processes in the OR. Identifying the surgical instruments used during an operation provides a crucial source of information in order to automatically retrace the intervention process.

In the preliminary work for this project, a pilot detection system was assembled and evaluated in conjunction with the central

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Fig. 2 - One of the digitalized surgical trays.

sterilization management department of Leipzig University Hospital (see Fig. 1). The results of the accompanying study were promising for the system's applicability to a single type of surgical intervention.
Various approaches have been presented in recent years for the automatic identification of surgical instruments. However, their suitability has not yet been analyzed in a structured manner. Studies addressing the identification of intra-operative surgical instruments often focus on a limited set of surgical instruments in a specific domain and are rarely transferable to the overall situation in the operating room (OR). Hence, there is currently no methodology available to quantify surgical instrument sets regarding their suitability for a certain identification method.

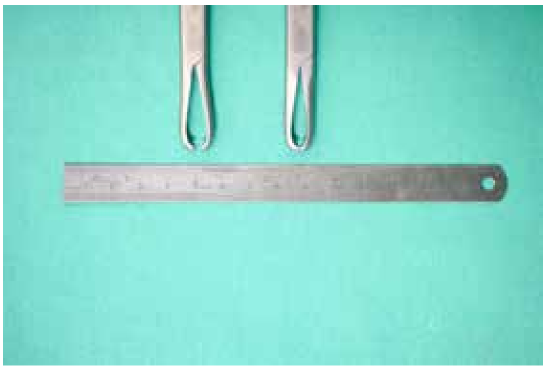

Fig. 3 - Differing opening angles in two exemplars of a surgical gripper.

The aim of this project is to develop the concept of a surgical instrument similarity metric which can be used to classify sets of surgical instruments in relation to their suitability for a certain identification method. This metric is to be used to generalize the results of the preceding study for intra-operative surgical instrument identification, which are limited to the domain of ENT (ear, nose and throat) surgery. In addition to providing a deeper insight into the methodology of the preceding project, by including a broad range of surgical domains the findings will also deliver valuable information for video and weight based surgical instrument detection approaches as a whole.

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ZENTREN FÜR INNOVATIONSKOMPETENZ
UNTERNEHMEN REGION
Die BMBF-Innovationsinitiative Neue Länder

Bernhard Glaser
Dipl.-Inf.

bernhard.glaser@medizin.uni-leipzig.de

Tobias Schellenberg
Dipl.-Inf.

tobias.schellenberg@medizin.uni-leipzig.de

Stefan Dänzer
Dipl.-Inf.

stefan.daenzer@machine-mind.com

Thomas Neumuth
Prof. Dr.

thomas.neumuth@medizin.uni-leipzig.de

PARTNERS
Leipzig University Hospital
Central Sterilization Department
Kerstin Schröter

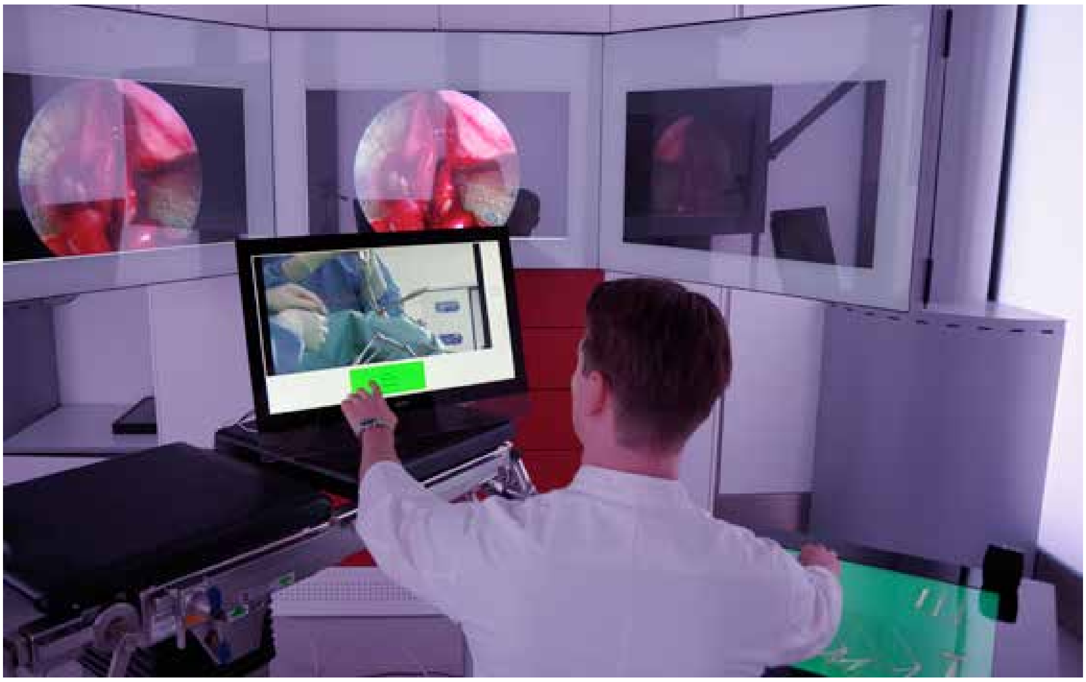

Fig. 1 - A running prototype of the training system in the ICCAS demo OR.

USAGE CONCEPTS FOR A SCRUB NURSE TRAINING SYSTEM

Those handling surgical instruments in their daily working routine face specific challenges such as identifying and distinguishing a wide range of sometimes very similar instruments. The project presents a working prototype of a surgical instrument training system which can be used by students without the need for a human supervisor.

Those handling surgical instruments in their daily working routine face specific challenges. Above all, they need to be able to identify and distinguish a wide range of sometimes very similar instruments.

Extensive research has been conducted into the simulation of surgical operations. Approaches with heavy emphasis on computer-generated simulation such as virtual reality mostly focus on a single technique or a single type of surgery, e.g. laparoscopic interventions. Due to their computer-based structure and their focus on the specific technical skills of a specialized surgeon, human interaction in the operating room is neglected in these approaches. There is currently no system available that focuses exclusively on the skills and needs of scrub nurses on an entirely technical simulation basis.

The project presents the concept of a surgical instrument training system which can be used by students without the need for a human supervisor. The system works without real surgical instruments. The central component is the simulation of an

Fig. 2 - A gaze-tracking analysis can deliver detailed aspects for the better understanding of the workflow of a scrub nurse.

instrument table on a Microsoft Surface 2 system with multitouch functionality (see Fig.1). The system is realistic in that all the virtual instruments and objects on the table can be moved, rotated and stacked.
The trays containing instruments for the operation that are not on the table yet but may be necessary as the operation proceeds are simulated by a selection menu on the side of the table, where the contents of the trays can be scrolled through and additional instruments can be added to the main area via drag-and-drop.
The second main component is the surgeon screen, which shows a video of the type of operation being practiced. The training videos are recorded in real operations from the assistant's point of view and afterwards enhanced with additional information stored in an accompanying XML metafile. The test person passes an instrument to the virtual surgeon by selecting it on the instrument table simulation and clicking on the »Pass instrument« button of the Surgeon Screen System, which features touch functionality. The original sound of the operation is also played back, including all the surgeon's verbal comments.
Current work on the project is focusing on a multi-center study to determine system requirements using an initial working prototype. Future work on the project will in particular address ergonomic features of the scrub nurse's workplace (see Fig. 2).

Bernhard Glaser
Dipl.-Inf.

bernhard.glaser@medizin.uni-leipzig.de

Tobias Schellenberg
Dipl.-Inf.

tobias.schellenberg@medizin.uni-leipzig.de

Lucas Koch
M. Sc.

lucas.koch@medizin.uni-leipzig.de

Thomas Neumuth
Prof. Dr.

thomas.neumuth@medizin.uni-leipzig.de

PARTNERS

Leipzig University Hospital
Central Sterilization Department
Kerstin Schröter

University Hospital Leipzig
Department of ENT-Surgery
Dr. med. Mathias Hofer

Bern University Hospital
Inselspital
Dr. med. Patrick Dubach

Acqua Klinik / IRDC Leipzig
Dr. med. Susanne Modemann

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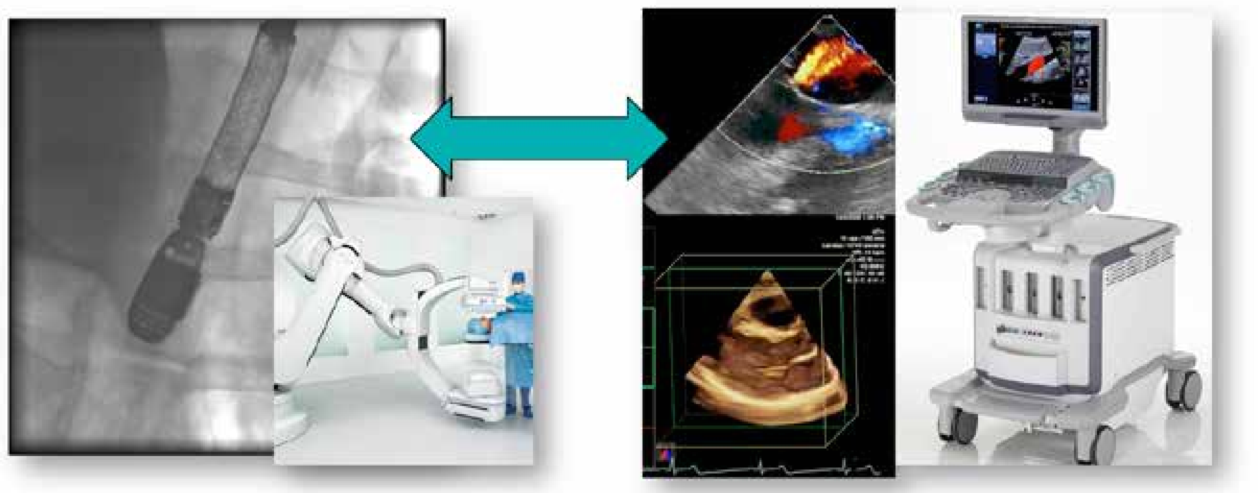


Fig. 1 - Fusion of Ultrasound and X-ray combines advantages of both modalities and could lead to better mutual understanding of image contents, better navigation and communication and potentially allow new kinds of procedures.

FUSION OF FLUOROSCOPY AND INTERVENTIONAL ULTRASOUND

Ultrasound and X-ray are two facilitating imaging modalities used in transcatheter-based minimally invasive procedures in structural heart disease. X-ray fluoroscopy provides excellent instrument imaging while ultrasound shows high-quality images of soft tissue. Fusing these two modalities could potentially improve the surgical workflow and the catheter navigation. X-ray fluoroscopy can be fused with trans-esophageal echo (TEE) with the help of 2D/3D registration. An ultrasound probe model is registered to X-ray images, which inherently provides a registration of ultrasound images to X-ray.

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

These procedures are usually performed under fluoroscopic X-ray and trans-esophageal echo (TEE). Intra-operatively, these modalities are mainly used independently of each other: X-ray imaging is performed by the cardiologist or surgeon to the left or right side of the patient whereas ultrasound imaging is carried out by the anesthesiologist at head side of the patient. An image fusion of the two systems could improve mutual understanding of the im-

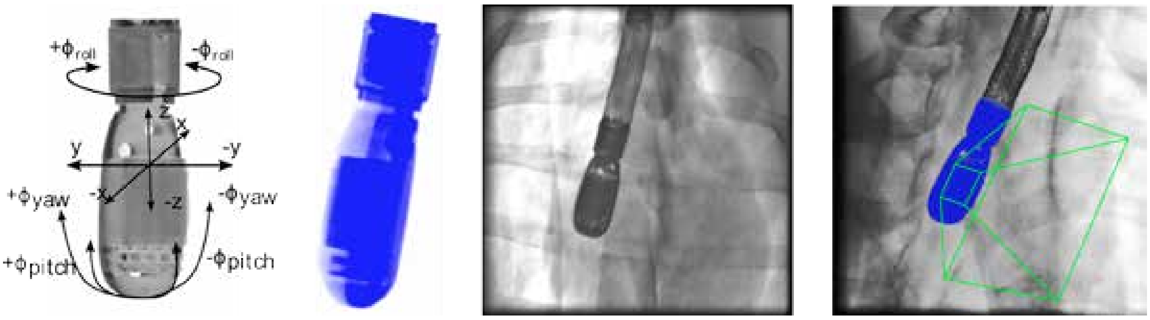


Fig. 2 - From left to right: CT volume of the TEE probe prototype with object axes. DRR of the TEE probe volume. TEE probe under fluoroscopic X-ray. Possible visualization of a registration of a TEE probe. The 2D/3D registration inherently provides a registration of the ultrasound (symbolized as pyramid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

age contents and ultimately even lead to new kinds of procedures. The ultrasound and X-ray images move relatively to each other because the position of the imaging devices is changed by the operator, as well as because of the motion of the patient's heart and breathing. Therefore, almost real-time updating is needed in order to synchronize the relative position of the two images. The success of such an approach hinges on the clinical usability of a fusion system.

One way of fusing ultrasound with fluoroscopic X-ray is 2D/3D registration. A TEE probe is detected in the X-ray image and derives the 3D position of the TEE probe relative to the X-ray detector, which inherently provides a registration of the ultrasound image to the X-ray image. To estimate the 3D position, a model of the TEE probe is registered to the X-ray image via a 2D/3D registration algorithm. Here a 3D position of the probe is iteratively adapted using an optimization method until high similarity is measured between the projected probe model image and the X-ray image. The method does not need any modifications to the TEE probe and does not entail setting up the system specifically for each procedure.

Fusing ultrasound and fluoroscopic X-ray images could potentially improve the whole workflow of today's minimal invasive cardiac interventions. It could be of great help for better image understanding interpretation and faster and more accurate interventional navigation. This might increase the patient's safety and could also shorten the procedure time.

Markus Kaiser
Dipl.-Inf.

kaiser.ext@siemens.com

PARTNERS

Herzzentrum Leipzig GmbH, University Hospital
Prof. Dr. med. Joerg Seeburger

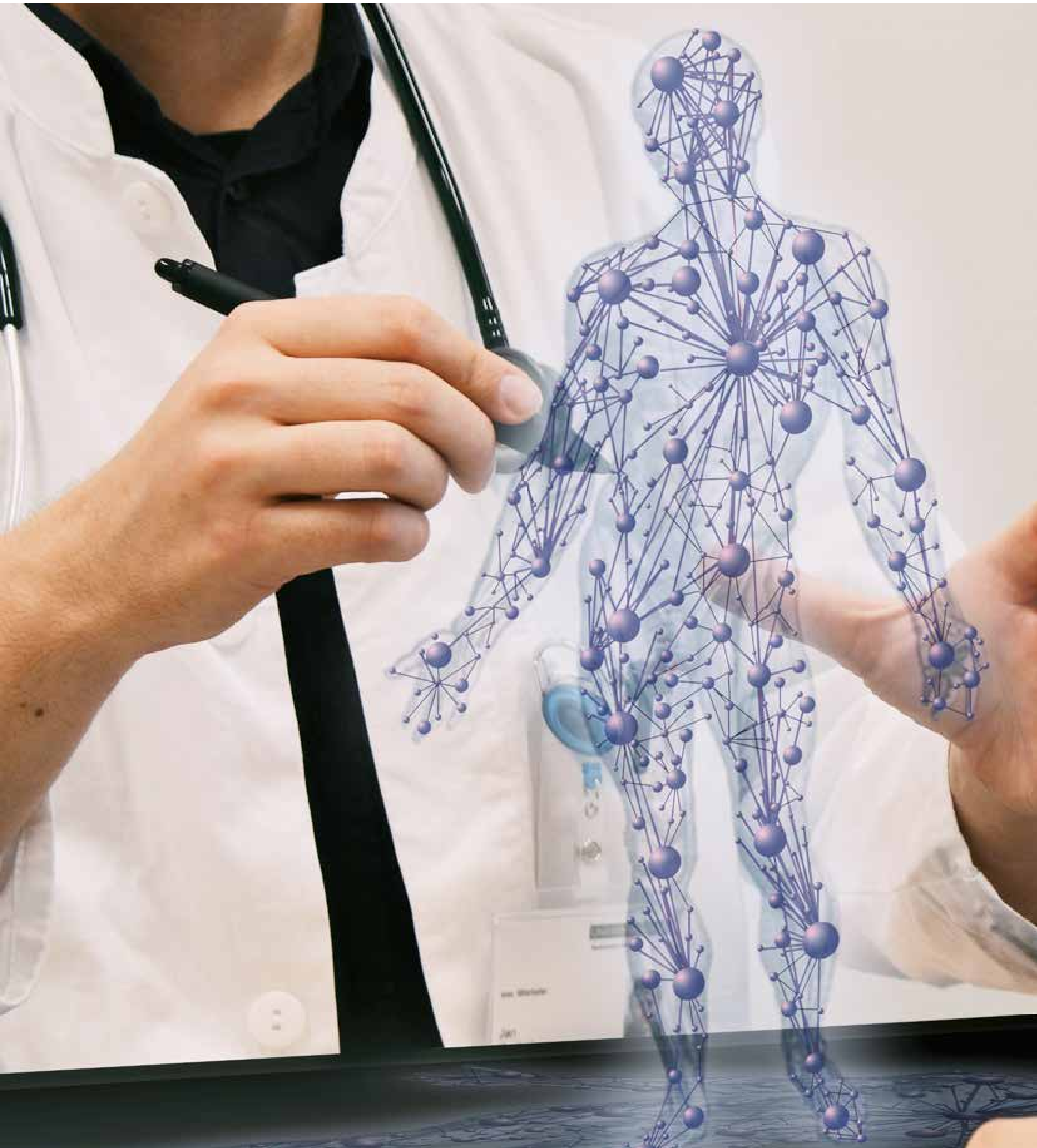
Otto von Guericke University Magdeburg
Faculty of Electrical Engineering and Information Technology (FEIT)
Institute for Information- and Communication Technology (IIKT)
Prof. Dr. Georg Rose

Siemens AG, Healthcare
Dr. Matthias John

SIEMENS

DPM

DIGITAL PATIENT- AND PROCESS MODEL



RESEARCH VISION

Semantic integration of patient data and medical knowledge as clue to high-quality care and reproducible treatment decisions.

Digital Patient- and Process Model

Group leader

Dr. Kerstin Denecke
kerstin.denecke@medizin.uni-leipzig.de

Clinical decision making becomes more complex by the increased availability of specialized clinical tests and the corresponding results. The Digital Patient Modeling Group at ICCAS is addressing this problem by developing methods for integrating information and patient data related to specific medical conditions and making it available for various applications such as decision support.

In 2014, research focused on developing information structures, methods of information extraction and data annotation, and techniques for data integration at a semantic level. Further, work towards modeling of diagnosis and treatment decisions was continued. All these aspects are required for digital patient modeling. The findings have been presented and discussed at dedicated conferences and workshops such as CARS, VPH, SIGIR and MIE. One major achievement was the development of methods for the extraction of critical events from operation records and other clinical documents. They enable to forward this information to physicians, to integrate it into patient-specific models and in this way, support the decision-making process.

Selected Publications

Denecke K, Cypko M, Deng M. A concept for semi-automatic generation of digital patient models. Biomed Tech (Berl). 2014; 59(1): 754-757.

Deng Y, Denecke K. Visualizing unstructured patient data for assessing the health status. Stud Health Technol Inform. 2014; 205: 1158-62.

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

Fig. 1 - Teamwork between an ENT physician and computer scientist at ICCAS.

USER INTERACTIVITY WITH LARGE PATIENT-SPECIFIC TREATMENT DECISION MODELS BY USING MEBN WITH AN EXAMPLE OF LARYNGEAL CANCER

A clinical decision support system based on multi-entity Bayesian networks may improve physicians' complex treatment decision-making. This project addresses the many challenges involved in developing and integrating such a system into a clinical workflow.

Growing understanding of the complexity of oncological diseases and the dramatic increase in available patient information theoretically enable the treatment of patients to be highly individualized. On the other hand, optimal treatment decisions are becoming harder to make. The aim of this project is to support complex treatment decisions with patient-specific models (PSMs) known as multi-entity Bayesian networks (MEBNs). Based on both a graphical and a probabilistic model, MEBNs are used to model and simulate the abstraction of real-life situations and processes. In the graphical structure, random variables are used to represent information entities (IE) such as medical examinations, medical imaging, patient behavior and patient characteristics (e.g. age, gender, tobacco and alcohol consumption), while arcs or directed edges represent the direct causal dependencies between IEs. In the probabilistic model, conditional probability tables need to be set for each IE and are used to describe the correlation between an IE and its direct causes. Based on the MEBN structure and depending on the patient's data, a patient-specific Bayesian network (PSBN) is instantiated with repeatable IEs by time and other reasons. The development of MEBNs can be considered on

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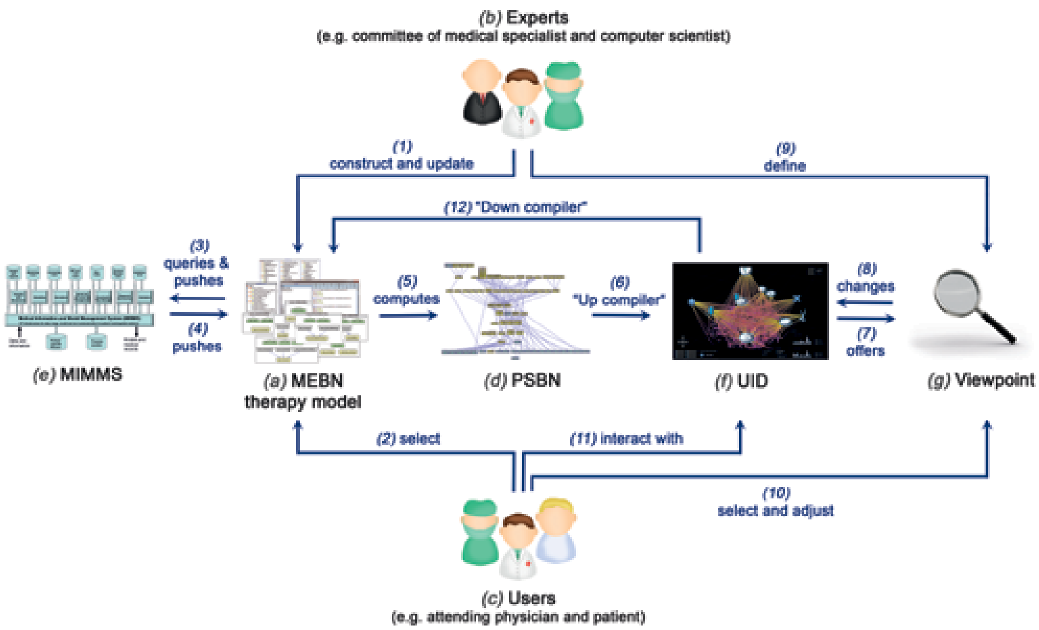

Fig. 2 - Concept for realizing treatment decision modeling and interaction with the model.

three levels of abstraction with different questions of interest: 1) The model layer concerns questions such as how to develop models, who is developing them, and in what environment; 2) The inference layer addresses how accurate computed reasoning needs to be, and what IEs need to be considered or updated; 3) The visualization layer comprises how to visualize the PSBN, what devices can be used, and the identity and location of the user. During a period of over a year, a team comprising an ENT specialist and a computer scientist built a treatment decision model manually based on MEBNs for laryngeal cancer. It was implemented using the open-source software UnBBayes and currently contains more than 800 IEs with over 1,100 direct dependencies. The experience of this project highlighted the challenges that need to be dealt with (see Fig. 2). The current focus is on solving the difficulties involved in the creation of treatment decision models [for more information see page 43], implementing visualization in order to make it easier for the user to grasp the patient's situation, and developing viewpoints representing a PSBN depending on the type of user (e.g. surgeon, radiotherapist, radiologist, or even the patient) and their main interest (for example a surgeon may be more focused on the patient information, whereas the patient will be more interested in the outcome of therapy and their quality of life).

Mario Cypko

Dipl.-Inf.

mario.cypko@medizin.uni-leipzig.de

Matthäus Stöhr

Physician

matthaeus.stoehr@medizin.uni-leipzig.de

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ZENTREN FÜR INNOVATIONSKOMPETENZ
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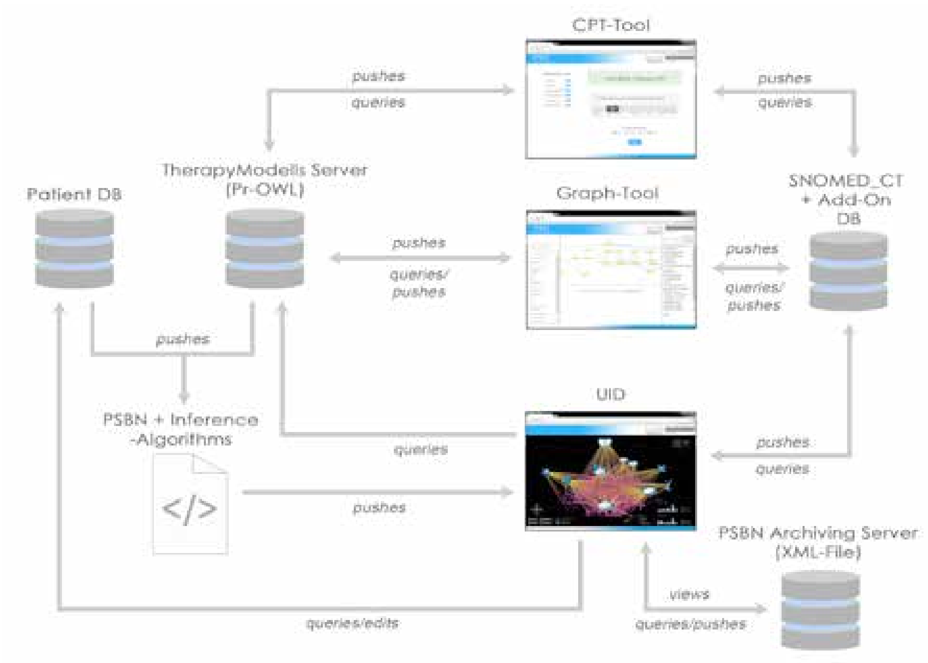

Fig. 1 - Concept of the ICCAS-MEBN-Modeling-Tool-Kit interconnection.

TOOLKITS FOR EXPERT-BASED DEVELOPMENT OF PATIENT-SPECIFIC TREATMENT DECISION MODELS WITH AN EXAMPLE OF LARYNGEAL CANCER

The manual development of MEBN-based clinical decision support systems can be very complex and time-consuming as our previous work showed (see page 41). In this project, we are developing toolkits to support intuitive IT-supported modeling.

Patient-specific models (PSMs) [for more information see page 41] based on multi-entity Bayesian networks (MEBN) can be created in two ways: automatically by means of machine learning algorithms, and manually by experts. It is well known that a model reflects the viewpoints and thoughts of the developer, and this leads to several challenges in modeling. The main challenge when modeling the graphical structure of MEBNs is to find the right balance between the granularity of IEs and the complexity of the model in order to avoid conditional probability tables (CPTs) with an exponential size. Other issues include the direct correlations between nodes that are not usually described in clinical practice guidelines, an important source for model generation. Machine learning algorithms are incomparably fast at reading medical sources and creating models but need defined rules, definitions and well described sources. However, before a model can be integrated into practical applications such as a treatment decision support system, it needs to be understood and validated by medical experts. Expert-based model development

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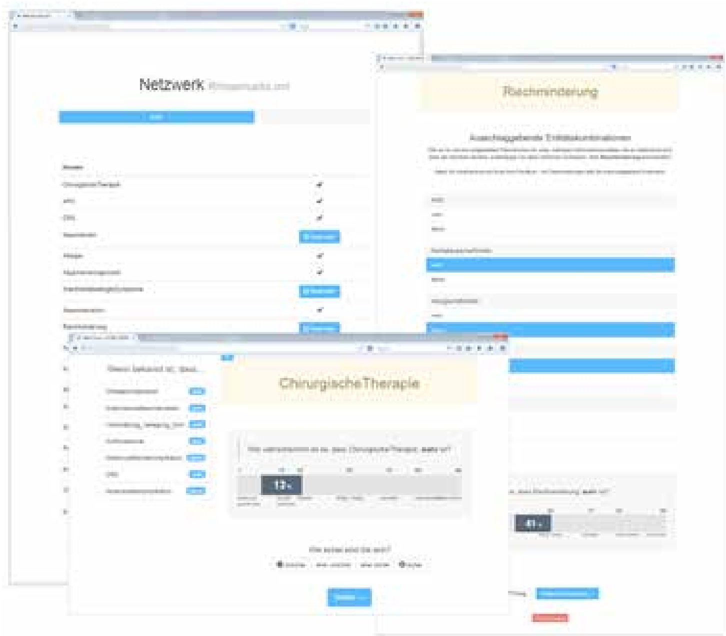

Fig. 2 - Tool for assigning conditional probabilities to information entities in the decision model.

requires collaboration between physicians specialized in the disease to be modeled and computer scientists (MEBN experts) and is time-consuming. One focus of our project is to develop systems to make manual modeling more intuitive so that medical experts can model and set CPTs by themselves without any knowledge of MEBNs. Based on research and our experience over the past year, we are developing web-based modeling tools that allow natural language model-building similar to how medical students ask experts to explain something. Two tools, one for the creation of graphical structures and a CPT tool to set the probabilities, will allow users to build their own models or augment existing models in a database (see Fig. 1). An additional PSBN tool will allow doctors and even patients to visualize and interact with PSBNs. An example of our first CPT tool successfully used in an initial trial with medical experts from the IRDC and UKL in an example therapy decision model of chronic rhinosinusitis is shown in Fig. 2.

The results from this study showed that the time for setting probabilities could be decreased and prompted the development of new features to be integrated in the next steps. Additionally, we will start to work on the graph and visualization tool. By using integrated standardized terminologies (e.g. SNOMED CT) and the modeling structure developed in this project, we hope to create a developing platform which brings developers together and enables important yet time-consuming development to be divided into smaller modeling parts.

Mario Cypko
Dipl.-Inf.
mario.cypko@medizin.uni-leipzig.de

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Bundesministerium für Bildung und Forschung
ZENTREN FÜR INNOVATIONSKOMPETENZ
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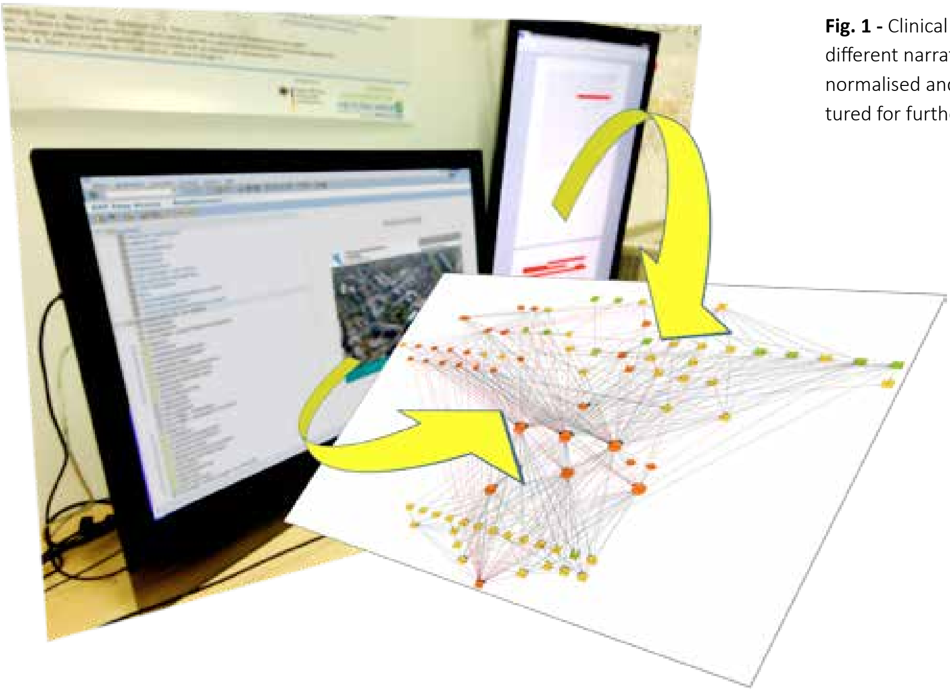

Fig. 1 - Clinical information from different narratives and sources are normalised and semantically structured for further processing.

EXTRACTION OF ADVERSE EVENTS FROM MEDICAL NARRATIVES

When assessing a patient's case, a physician needs to gather different information from multiple sources. Treatment decisions may be affected by adverse events during previous therapy. In this project, a new method for automatically extracting information on adverse events is being developed. This information can then be harnessed by clinical decision support systems.

The majority of clinical documentation is written in a narrative form. Many key facts are distributed among different documents and sources (e.g. admission forms and surgery reports). For a physician, assessing all relevant information is a time-consuming, complex process. To support information processing for a physician for a specific case, computer-based clinical decision support systems (CDSS) are being developed. Natural language processing methods offer a solution by structuring narrative text and identifying text passages that then can be processed by the CDSS.

In this project, a method is being developed to identify and extract information on adverse events from clinical documents. Adverse events comprise complications and other severities impacting the patient's health status. They influence follow-up treatment and health care planning and thus need to be considered by a physician. Structuring information on such events from routinely recorded medical data has a number of advantages. First-

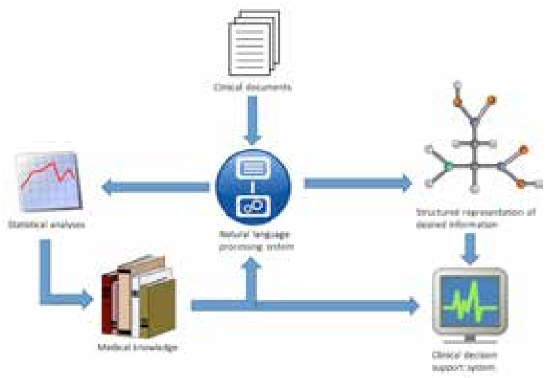

Fig. 2 - Clinical documents are processed by the natural language processing system. Medical knowledge is integrated. The result is a structured representation of the information.

ly, clinical decision-making benefits from the possibility of providing appropriate information in a suitable form at the right time to the attending physicians. Secondly, knowledge about adverse events is enhanced. Clinicians may learn about the likelihood of complications given certain pre-existing conditions. Thirdly, the hospital management may benefit as well by considering information on critical events automatically when calculating diagnosis-related groups.

To be able to identify text passages describing critical events, a given document needs to be semantically analyzed. Medical facts have to be identified and mapped to a medical terminology. Semantic mapping in our method is realized with the ID MACS medical semantic network (MSN). It matches each medical term found to a medical concept (e.g. topological, functional or morphological). The result is a structured, semantic representation of the document (see Fig. 2). Based on this preprocessing, our algorithm identifies adverse events by concepts indicating abnormal changes in the patient status and reinforced by the surrounding context.

The structured extracted information is now available for multiple usages. Presented in a suitable manner, it is still readable by a physician. A summary of a complete case can be achieved by for example condensing the relevant information on adverse events. The clinician then only has to review a smaller subset of all the information instead of the whole document. On the other hand, the results are also machine-readable and can be used for billing purposes. More importantly, medical knowledge on the occurrence of adverse events can be improved by analyzing data over several cases. The extracted information can also be input into CDSSs, which as well as presenting medical data also aid by calculating treatment options based on the documented data in the hospital information system.

Jan Gaebel
M. Sc.

jan.gaebel@medizin.uni-leipzig.de

Kerstin Denecke
Dr.

kerstin.denecke@medizin.uni-leipzig.de

PARTNERS

Leipzig University Hospital
Department of Neurosurgery
Dr. med. Felix Arlt

ID Information und Dokumentation im Gesundheitswesen GmbH & Co KGAA

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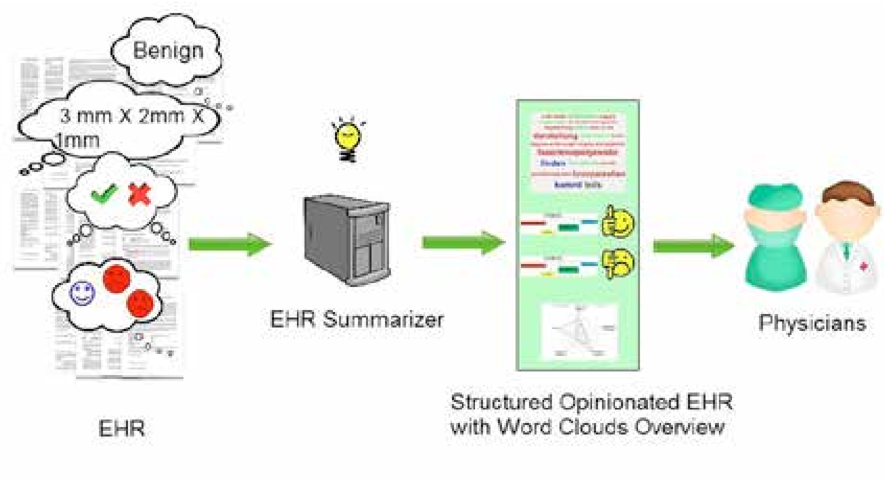

Fig. 1 - EHR summarizing.

SUMMARIZATION OF EHR USING INFORMATION EXTRACTION, SENTIMENT ANALYSIS AND WORD CLOUDS

As medical treatment proceeds, the volume of clinical narratives for each patient increases rapidly. The large amount of patient data can easily overwhelm the processing capability of doctor. There needs to be a simpler way for physicians to gauge a patient's status. In this project, an EHR summarization approach based on information extraction, sentiment analysis and tag clouds is being introduced to simplify daily clinical work.

When patients are monitored over a long period of time, it is essential for physicians to quickly have an overview of the progress and changes in the patient's status at each appointment. This information is documented in the clinical narratives. As medical treatment proceeds, the volume of these records increases rapidly, the large amount of patient data can easily overwhelm the processing capability of physicians. Patient information overload may lead to the following practical problems:

1) It becomes increasingly hard for physicians to get a rapid overview of each patient's health status.

2) Physicians can only use keywords or Boolean queries to search patient records. Semantic aspects such as symptoms, opinions, intentions, and judgment cannot be queried.

3) Summarizing patient status and treatment is highly labor-intensive and time-consuming. In particular, writing the discharge summary of differential diagnoses still requires all the previous judgments and diagnoses to be perused.

In order to solve the »big data« problem concerning clinical records and provide physicians with swift access to the patient's status, we plan to develop a decision support system that aggregates rele-

Fig. 2 - Example for word clouds generated from clinical texts.

vant information from clinical records and presents it in an easily understandable manner. To this end, we have defined a novel processing pipeline based on information extraction, sentiment analysis, word clouds, and summarization technologies. The feasibility of this approach has been evaluated in experiments and user studies.

First of all, the clinical information is extracted, the results forming the basis for further analysis. The information extracted includes linguistic elements, sentiment terms and clinical terms. Next, the subjective parts of clinical narratives are analyzed using methods originating from sentiment analysis in order to glean the physician's attitude from the recommendations, suggestions and judgments in differential diagnosis and treatment outcomes. The extracted information is presented in a structured way or can in future be integrated into probabilistic models developed in the digital patient modeling group for decision support. To summarize the relevant aspects of a document or document set, word clouds are generated using the 50 most common tokens or the most frequently extracted medical concepts. Words or concepts are shown in the

Fig. 3 - Example for word clouds generated from clinical texts with colour-coded parts of speeches.

cloud, their size depending on their frequency in the document.

A user study demonstrated the usefulness of word cloud visualization. All participants agreed that this provided a good initial overview of the patient and their medical condition. In future work, we will improve tag cloud visualization by considering only the most relevant parts of a clinical document when gathering the important terms. Furthermore, the relationships between the entities will be created so that the word clouds can be used to navigate to the relevant data such as texts, radiological images and other clinical data.

Yihan Deng
Dipl.-Inf.

yihan.deng@medizin.uni-leipzig.de

Kerstin Denecke
Dr.

kerstin.denecke@medizin.uni-leipzig.de

GEFÖRDERT VOM
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AUTOMATIC CERVICAL SPINE DEFECT CLASSIFICATION BASED ON CLINICAL NARRATIVES

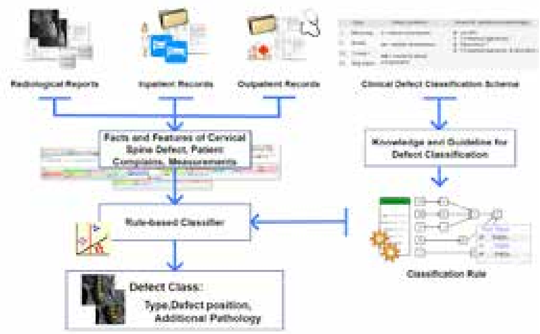

Fig. 1 - Automatic rule-based defect classification system based on clinical narratives.

Classifying defects in the cervical spine provides the basis for unified therapy planning. In this work, we are addressing defect classification based on evidence from textual clinical narratives. The future system will provide suggestions for defect classes and show the relevant information extracted from the patient record, including the radiological image to enable cross-checking by the physician.

Classifying the defects occurring in the cervical spine provides the basis for treatment planning. This process requires evidence from patient records, and the degree of defect needs be encoded in a standardized form to facilitate data exchange and multimodal interoperability. Subsequently, therapy recommendations corresponding to different defect stages can be provided to increase the quality of treatment.

Hitherto, surgeons have based their decisions on the manual interpretation of radiological images showing the location and degree of defects. However, studies have found that this classification is often not reproducible and far from standardized. The patient records contain supplementary documents with additional important evidence which is currently not considered or available at the time of decision-making. Nevertheless, the defect situation and patient status described in the radiological report, anamnesis and admission note are crucial for classification and follow-up therapy planning. To improve existing defect classification, we have augmented automatic image-based classification developed at ICCAS (see project description by Sandra von Sachsen, page 76) with an approach relying on information extraction and classification from the clinical narratives. Automatic defect classification is beset by the following problems:

1) The relevant information needs to be identified in the text.
2) Contexts need to be determined.
3) Rules of defect category mapping need to be defined.

We are addressing these issues by identifying medical concepts, developing ontologies, and establishing classification rules. More specifically, the following components are being developed:

1) Establishment of defect ontology: The defect-related terminology is initially gathered from clinical narratives. The terms are

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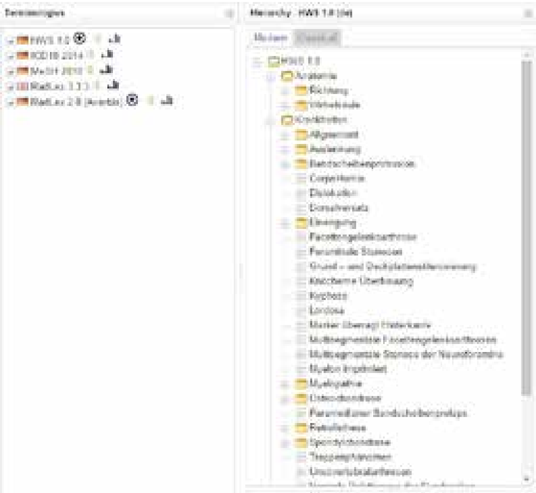

Fig. 2 - Cervical spine defect terminology.

manually classified into topics such as disease, anatomical concept and symptoms.

2) Configuration of an extraction pipeline: The vocabulary related to defect recognition is extracted by a concept mapper that harnesses the defect ontology. Regular expressions are used to detect acronyms, conventional expressions and special word combinations. Other components are also deployed to boost performance.

3) Definition of classification rules: The rules regulate the mapping between extracted features and defect categories. A classification scheme has already been drawn up with defect categories defined according to three main types: defect type (the amount of defect segments), position (medial, lateral or medial lateral) and additional pathology (thickened ligaments, disorders).

4) Clinical data interface: In order to gather the patient records from the clinical system, links are to be established to the hospital information system (HIS) and PACS while employing the corresponding authentication and authorization process to protect patient privacy.

5) User interface: A web-based user interface will be employed due to its high accessibility.

The final system will provide suggestions for defect classes and show the relevant information extracted from the patient record, including the radiological image to enable cross-checking by the physician. At present, we are focussing on the design and validation of classification rules and the extension of defect ontology. In the next stage, the pipeline will be configured and evaluated based on the clinical narratives. In the medium term, the clinical data interface and user interface will be integrated. In the long term, a clinical study will be conducted to evaluate system performance and the outcome of defect classification.

Yihan Deng
Dipl.-Inf.

yihan.deng@medizin.uni-leipzig.de

Kerstin Denecke
Dr.

kerstin.denecke@medizin.uni-leipzig.de

PARTNERS

Leipzig University Hospital
Department of Neurosurgery
Dr. med. univ. Mathias Jakob Groll

Averbis GmbH, Freiburg

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung
ZENTREN FÜR INNOVATIONSKOMPETENZ
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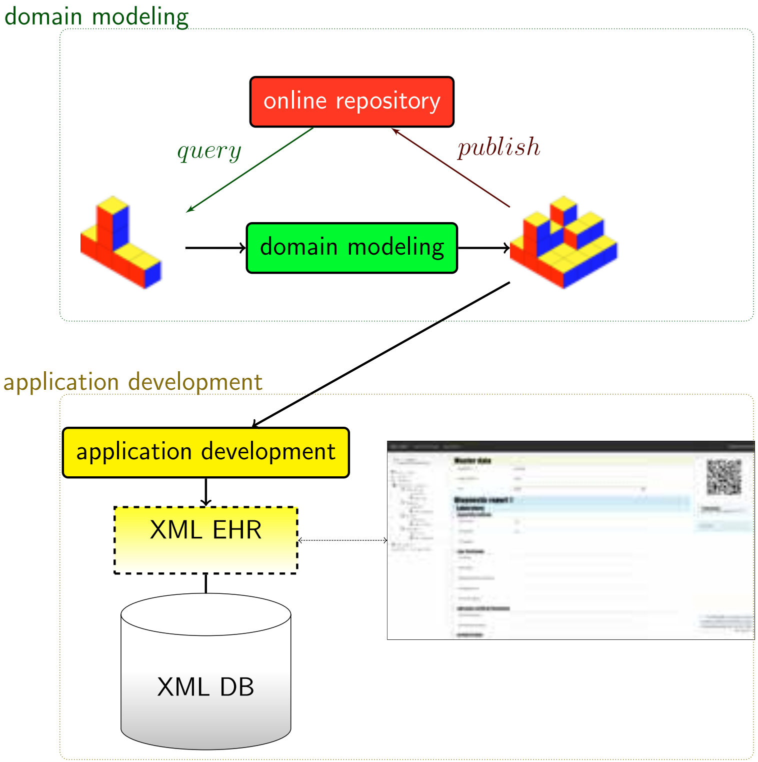

Fig. 1 - Processes of modeling and development.

DIGITAL PATIENT MODEL INFORMATION MODEL

*Electronic Health Records (EHRs) are the main information source of clinicians and researchers. However, their distributed nature means that an integrated disease-specific view often cannot be obtained from EHRs. A Digital Patient Model (DPM) addresses this problem by mapping distributed digital information within a single overarching model. The objective of this work was to evaluate the suitability of the information modeling standard **openEHR** for generating a DPM and EHRs.*

The aim of digital patient modeling is to integrate distributed patient data within a single overarching model. This process of integration requires both a theoretical, standards-based model, and information structures combined with concrete development instructions in the form of a lightweight, standardized development pipeline of individual Electronic Health Records (EHRs). A prototype information system for supporting and managing the treatment of patients with pituitary adenoma was developed using the *openEHR*/ EN 13606 standard for information modeling. The development process consists of domain modeling and application development (see Fig. 1). During domain modeling, the models (or patterns) for the capture of clinical information (known as archetypes) are queried in the online repository and compiled for specific use cases. Missing archetypes were specified

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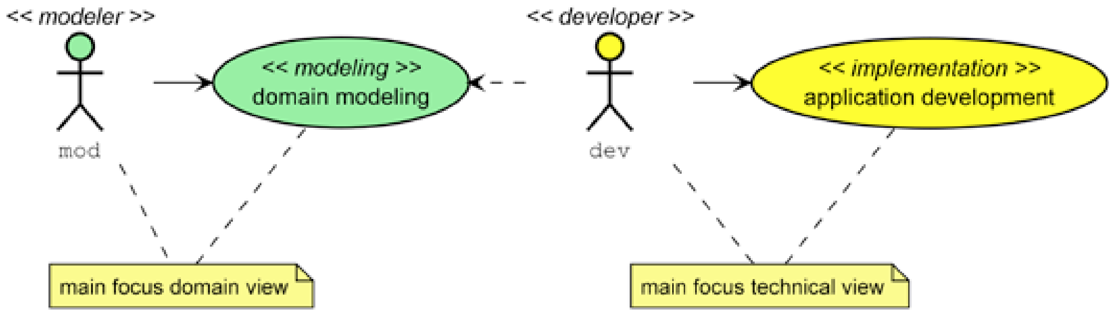

Fig. 2 - Division of work: Modelling an implementation is realized by the respective experts.

for our specific use case. So far, six existing archetypes (for example for »imaging examination result«) have been reused from the *openEHR* database and four new archetypes developed (for example for pituitary adenoma histology). Domain modeling is performed in collaboration with a neurosurgeon. The resulting composite of information is used as a template for application development, as shown at the bottom of Fig. 1. The application builds on the archetypes and templates and delivers XML-based EHRs and dedicated entry forms used to submit clinical data. Finally, the EHRs are persisted in an XML database. From the implementation process we learned that EN 13606, which is influenced by *openEHR*, has three especially advantageous methods. It enables the reuse of predefined building blocks, the archetypes, which are accessible from a worldwide repository [http://www.openehr.org/ckm]. The EHR modeler queries a repository for archetypes suitable for their specific use case. This reuse accelerates the development process. In addition, it allows different systems constructed on the same archetypes to understand the messages without expensive transformation processes, hence enabling semantic interoperability.

Free modeling tools are provided by *openEHR* which allow domain experts to be involved in the modeling process. They can model their information structures themselves better than an external computer scientist. In this way, *openEHR* enables work to be shared (see Fig. 2). Clinicians and researchers can model the domain separately from the underlying reference model. On the other hand, the developers do not have to understand every detail of the domain during the application development process.

Our prototype of an *openEHR*-based information system dedicated to the treatment of patients with pituitary adenoma stores only the patient data relevant for the given disease in a structured, standardized way.

Stefan Kropf
Dipl.-Inf.

stefan.kropf@medizin.uni-leipzig.de

Claire Chalopin
Dr.

claire.chalopin@medizin.uni-leipzig.de

PARTNERS

Leipzig University Hospital
Department of Neurosurgery

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung
ZENTREN FÜR INNOVATIONSKOMPETENZ
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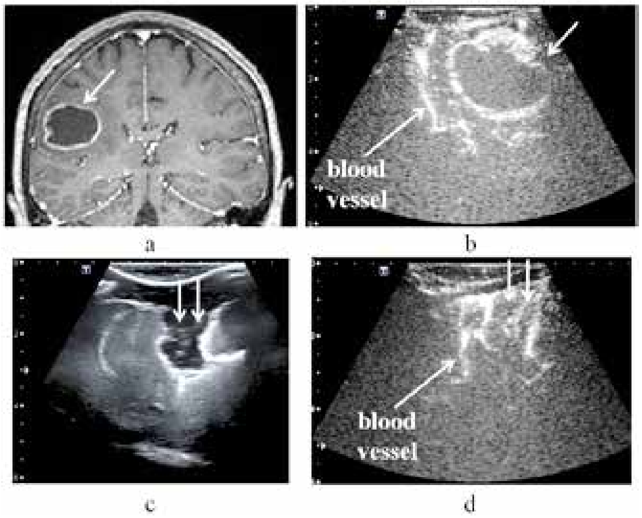

Fig. 1 - The brain tumor (white arrow) is represented in the preoperative cT1MR data (a) and in the 3D US data acquired during the surgery (b, c and d). After operation, the resection cavity (indicated by two white arrows in c and d) is well visible in the B-mode ultrasound image (c). In the 3D-iCEUS (d) the borders of the cavity can be easily misinterpreted as a blood vessel in the image slices.

VASCULAR STRUCTURE TRACKING IN INTRAOPERATIVE ULTRASOUND DATA OF BRAIN TUMORS

In this project, a tool was developed to help the neurosurgeon differentiate the vascular segments from possible remnants of tumor in ultrasound data acquired during brain tumor operations. The method consists in automatically identifying a vascular segment in the intraoperative ultrasound data based on a model. The model of a blood vessel is manually defined in the preoperative MR data and tracked in the ultrasound data acquired before and after tumor resection based on registration methods.

Intraoperative ultrasound imaging is commonly used in brain tumor surgery to investigate the possible presence of residual tumors after operation. In B-mode ultrasound images, tumor remnant is difficult to distinguish from other hyperechogenic structures. An ultrasound contrast agent can be used to highlight not just remnants of tumor but also the vascular structures which therefore have to be identified in the images (see Fig. 1).
The automatic segmentation of vascular structures in ultrasound data is complex because of the image noise and the small diameter of the blood vessels close to the tumor. An alternative method consists in tracking the vascular structures in the 3D intraoperative contrast-enhanced ultrasound (3D-iCEUS) data based on a specific patient model of a vascular segment (see Fig. 2).

Step 1: A vascular segment is manually defined in the preoperative MR data (cT-1MR) in the area surrounding the tumor. This sub-image is called the pattern (white frame in Fig. 2, Step 1).

Step 2: The pattern is rigidly registered with image features of the 3D-iCEUS data acquired before resection, which were extracted within a limited search space taking

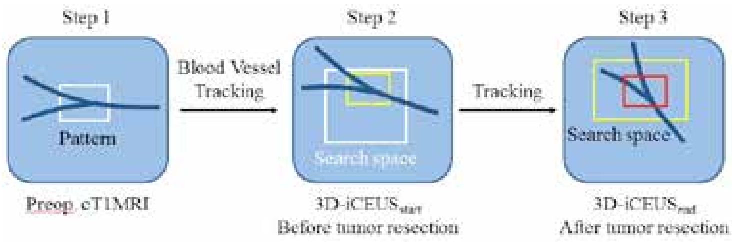

Fig. 2 - Description of the vascular segment tracking in the 3D-iCEUS data performed in three steps.

into account the brain shift (white frame in Fig. 2 Step 2). The limited deformations of the brain at this stage of the operation enable the success of the method. The result is the localization of the position of the vascular segment in the 3D-iUS data (yellow frame in Fig. 2, Step 2).

Step 3: The previously identified vascular segment then becomes the new pattern to track the blood vessel in the 3D-iCEUS acquired after resection based on the same method.

Step 4: The vascular segments are segmented in the identified frames and visualized (see Fig. 3, b and c).

Our method was tested on data of three patients overcoming a brain tumor operation. Its validation was performed by computing an overlap index of the vascular segments before and after tracking and by comparing it with manual registration. Three different similarity measures used in the registration were tested: Normalized Cross Correlation (NCC), Mutual Information (MI) and Normalized Gradient Field (NGF).
Despite the small size of the vascular structures and the image noise in the intraoperative ultrasound images, it was possible to successfully identify a given vascular segment in the 3D-iCEUS data acquired after tumor resection.
The MI similarity measure provided the best performance compared to manual registration and within a minimum computing time, especially when the brain tissue deformations are important. The algorithm is more robust if vessel bifurcations or curved segments are selected as the pattern.

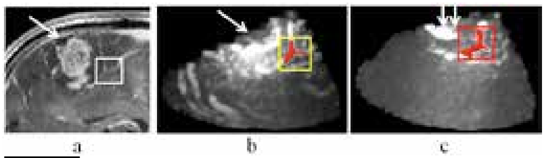

Fig. 3 - Once the frames corresponding to the vascular segment pattern (manually defined in a) were identified in the 3D-iCEUS data (yellow and red frames in b and c), the blood vessels are segmented and visualized (in red in b and c).

In future, longer and several vascular segments will have to be automatically identified. The use of additive information extracted from B-mode ultrasound data should make the tracking tool more robust.

Student Grant Program of the National Council of Science and Technology of Mexico (CONACYT)

Élisée Ilunga Mbuyamba
M. Sc.

e.ilungambuyamba@ugto.mxc

Claire Chalopin
Dr.

claire.chalopin@medizin.uni-leipzig.de

PARTNERS

Leipzig University Hospital
Department of Neurosurgery
Dr. med. Dirk Lindner

University of Guanajuato, Salamanca, Mexico

STANDARDS

STANDARDS FOR MODULAR SYSTEM ARCHITECTURES FOR COMPUTER ASSISTED SURGERY

RESEARCH VISION

Development of standard based methods and tools relating to DICOM in Surgery and IHE Surgery which take account of the specific requirements for surgical/interventional workflows to achieve interoperability of medical devices and systems in the OR.

Standards for Modular System Architectures for Computer Assisted Surgery

Group leader

Prof. Dr. Heinz U. Lemke
hulemke@cars-int.org

During the last decade it was recognised, that the realisation of the »OR of the Future« or DOR, will be a comprehensive undertaking, requiring among others, the development of standards for achieving interoperability of medical devices and systems in the OR. DICOM and IHE have been considered, in principle, as enablers for fulfilling these requirements. Since 2005, ICCAS has taken a leading role in establishing working groups for »DICOM in Surgery« and the domain »IHE Surgery«.

DICOM in Surgery was founded with the aim to develop DICOM objects and services related to Image and Model Guided Therapy (IMGT) and related interventions.
The IHE Surgery domain addresses the issues of IMGT relating to interoperability, information sharing, and model sharing in order to improve the quality of care in surgery and related interventional therapies.

It can be expected that the role of IHE integration profiles will increase in importance for DOR related activities in the future. The significant involvement of the ICCAS Standard Group in DICOM Supplements and conception of IHE Surgery integration profiles and its strong international position in workshops addressing the DOR, have become a trademark of ICCAS.

Selected Publications

Burgert O, Liebmann P, Treichel T, Lemke HU. Towards a new IHE-Domain »Surgery«. Int J Comput Assist Radiol Surg. 2011; 6(1): 156.

Meier J, Liebmann P, Neumuth T, Lemke HU. IHE/XDS-based infrastructure for information management of model guided therapy. Int J Comput Assist Radiol Surg. 2012; 7(1): 477-478.

Lemke HU. Interoperability standards for medical device integration in the OR and issues relating to international approval procedures. Health Management. 2014. [peer reviewed]

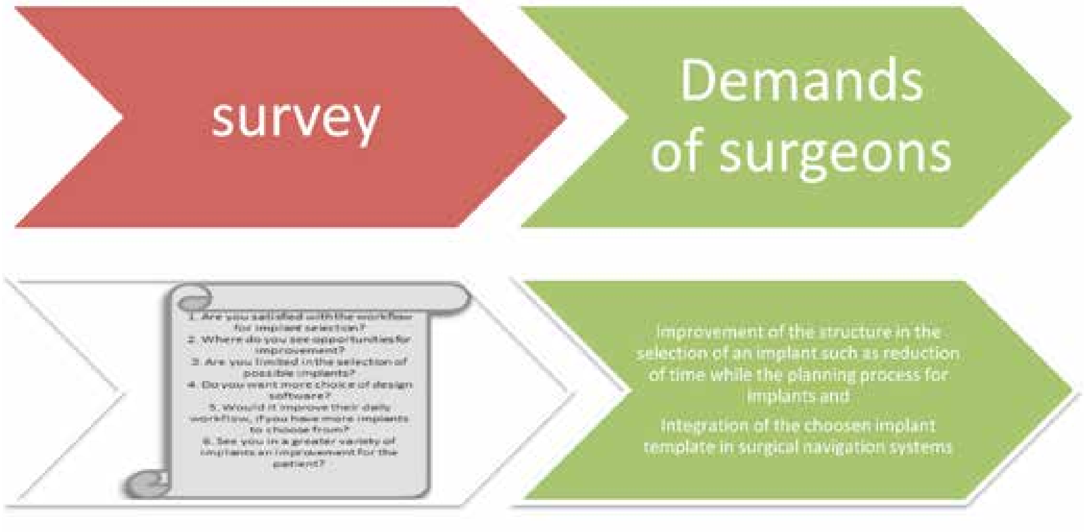

Fig. 1 - A survey with clinical experts from Switzerland and Germany was conducted by us. The results of the survey with clinical experts are summarized as point of criticism.

TOWARDS IHE SURGERY PROFILE FOR IMPLANT TEMPLATE DISTRIBUTION AND IMPLANT PLAN DISTRIBUTION

In clinical practice rigid implants are widely used for example in endoprosthetic or dental surgeries. During planning and applying such rigid implants the surgeon's daily work has an improvement, if the surgeon can dip on work- alleviating and work -accelerating standards. Thus, a new integration profile for rigid implants has to be developed.

In clinical practice rigid implants are widely used for example in endoprosthetic or dental surgeries. During planning and applying such implants, the surgeon's daily work is improved by using work-alleviating and work-accelerating standards. A standardized way of storing, accessing and sharing implant templates is represented in the Digital Imaging and Communications in Medicine (DICOM) supplement 131. To implement this standard in clinical practice several interdisciplinary actors have to interact. In the case of endoprosthetic, actors like manufacturers, software planning vendors and PACS System Integrators are involved. By IHE (Integrating the Healthcare Enterprise), which is an initiative aligning healthcare processes by bringing together healthcare professionals, clinicians, IT specialists and standards development organizations, the implementation of standards can be achieved effectively. The IHE Surgery Profile for Implant Template Distribution and Implant Plan Distribution (ITD/IPD) as supplements of the 2012 founded »IHE Surgery« domain can close the gap between different clinics as well as between manufacturers and cus-

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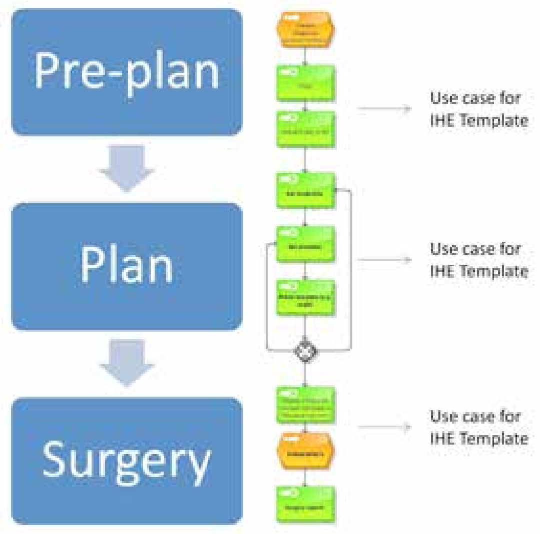

Fig. 2 - In most cases, templates of rigid implants are planned in the same chronological order. As a result of a survey a surgeon's workflow was modeled from which we can infer use cases for IHE Surgery Profile for Implant Template Distribution and Implant Plan Distribution.

tomers by offering standardized DICOM and HL7 usage descriptions.
According to surveys conducted by us, international clinical endoprosthetic experts from several hospitals require a standardized way to choose an implant. This standardized way should not depend on any software or any manufacturer but rather on the patient. In most cases, templates of rigid implants are planned in the same chronological order. The survey with clinical experts was performed with surgeons from Switzerland and Germany. As a result of a survey a surgeon's workflow was modeled. Based on the workflow we can infer use cases for IHE Surgery Profile for Implant Template Distribution and Implant Plan Distribution (see Fig. 2). In addition, the surgeons formulated points of criticism like:

» The demand for improvement of the structure in the selection of an implant
» The demand for integration of the chosen implant template in surgical navigation systems (see Fig. 1).

Thus, the process from planning implants via applying implants through to backtracking the implant is addressed in the ITD and IPD Profile. Based on the ITD and IPD Profile the manufacturer, software vendor and PACS System integrator can implement this standardized way of implant templates usage in clinical daily routine.
Hence, implant manufacturers will have new opportunities to provide digital data about their products; meanwhile vendors of relevant medical devices can facilitate the use of implant template data throughout the clinic. Patient care will be essentially enhanced based on proper and widespread handling of implant templates from acquisition through planning software to intraoperative assistance systems.

Marianne Maktabi
Dipl.-Ing.

marianne.maktabi@medizin.uni-leipzig.de

Philipp Liebmann
M. Sc.

philipp.liebmann@medizin.uni-leipzig.de

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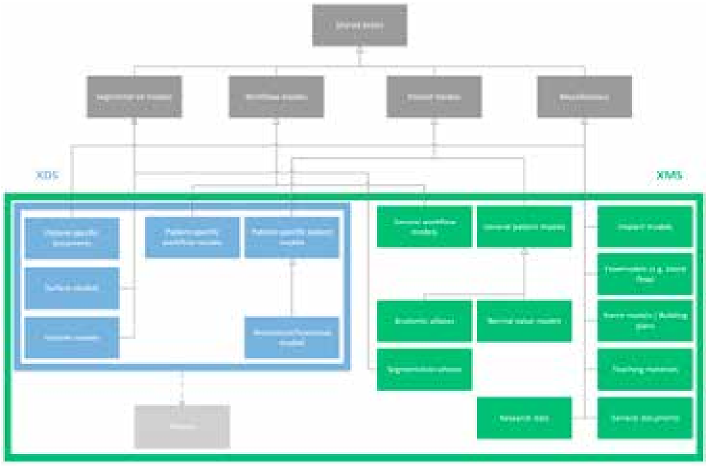

Fig. 1 - Overview of specific and abstract document types in medicine. While IHE XDS includes only patient-specific documents (blue), XMS can handle additionally patient-independent documents (green) as well.

CROSS-ENTERPRISE MODEL SHARING

The IHE Integration Profile Cross-Enterprise Document Sharing (XDS) facilitates the registration, distribution and access of patient-related documents across health enterprises. However, although XDS supports all kinds of patient-specific documents, it does not support patient-independent documents, such as generalized workflows, treatment guidelines or study data. ICCAS aims to develop a generalized data model within a new Integration Profile named Cross-Enterprise Model Sharing (XMS) to cover all types of clinical documents, irrespective of whether they are patient-specific.

Sharing data across healthcare enterprises is crucial for the efficiency and success of both treatment and research. For one thing, healthcare enterprises need to share their experience and specialist services. Furthermore, redundant data input by hand and media faults that could cause misentries are minimized when institutions pool their treatment-related documents.

The IHE Integration Profile Cross-Enterprise Document Sharing (XDS) provides a standards-based specification for sharing all kinds of 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 enable quick access without having to waste time searching in all the repositories.

Unfortunately, XDS only supports documents related to a specific patient. However, there are plenty of non-patient-dependent documents which could usefully be shared such as surgical procedure models, treatment guidelines or study data. To resolve this discrepancy, ICCAS aims to develop a generalized data model within a new Integration Profile named Cross-Enterprise Model Sharing (XMS). XMS embraces all

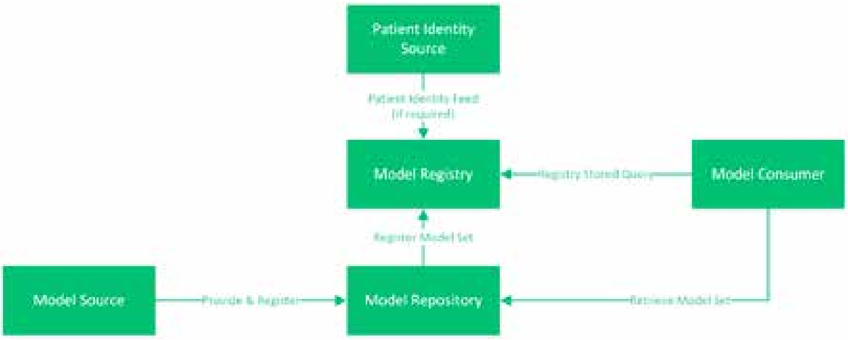

Fig. 2 - Scheme of all XMS actors and transactions. The Patient Identity Source is only required, when handling patient-specific document types.

kinds of clinical documents, regardless of whether they relate to a specific patient. During a needs 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 miscellaneous. Each category contains both patient-specific and patient-independent document types (see Fig. 1).

Although based on XDS architecture, XMS expands its potential by removing the limitations. A model source (e.g. a physician) provides new documents by registering and uploading them into a repository. Having been logged in the registry, they can then be queried by model consumers. In the case of patient-specific documents, the patient identity source identifies the patient concerned. In order to retrieve a document, a model consumer queries the registry. The registry provides the model consumer with information about the document's storage repository and other metadata. This information enables the model consumer to directly retrieve the required document (see Fig. 2).

An XMS registry contains entries referencing documents in a repository. New entries can be submitted by a repository either individually or 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.

XMS systems are hence capable of sharing all kinds of clinical documents among healthcare enterprises as well as communicating patient-specific data with XDS-compliant systems.

Erik Schreiber
M. Sc.

erik.schreiber@medizin.uni-leipzig.de

Gerald Sommer
Dipl.-Inf.

gerald.sommer@medizin.uni-leipzig.de

Philipp Liebmann
M. Sc.

philipp.liebmann@medizin.uni-leipzig.de

Jens Meier
Dipl.-Ing.

j.meier@medizin.uni-leipzig.de

PARTNERS
IHE Germany
IHE International

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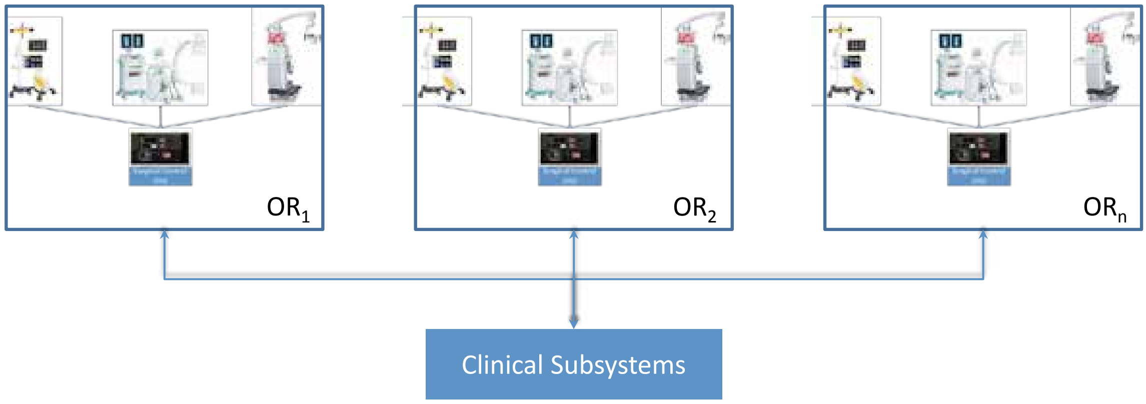

Fig. 1 - In a typical hospital several ORs are operated simultaneously. Communication to the clinical subsystems and other information systems is managed through surgical control units (SCU), one for each operating room (OR).

DISTRIBUTION OF PATIENT IDENTIFICATION INFORMATION TO SURGICAL OR EQUIPMENT – IHE PID

A new integration profile for Patient Identity Distribution among all devices in an OR is being developed in close cooperation with clinicians, industry partners and the newly founded IHE Surgery domain under the internationally recognized IHE initiative.

Sharing data across healthcare enterprises is crucial for the efficiency and success of both treatment and research. For one thing, healthcare enterprises need to share their experience and specialist services. Furthermore, redundant data input by hand and media faults that could cause misentries are minimized when institutions pool their treatment-related documents.

The aims of computer-assisted surgery include reducing effort and redundancy as well as avoiding errors in the transmission of patient demographic data. If they are to be achieved, all devices creating patient-specific data during surgery first have to receive patient demographics such as a unique patient ID, date of birth, gender, etc.

In an ideal world, all the equipment used on a specific patient in a specific OR during surgery would be automatically initialized with the correct unique patient ID so that it can store and communicate data and the diagnosis together with this information to the subsequent clinical archiving systems.

The DICOM Modality Worklist standard has proven very useful in the radiological environment. However, in the OR environment, difficulties are caused by modalities which are called in on demand. In this case, the patient’s data has to be entered or chosen from a list of possible patients on every device to be used on him or her.

The answer would be a central system that distributes the necessary patient information to all the devices in the OR requiring it at some point during surgery. Such a sys-

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Fig. 2 - Each modality in the OR communicates through its associated SCU, reducing the effort for initializing devices for the patient and also reducing the likeliness of errors due to redundancy.

tem is feasible because the information only changes when a patient is taken into or out of the OR, whereas devices may change more frequently.

Existing standards such as DICOM, HL/7 and ISO11073 solve the problem of patient identity distribution for specific limited use cases by means of a Modality Worklist originally designed for a radiological environment.

To find a unified solution which also works for surgical environments, all the existing approaches are to be combined within the Integrating the Healthcare Enterprise (IHE) initiative in a new Integration Profile PID. This will provide a generalized way to cover more aspects of clinical practice and lead to the improved homogeneity of standards, thus enhancing interoperability and interdisciplinary communication.

ICCAS is therefore cooperating with healthcare professionals and industry partners through IHE Surgery to design the best strategy for standardization. This began with a workshop held at ICCAS with various manufacturers of imaging and display systems which resulted in agreement to engineer a solution based on DICOM. The next step will be a workshop to detail the potential IHE Profile. Henceforth, when purchasing new equipment, clinicians need only look for a declaration of conformity with the IHE Integration Profile PID because IHE-compliant devices can easily and reliably communicate with each other, even in today's heterogeneous environments.

In order to prove compliance, manufacturers have to demonstrate under independently controlled conditions at a Connectathon that their devices can communicate with any other PID-compliant equipment. ICCAS is supporting manufacturers and clinicians throughout the process with expertise and advice.

Philipp Liebmann
M. Sc.

philipp.liebmann@medizin.uni-leipzig.de

PARTNERS

IHE International
BrainLab AG, Feldkirchen

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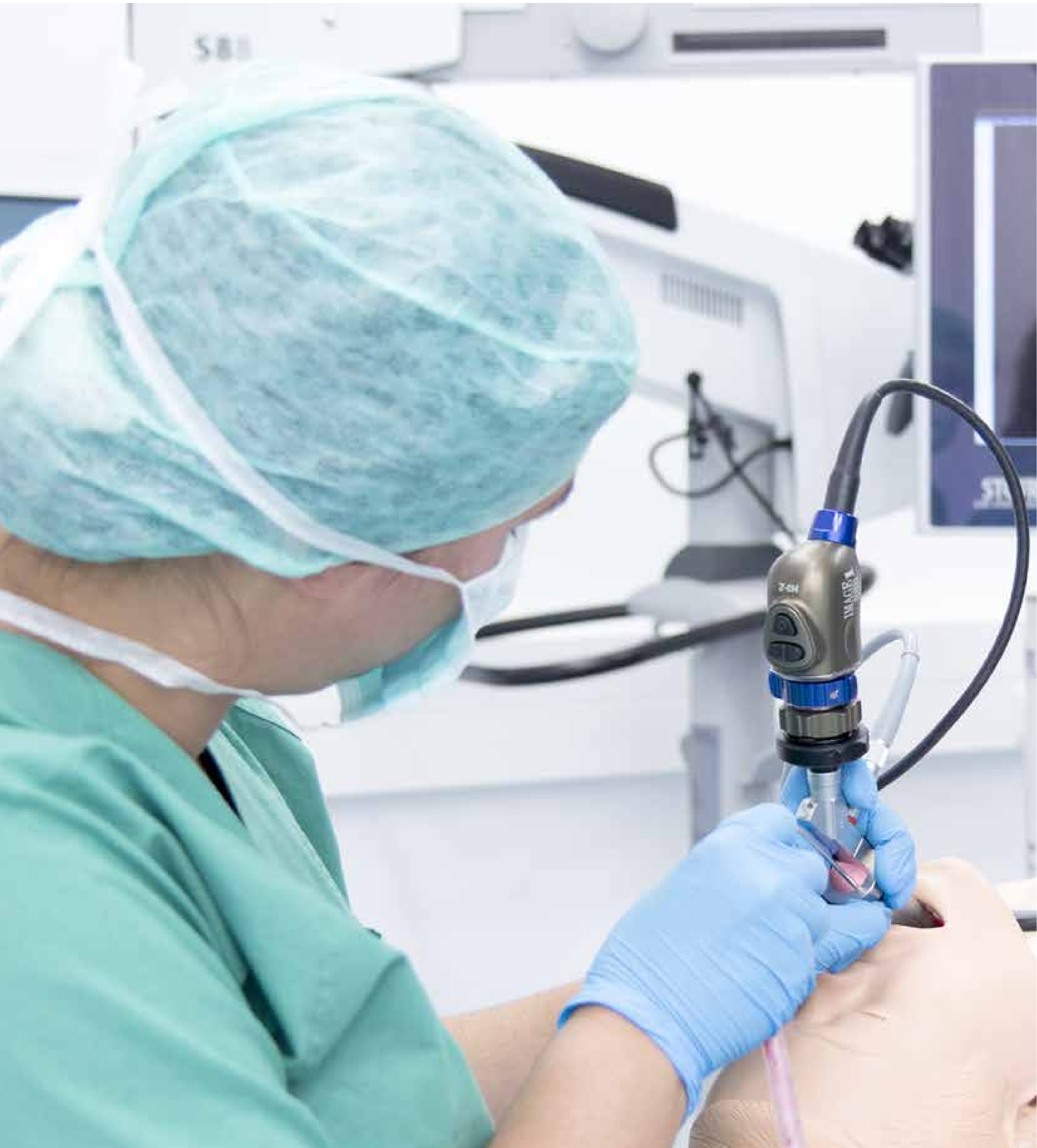
PascAL

PATIENT SIMULATION MODELS FOR SURGICAL TRAINING AND TEACHING



RESEARCH VISION

To improve the training of young surgeons in an increasingly complex environment.

Patient Simulation Models for Surgical Training and Teaching

Project leaders

Prof. Dr. Jürgen Meixensberger

juergen.meixensberger@medizin.uni-leipzig.de

Prof. Dr. Andreas Dietz

andreas.dietz@medizin.uni-leipzig.de

PascAL is a joint research project by the Leipzig University and HTWK Leipzig University of Applied Sciences. Junior scientists from ICCAS and the HTWK research group Innovative Surgical Training Technologies are performing research and development into intelligent surgical training models. This takes place in scientific tandems consisting of a physician and an engineer.

The training models allow physicians to realistically practice surgical interventions and to prepare for complex medical decisions and complicated situations during an operation. With technical complexity steadily rising, these advanced training methods improve surgeons' accuracy – and hence patient safety.

Selected Publications

Pilic T, Busch F, Lorber I, Seeburger J, Korb W. Development of a hybrid surgical training simulator for the replacement of the aortic valve facilitating porcine hearts. 48th Annual Conference of the German Society for Biomedical Engineering (DGBMT); Hannover; 2014.

Hafez J, Koehler C, Boehm A, Dietz A. Konzeption eines CT-Daten basierten, realitätsnahen Kunststoffsimulators der oberen Atem- und Speisewege für die Panendoskopie. Jahresversammlung Deutsche HNO Gesellschaft; Dortmund; 2014.

Hafez J, Koehler C, Korb W, Boehm A, Dietz A. Ein realistischer Trainingssimulator fuer die schwierige Intubation bei HNO-Tumorpatienten und dessen Validierung durch Anästhesisten. InSiM 2014; Frankfurt am Main; 2014.

Fig. 1 - Minimal invasive aortic valve simulator.

DEVELOPMENT AND VALIDATION OF ENVIRONMENTS OF SIMULATED TRAINING FOR CONVENTIONAL AND MINIMAL INVASIVE OPERATION IN HEART SURGERY

The aim of the PascAL project is to develop a surgical training simulator for minimal invasive aortic valve replacement in close cooperation with the research group »ISTT – Innovative Surgical Training Technologies« at HTWK Leipzig University of Applied Sciences and the Department of Cardiac Surgery at Heart Center Leipzig. It comprises a realistic hybrid simulator using a porcine heart as a replaceable, destructible item inside a synthetic thorax model.

Cardiac surgery is a dynamic field that will continue to face diverse challenges such as increasingly complex operations and the development of innovative techniques. The high complexity of minimally invasive surgery is especially important and places special demands on the surgical training of doctors. In response to this, a simulator comprising a hybrid model was developed for minimally invasive aortic valve replacement in the PascAL project. The synthetic thorax was made on the basis of real patient computed tomography data. It surrounds a porcine heart, which is a replaceable, destructible element resting on a support system. Because the depth and longitudinal axis are adjustable,

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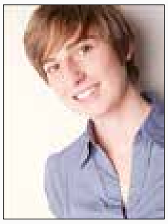
Fig. 2 - Minimal invasive aortic valve simulator in »training«.

the surgical site can be shown realistically and in various levels of difficulty. The validity of the simulator was tested in conjunction with consultants and specialists from Heart Center Leipzig.

Fig. 3 - Minimal invasive aortic valve simulator prepared for validation.

It allows realistic cannulation for cardiopulmonary bypass and the realistic implantation of an aortic valve prosthesis. The simulator can be used to practice the main steps and reproduces the challenges of keyhole surgery. The success of a simulated operation is assessed by visual inspection and leak testing, providing an objective rating of the surgeon's skills. The simulation model is to be regularly used in surgical training courses and will contribute to the close study of various techniques, operating methods and in particular fundamental cardiac surgery skills.



Franziska Busch
Physician

franziska.busch3@medizin.uni-leipzig.de

Tobias Pilic
M. Sc.
pilic@istt.htwk-leipzig.de

Joerg Seeburger
Prof. Dr. med.
joerg.seeburger@medizin.uni-leipzig.de

PARTNERS

Leipzig University of Applied Sciences (HTWK)
Institute of Innovative Surgical Training Technologies (ISTT)
Prof. Dr. sc. hum. Werner Korb

Herzzentrum Leipzig, University Hospital

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Fig. 1 - Videolaryngoscopy performed on the panendoscopy simulation system. The assisting doctor points to the monitor in the background of the picture, where the right vestibular fold shows swelling and reddening hiding the vocal fold from sight.

DEVELOPMENT AND EVALUATION OF SIMULATED TRAINING ENVIRONMENTS FOR PANENDOSCOPIES

The aim of the PascAL subprogram »Development and Evaluation of Simulated Training Environments for Panendoscopies« was to construct a realistic silicone simulator to practice rigid panendoscopy and the associated therapeutic decisions in ENT oncology. The simulator shows a case of advanced supraglottic larynx carcinoma. In addition, it represents a difficult airway management situation suitable for training anesthetists and doctors working in emergency medicine.

The development of the simulator based on CT data was continued. After material tests, the first prototype was unveiled at the German Anesthesia Congress in May in Leipzig. As anesthetists share their »area of interest« – the upper airways – with ENT specialists, we decided to validate the simulator with its standard anatomy and the training system setting for intubation (which is always part of panendoscopy). The haptics and appearance of the simulator's components were considered realistic by 73% (n=8), while overall the simulator was rated as realistic by 58% (n=7). Further development addressed the tumor of the larynx and improving the stability of the material used for the larynx following the observation of material defects in the larynx after 25 intubations. Additionally, the modular construction

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Fig. 2 - The panendoscopy training module is integrated into a LAERDAL training system (Laerdal MegaCode Kelly) widely spread in Germany for training of professionals in advanced life support. The exchange of the module is done by unscrewing 4 screws and takes only 5 minutes.

was improved to simplify the repair and replacement of damaged structures. In September, the prototype of the simulator including a tumor pathology of the larynx was demonstrated in Chemnitz at the annual meeting of ENT specialists in central Germany. Twelve panendoscopies were performed on the simulator. All the participants rated panendoscopy training using the simulator (including intubation) as useful and highly motivating and the simulator itself was described as fairly realistic by the majority (n=10). However, the esophagus and the entrance to the esophagus were considered too wide (n=9) and the lack of the typical star-shaped mucosal rugs was criticized. The tumor design was rated realistic by 9 specialists. In the concluding project phase, we will continue to validate and modify the simulator in response to the findings, devoting particular attention to the stability of the materials.

Joumanah Hafez
Dr. med.
joumanah.hafez@medizin.uni-leipzig.de

Christian Köhler
M. Eng.
koehler@istt.htwk-leipzig.de

Andreas Dietz
Prof. Dr. med.
andreas.dietz@medizin.uni-leipzig.de

Andreas Boehm
Dr. med.
andreas.boehm@medizin.uni-leipzig.de

CONTRIBUTORS
Carol Selig (Dipl.-Des.)
selig@istt.htwk-leipzig.de

Jochen Handwerk (Dipl.-Des.)
handwerk@istt.htwk-leipzig.de

Andrej Machno (Dipl.-Inf.)
machno@istt.htwk-leipzig.de

PARTNERS
Leipzig University of Applied Sciences (HTWK)
Institute of Innovative Surgical Training Technologies (ISTT)
Prof. Dr. sc. hum. Werner Korb

Leipzig University Hospital
Department of ENT-Surgery

Austrian Center for Medical Innovation and Technology (ACMIT)
M.Sc. Markus Krenn, Dr.-Ing. Gernot Kronreif

Dornheim Medical Images GmbH Magdeburg
Lars Dornheim

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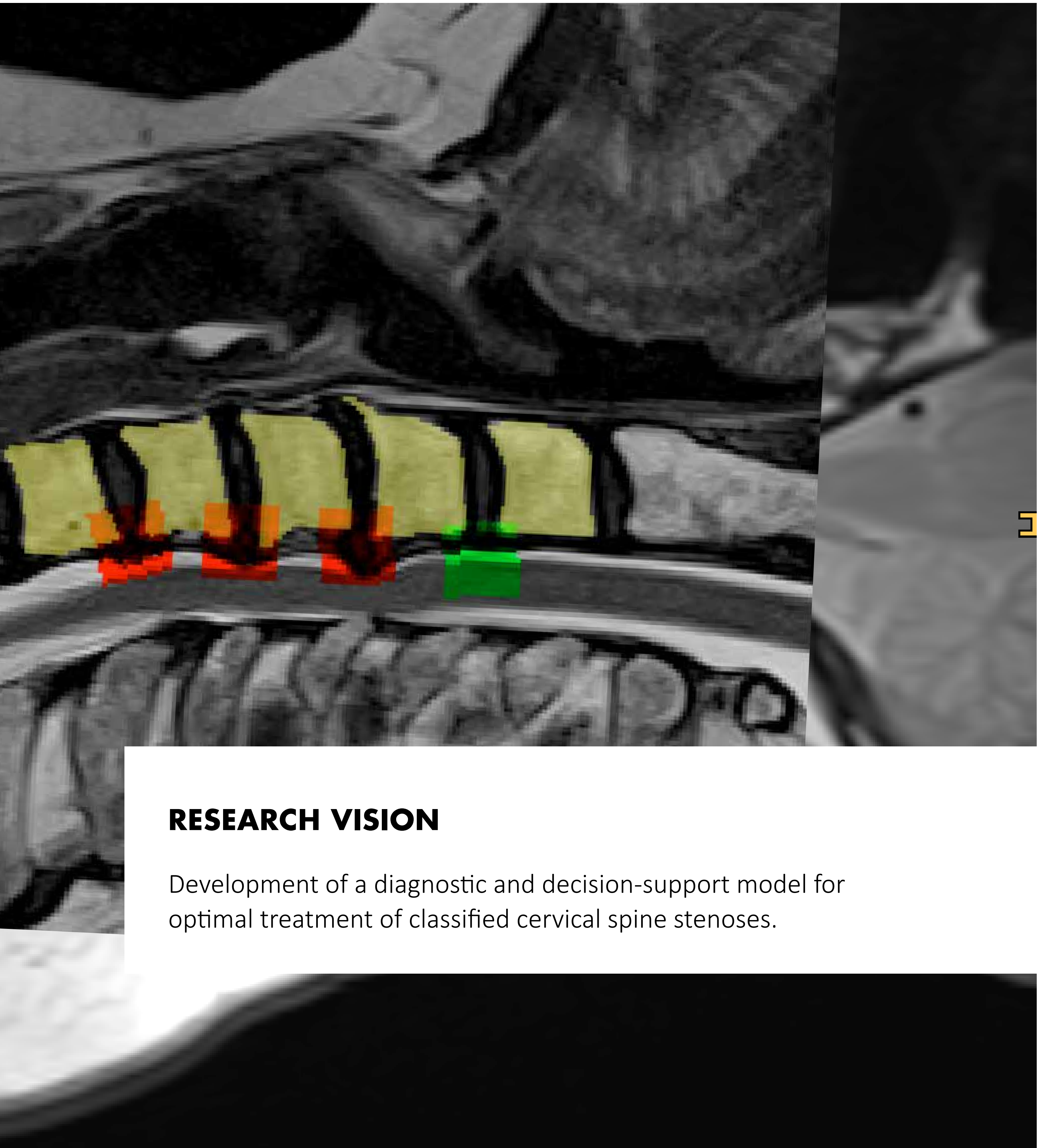
HWS

STRUCTURAL DEFECT CLASSIFICATION OF CERVICAL SPINE



RESEARCH VISION

Development of a diagnostic and decision-support model for optimal treatment of classified cervical spine stenoses.

Structural Defect Classification of Cervical Spine

Project leader

Prof. Dr. Jürgen Meixensberger

juergen.meixensberger@medizin.uni-leipzig.de

An interdisciplinary research group is developing a defect-specific planning model of the middle and lower cervical spine in order to improve the treatment of cervical spinal canal stenosis. Neurosurgeons, anatomists, computer scientists and engineers are collaborating on four sub-projects. The main goals are to define a defect classification for the degenerative modified cervical spine, to develop computer-based methods to assist the surgeon in classifying patients, and experimental work to examine the structural mechanics of vertebrae and ligaments.

Selected Publications

Daenzer S, Freitag S, von Sachsen S, Steinke H, Groll MJ, Meixensberger J, Leimert M. VolHOG: A volumetric object recognition approach based on bivariate histograms of oriented gradients for vertebra detection in cervical spine MRI. J Med. Phys. 2014; 41 (8): 082305.

von Sachsen S, Daenzer S, Freitag S, Groll MJ, Meixensberger J, Leimert M. Computer aided defect classification for model-based therapy of cervical spinal stenosis. Proceedings of the International Conference on Biomedical Engineering and Systems (ICBES); Prague, Czech Republic; 2014; 126.1-126.6.

Daenzer S, Freitag S, von Sachsen S, Groll MJ, Steinke H, Meixensberger J, Leimert M. A Computer-based approach for classification of cervical spine defects in MR images. DGNC-Jahrestagung; Dresden; 2014; Postersession.

STRUCTURAL MECHANICAL DEFECT CLASSIFICATION AND MODELING OF THE CERVICAL SPINE

Zunahme Schweregrad (von I bis IV und von 0 bis 3)

	Type	Defect position	Grade AP (additional pathology)
I	Mono-seg.	**l** = lateral compression	**0** (no AP)
II	Bi-seg.	**m** = medial compression	**1** (Thickened ligaments) [1]
III	Tri-seg.+	**ml** = medial & lateral compression	**2** (Disorders) [2]
IV	Skip lesion		**3** (Thickened ligaments & disorders)

Fig. 1 - MRI-based defect classification scheme for systematic description of cervical spinal stenosis with concomitant pathology.

An interdisciplinary research group is developing a defect-specific planning model of the middle and lower cervical spine in order to improve the quality of treatment of cervical spinal canal stenosis. Neurosurgeons, anatomists, computer scientists and engineers are collaborating on four sub-projects. The main goals of research are to define a system of defect classification for the degenerative modified cervical spine, to develop computer-based methods to assist the surgeon in classifying patients, and experimental work to examine the structural mechanics of vertebrae and ligaments in order to aid the development of defect-specific treatment strategies.

Subproject »Defect classification«

A system of defect classification based on magnetic resonance imaging (MRI) to describe cervical spinal stenosis with concomitant pathologies was developed by the neurosurgery departments at the university hospitals in Dresden and Leipzig (see Fig. 1). For this purpose, a patient collective of n = 182 was analyzed. The current classification scheme contains three categories. The first category is the defect dimension (e.g. spinal canal narrowing over several segments) described by roman numerals. The defect position is specified by lower case (m, l, ml). The third category breaks down possible concomitant pathologies using numbers from 0 to 3. The image-based classification scheme introduced has to be considered as a component of the intended defect classification system which, alongside anatomical defect characteristics, also contains clinical symptoms.

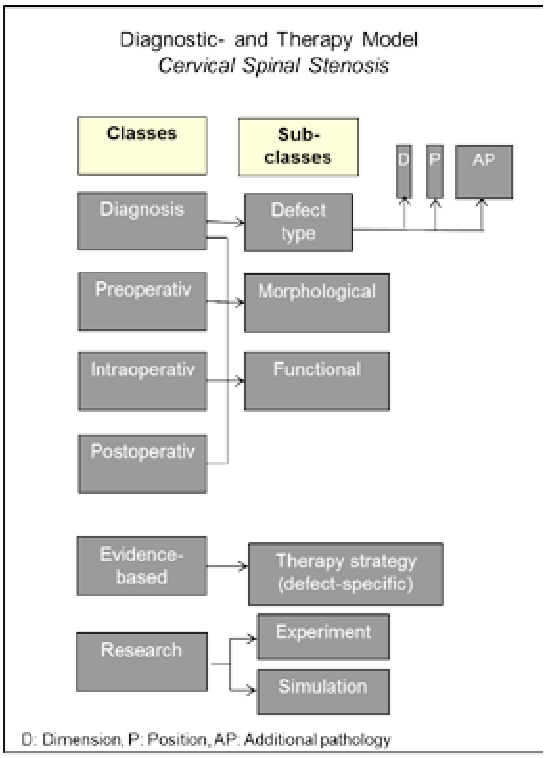


Fig. 2 - Concept of the diagnosis and therapy model cervical spine canal stenosis.

Subproject »Computer-based modelling«

Model concept and defect encoding

An initial model concept to assist the diagnosis and therapy of cervical spinal stenosis was developed (see Fig. 2). The concept contains six classes for data storage. Four classes are for the storage of data generated during the common phases of patient treatment and can be divided into diagnosis and the pre-operative, intra-operative and post-operative phases. Furthermore, a class is introduced which contains data of patients previously treated and which have already been classified using the classification scheme developed.

These data may be helpful for developing defect-specific treatment strategies. The latest research findings are to be stored in another class which can also contribute to the development of optimized treatment strategies. The work performed so far concerns class diagnosis and its defect classification with the related coding scheme for the explicit and reproducible description of defect characteristics (see Fig. 3).

Automatic identification of defect characteristics in MRI images

Different methods for the automatic detection of spinal canal stenosis were tested to help physicians identify defect characteristics in MRI images. For this purpose, the image area adjacent to the spinal canal considered for the detection of stenosis has to be initially defined (see Figs 4 and 5). Afterwards, the detected area has to be classified as an area of stenosis or no stenosis using the HOG feature vector and a suitable classifier. To generate the descriptor vector MRI, data of n = 155 patients were used. The results show the correct classification of detected spinal canal areas for 76% of the 80 cases tested. The color-coded classification results are shown in Fig. 6 with green indicating no stenosis and red showing stenosis.

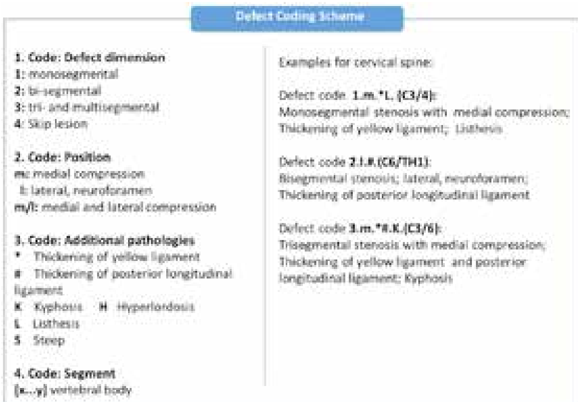


Fig. 3 - Defect coding scheme for explicit description of defect characteristics by the system.

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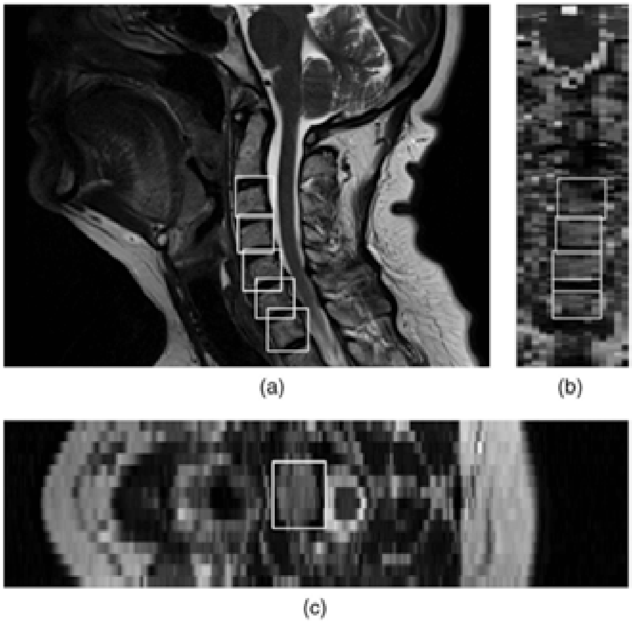


Fig. 4 - Detection of cervical vertebrae in MRI using the developed HOG-algorithm (marked by white boxes), a: sagittal, b: coronal, c: transversal.

Fig. 5 - Definition of relevant detection areas for stenosis classification.

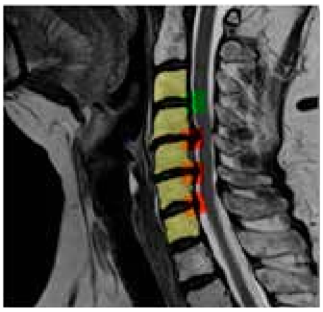


Fig. 6 - Color-coded classification result (green: no stenosis, red: stenosis).

Jürgen Meixensberger

Prof. Dr. med.

juergen.meixensberger@medizin.uni-leipzig.de

Sandra von Sachsen

Master Multimédia, Dipl.-Inf. (FH)

sandra.vonsachsen@medizin.uni-leipzig.de

Stefan Dänzer

Dipl.-Inf.

stefan.daenzer@machine-mind.com

Stefan Freitag

M. Sc.

stefan.freitag@medizin.uni-leipzig.de

PARTNERS

Subproject »Biomechanical Analysis«
Leipzig University Hospital
Department of Anatomy
PD Dr. rer. Medic Hanno Steinke

Subproject »Defect Classification«
Leipzig University Hospital
Department of Neurosurgery
Dr. med. univ. Mathias Jakob Groll

Subproject: »Defect Classification«
University Hospital Carl Gustav Carus Dresden
Department of Neurosurgery
OA Dr. med. Mario Leimert

Subproject »Biomechanical Analysis«
Fraunhofer IWU Dresden
Dipl.-Ing. (FH) Michael Werner

PUBLICATIONS

Articles

Amato C, Lemke HU, Ratib O. Intelligent operating rooms: preparing for the new digital patient model challenges. Int J Comput Assist Radiol Surg. 2014; 9 (1): 205-206.

Berliner L, Lemke HU, editors. An Information Technology Framework for Predictive, Preventive and Personalised Medicine – A Use-Case with Hepatocellular Carcinoma. In: Golubnitschaja O, series editor. Advances in Predictive, Preventive and Personalised Medicine. Vol. 8; Springer 2015.

Berliner L, Lemke HU et al. Model-guided therapy for hepatocellular carcinoma: a role for information technology in predictive, preventive and personalized medicine. EPMA J. 2014; 5: 16.

Cypko M, Stoehr M, Denecke K, Dietz A, Lemke HU. User interaction with MEBNs for large patient-specific treatment decision models with an example for laryngeal cancer. Int J Comput Assist Radiol Surg. 2014; 9(1).

Daenzer S, Freitag S, von Sachsen S, Steinke H, Groll M, Meixensberger J, Leimert M. VolHOG: A volumetric object recognition approach based on bivariate histograms of oriented gradients for vertebra detection in cervical spine MRI. J Med Phys. 2014; 41(8): 082305.

Denecke K. Ethical Aspects of Using Medical Social Media in Healthcare Applications. Stud Health Technol Inform. 2014; 198: 55-62.

Denecke K. Use Cases and Application Purposes of Social Media in Healthcare. In: Househ M, Borycki E, Kushniruk A, editors. Social Media and Mobile Technologies for Healthcare. IGI Global. 2014; 59-74.

Denecke K. Sublanguage Analysis of Medical Weblogs. Stud Health Technol Inform. 2014; 205: 565-569.

Denecke K, Cypko M, Deng Y. A Concept for Semi-Automatic Generation of Digital Patient Models. Biomed Tech (Berl). 2014; 59(1): 754-757.

Deng Y, Denecke K. Visualizing Unstructured Patient Data for Assessing the Health Status. Stud Health Technol Inform. 2014; 205: 1158-62.

Glaser B, Daenzer S, Neumuth T. Intra-operative surgical instrument usage detection on a multi-sensor table. Int J Comput Assist Radiol Surg. 2014; 1–12.

Hansen C, Heckel F, Ojdanic D, Schenk A, Zidowitz S, Hahn H K. Genauigkeit und Fehlerquellen im Operationssaal am Beispiel der Leberchirurgie. In: Niederlag W, Lemke H U, Strauß G, Feußner H, editors. Health Academy: Der digitale Operationssaal. Genauigkeit und Fehlerquellen im Operationssaal am Beispiel der Leberchirurgie. De Gruyter; 2014. 69-87.

Heckel F, Meine H, Moltz J H, Kuhnigk J M, Heverhagen J T, Kießling A, Buerke B, Hahn H K. Segmentation-Based Partial Volume Correction for Volume Estimation of Solid Lesions in CT. IEEE Transactions on Medical Imaging. 2014; 33(2): 462-480.

Heckel F, Moltz J H, Meine H, Geisler B, Kießling A, D'Anastasi M, dos Santos D P, Theruvath A J, Hahn H K. On the Evaluation of Segmentation Editing Tools. SPIE Journal of Medical Imaging. 2014; 1(3); 034005-1-034005-16.

Ilunga Mbuyamba E, Lindner D, Arlt F, Muens A, Meixensberger J, Chalopin C. Vascular structure tracking in intraoperative 3D ultrasound data during brain tumor resection. Biomed Tech. 2014; 59(1): 457.

Kaiser M, John M, Heimann T, Brost A, Neumuth T, Rose G. 2D/3D Registration of TEE Probe from Two Non-orthogonal C-arm Directions. In: Golland P, Barillot C, Hornegger J, Howe R, editors. Medical Image Computing and Computer-Assisted Intervention MICCAI 2014. vol. 8673 of Lecture Notes in Computer Science. Boston, USA; 2014. 283-290.

Kaiser M, John M, Heimann T, Neumuth T, Rose G. Comparison of Optimizers for 2D/3D Registration for Fusion of Ultrasound and X-Ray. In: Deserno TM, Handels H, Meinzer HP, Tolxdor T, editors. Bildverarbeitung fuer die Medizin 2014. Informatik aktuell. Aachen, Germany: Springer Berlin Heidelberg; 2014. 312-317.

Kaiser M, John M, Heimann T, Neumuth T, Rose G. Improvement of Manual 2D/3D Registration by Decoupling the Visual Influence of the Six Degrees of Freedom. In: IEEE 11th International Symposium on Biomedical Imaging (ISBI). 2014; 766-769.

Kaiser M, John M, Koerner M, Heimann T, Neumuth T, Rose G. Necessity of Calibrated Projection Matrices for the 2D/3D Registration of TEE ultrasound and X-ray. In: Image-Guided Interventions- IGIC. Beijing, China; 2014.

Lassalle R, Marold J, Schoebel M, Manzey D, Bohn S, Dietz A, Boehm A. Entscheidungsprozesse im Tumorboard bei eingeschraenkter Evidenzlage. Laryngo-Rhino-Otologie. 2014; 93(4): 237-243.

Lemke HU. Interdisciplinary cooperation between radiology and surgery: What can International Hospital (or the media generally) do to make this possible?, International Hospital, Vol. 40, 2014, 22-23.

Lemke HU, Berliner L (2014): Der digitale Operationssaal – Stand und zukuenftige Entwicklungsphasen. In: Niederlag W, Lemke HU, et al. (2014) (Editors): 2. Auflage. Der Digitale OP-Saal, Health Academy. Walter de Gruyter Verlag Berlin, Boston.

Lemke HU, Cypko M, Warner D, Berliner L. 3D++ visualisation of MEBN graphs and screen representations of patient models (PIXIE II). Studies in Health Technology and Informatics. Volume 196: Medicine Meets Virtual Reality 21. 248-51.

Lemke HU, Cypko M, Berliner L (2014): Der virtuelle Patient im Rahmen der Therapieplanung am Beispiel des Larynxkarzinoms. In: Niederlag W, Lemke HU, et al. (2014) (Editors): 2. Auflage. Der virtuelle Patient, Health Academy. Walter de Gruyter Verlag Berlin, Boston.

Lemke HU, Golubnitschaja O. Towards personal health care with model-guided medicine: long-term PPPM-related strategies and realisation opportunities within Horizon 2020. EPMA J. 2014; 5: 8.

Lemke HU, Vannier MW, Inamura K, Farman AG, Doi K, Cleary K, Jannin P, Hashizume M, editors. Proceedings of the 28th International Congress and Exhibition Computer Assisted Radiology and Surgery. International Journal of Computer Assisted Radiology and Surgery (CARS). 9 (1); Heidelberg: Springer Verlag; 2014.

Luz M, Manzey D, Modemann S, Strauss, G. Less is sometimes more: A comparison of distance-control and navigated-control concepts of image-guided navigation support for surgeons. Ergonomics. 2014; 1-11.

Luz M, Manzey D, Mueller S, Dietz A, Meixensberger J, Strauss G. Impact of navigated-control assistance on performance, workload and situation awareness of experienced surgeons performing a simulated mastoidectomy. Int J Med Robot. 2014; 10(2): 187-195.

Meier J, Boehm A, Kielhorn A, Dietz A, Bohn S, Neumuth T. Design and Evaluation of a Multimedia Electronic Patient Record »oncoflow« with Clinical Workflow Assistance for Head and Neck Tumor Therapy. Int J Comput Assist Radiol Surg. 2014; 1-17.

Meißner C, Meixensberger J, Pretschner A, Neumuth T. Sensor-Based Surgical Activity Recognition in Unconstrained Environments. Minim Invasive Ther Allied Technol. 2014; 23(4): 198-205.

Muens A, Muehl C, Haase R, Moeckel H, Chalopin C, Meixensberger J, Lindner D. A neurosurgical phantom-based training system with ultrasound simulation. Acta Neurochir (Wien). 2014 Jun; 156(6):1237-43.

Niederlag W, Lemke HU, Lehrach H, Peitgen H-O (2014) (Editors): 2. Auflage. Der virtuelle Patient, Health Academy. Walter de Gruyter Verlag Berlin, Boston.

Niederlag W, Lemke HU, Strauß G, Feußner H (2014) (Editors): 2. Auflage. Der digitale Operationssaal, Health Academy. Walter de Gruyter Verlag Berlin, Boston.

Rockstroh M, Franke S, Neumuth T. Requirements for the Structured Recording of Surgical Device Data in the Digital Operating Room. Int J Comput Assist Radiol Surg. 2014; 9(1): 49-57.

Schreiber E. Entwicklung einer Methode zur Generierung fallspezifischer Prozessmodelle mit Hilfe praeoperativer Daten. Masterarbeit 2014.

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

Strauß G, Schaller S, Gollnick I. Effekte eines multifunktionalen Instruments (HF-Schere) in der Parotischirurgie. HNO. 2014; 62: 196-201.

Velasco E, Agheneza T, Denecke K, Kirchner G, Eckmanns T. Social Media and Internet-Based Data in Global Systems for Public Health Surveillance: A Systematic Review. Milbank Quarterly. 2014; 92(1): 7-33.

von Aspern K, Foldyna B, Etz CD, Hoyer A, Girrbach F, Holzhey D, Luecke C, Grothoff M, Linke A, Mohr FW, Gutberlet M, Lehmkuhl L. Effective diameter of the aortic annulus prior to transcatheter aortic valve implantation: influence of area-based

versus perimeter-based calculation. Int J Cardiovasc Imaging. 2014.

von Sachsen S, Senf B, Burgert O, Meixensberger J, Florek HJ, Mohr FW, Etz CD. Stent Graft Visualization and Planning Tool for Endovascular Surgery Using Finite Element Analysis. Int J Comput Assist Radiol Surg. 2014; 9(4): 617-33.

Peer Reviewed Conference Proceedings

Amato C, Lemke HU, Ratib O. Intelligent operating rooms: preparing for the new digital patient model challenges. Int J Comput Assist Radiol Surg. 2014; 9 (1): 205-206.

Denecke K. Ethical Aspects of Using Medical Social Media in Healthcare Applications. 2nd eHealth Summit Austria; Vienna, Austria; 2014.

Denecke K. Extracting Medical Concepts from Medical Social Media with Clinical NLP Tools: A Qualitative Study. International Conference on Language Resources and Evaluation (LREC); Reykjavik, Iceland; 2014.

Denecke K. Sublanguage Analysis of Medical Weblogs. 25th European Medical Informatics Conference – MIE; Istanbul, Turkey; 2014.

Denecke K. Model-based medicine: Digital patient models for decision support. 59. Jahrestagung der Deutschen Gesellschaft fuer Medizinische Informatik, Biometrie und Epidemiologie e. V. (GMDS); Goettingen; 2014.

Denecke K. A Concept for Semi-Automatic Generation of Digital Patient Models. 48th Annual Conference of the German Society for Biomedical Engineering (DGBMT); Hannover; 2014.

Deng Y. Retrieving Attitudes: Sentiment Analysis from Clinical Narratives. Annual International ACM SIGIR Conference; Gold Coast, Australia; 2014.

Deng Y. Summarization of EHR Using Information Extraction, Sentiment Analysis and Word Clouds; 59. Jahrestagung der Deutschen Gesellschaft fuer Medizinische Informatik, Biometrie und Epidemiologie e. V. (GMDS); Goettingen; 2014.

Deng Y, Denecke K. Visualizing Unstructured Patient Data for Assessing Diagnostic and Therapeutic History; 25th European Medical Informatics Conference – MIE; Istanbul, Turkey; 2014.

Dubach P, Caversaccio M, Weber S, Strauß G. Otoendoscopic Tympanoscopy – Digital, Microscopic, Sialendoscopic and Rod Lens Endoscopic Visualization Compared. 101. Fruehjahrsversammlung der Schweizerischen Gesellschaft fuer Oto-Rhino-Laryngologie, Hals- und Gesichtschirurgie; St. Gallen; 2014.

Franke S, Neumuth T. Online Generation of Multi-Perspective Surgical Situation Descriptions. Fifth Workshop on Modeling and Monitoring of Computer Assisted Interventions (M2CAI); Boston, USA; 2014.

Franke S, Neumuth T. A framework for event-driven surgical workflow assistance. 48th Annual Conference of the German Society for Biomedical Engineering (DGBMT); Hannover; 2014.

Glaser B, Koch L, Schellenberg T, Neumuth T. Eye-Tracking Analysis of Scrub Nurse Viewing. Fifth Workshop on Modeling and Monitoring of Computer Assisted Interventions (M2CAI); Boston, USA; 2014.

Glaser B, Schellenberg T, Neumuth T. Konzeption einer Kommunikationsarchitektur fuer ein OP-Instrumententisch-Simulationssystem. 13. Jahrestagung der Deutschen Gesellschaft fuer Computer- und Roboterassistierte Chirurgie (CURAC); Munich; 2014.

Heckel F, Braunewell S. A Concept for the Application of a Hierarchical Image Subdivision to the Segmentation Editing Problem. MICCAI Workshop on Interactive Medical Image Computing; Boston, USA; 2014.

Ilunga Mbuyamba E, Lindner D, Arlt F, Muens A, Meixensberger J, Chalopin C. Vascular structure tracking in intraoperative 3D ultrasound data during brain tumor resection. 48th Annual Conference of the German Society for Biomedical Engineering (DGBMT); Hannover; 2014.

Kaiser M, John M, Heimann T, Neumuth T, Rose G. Improvement of Manual 2D/3D Registration by Decoupling the Visual Influence of the Six Degrees of Freedom; IEEE 11th International Symposium on Biomedical Imaging (ISBI); Beijing, China; 2014.

Kaiser M, John M, Koerner M, Heimann T, Neumuth T, Rose G. Necessity of Calibrated Projection Matrices for the 2D/3D Registration of TEE ultrasound and X-ray. Image-Guided Interventions – IGIC; Beijing, China; 2014.

Liebmann P. DICOM and IHE in Surgery; International Congress of Computer Assisted Radiology and Surgery (CARS); Fukuoka, Japan; 2014.

Maktabi M, Rockstroh M, Neumann J, Neumuth T. Concepts and requirements for an advanced clinicwide Operating Room Control Center. 48th Annual Conference of the German Society for Biomedical Engineering (DGBMT); Hannover; 2014.

Meier J, Boehm A, Neumuth T. Standardization of ENT Oncological Anamnesis and Evaluation using Levenshtein Distance Measure. 48th Annual Conference of the German Society for Biomedical Engineering (DGBMT); Hannover; 2014.

Meier J, Boehm A, Vinz S, Neumuth T. Aggregation patientenspezifischer Informationen zur Unterstuetzung der onkologischen Hals-, Nasen-, Ohren Chirurgie. 13. Jahrestagung der Deutschen Gesellschaft fuer Computer- und Roboterassistierte Chirurgie (CURAC); Munich; 2014.

Meier J, Deshpande R, Liu B, Neumuth T. A concept of a generalized electronic patient record for personalized medicine. SPIE Medical Imaging: PACS and Imaging Informatics: Next Generation and Innovations; San Diego, USA; 2014.

Pilic T, Busch F, Lorber I, Seeburger J, Korb W. Development of a hybrid surgical training simulator for the replacement of the aortic valve facilitating porcine hearts. 48th Annual Conference of the German Society for Biomedical Engineering (DGBMT); Hannover; 2014.

Rockstroh M, Wittig M, Franke S, Neumuth T. Approach to data collection in the operating room based on the analysis of video streams. 48th Annual Conference of the

German Society for Biomedical Engineering (DGBMT); Hannover; 2014.

Conference Proceedings

Bieck R, Franke S, Neumuth T. CephaLens-Towards a 3D Augmented Reality Visualization in Neurosurgery. 13th Research Festival for Life Sciences; 2014; Leipzig.

Chalopin C, Ilunga Mbuyamba E, Lindner D, Avina Cervantes JG, Arlt F, Muens A. Vascular structure tracking in intraoperative ultrasound data of brain tumors. 13th Research Festival for Life Sciences; 2014; Leipzig.

Cypko M. User interaction with MEBNs for large patient-specific treatment decision models with an example for laryngeal cancer; International Congress of Computer Assisted Radiology and Surgery (CARS); Fukuoka, Japan; 2014.

Cypko M. User interfaces for patient-specific treatment- decision models using MEBN. Medicine Meets Virtual Reality; Manhattan Beach, USA; 2014.

Cypko M, Stoehr M, Denecke K. Expert-Based development of CDSS by using MEBN with an example for laryngeal cancer. 13th Research Festival for Life Sciences; 2014; Leipzig.

Denecke K. A multi-layer approach to Digital Patient modeling. Virtual Physiological Human Conference (VHP). Trondheim, Norway; 2014.

Deng Y, Groll MJ, Denecke K. Automatic Cervical Spine Defect Classification based on Clinical Narratives. 13th Research Festival for Life Sciences; 2014; Leipzig.

Franke S, Maktabi M, Neumuth T. EVENTOR – A framework for event-driven operating room infrastructure. 13th Research Festival for Life Sciences; 2014; Leipzig.

Franke S, Neumuth T. Adaptive Surgical Process Models for workflow-driven assistance in the digital operating room 13th Research Festival for Life Sciences; 2014; Leipzig.

Gaebel J, Denecke K. Usefulness of Information Extraction Methods in Medicine for Clinical Decision Support. 13th Research Festival for Life Sciences; 2014; Leipzig.

Glaser B, Schellenberg T, Franke S, Daenzer S, Neumuth T. Towards a structured suitability determination of identification approaches for surgical instruments. 13th Research Festival for Life Sciences; 2014; Leipzig.

Hafez J. L' endoscopie »fantôme«. Deutsch-Franzoesischer HNO-Kongress; Lyon, France; 2014.

Hafez J, Koehler C, Boehm A, Dietz A. Konzeption eines CT-Daten basierten, realitaetsnahen Kunststoffsimulators der oberen Atem- und Speisewege für die Panendoskopie. Jahresversammlung Deutsche HNO Gesellschaft; Dortmund; 2014.

Hafez J, Koehler C, Korb W, Boehm A, Dietz A. Ein realistischer Trainingssimulator fuer die schwierige Intubation bei HNO-Tumorpatienten und dessen Validierung durch Anaesthesisten. 23. Jahrestagung der Vereinigung Mitteldeutscher Hals-Nasen-Ohrenaerzte; Chemnitz; 2014.

Hafez J, Koehler C, Korb W, Boehm A, Dietz A. Ein realistischer Trainingssimulator fuer die schwierige Intubation bei HNO-Tumorpatienten und dessen Validierung durch Anaesthesisten. InSiM 2014; Frankfurt am Main; 2014.

Kropf S, Chalopin C, Denecke K. Modeling and Development of Electronic Health Records using the openEHR Standard. 13th Research Festival for Life Sciences; 2014; Leipzig.

Maktabi M, Neumuth T. Analysis of surgical workflows in the frequency domain. 13th Research Festival for Life Sciences; 2014; Leipzig.

Maktabi M, Oeser A, Rockstroh M, Neumuth T. Concept for a clinic-wide Operating Room Control Center. 13th Research Festival for Life Sciences; 2014; Leipzig.

Maktabi M, Liebmann P. Towards IHE Surgery Profile for Implant Template Distribution and Implant Plan Distribution. 13th Research Festival for Life Sciences; 2014; Leipzig.

Meier J, Bohn S, Krauß O, Boehm A, Neumuth T. Clinical workflow assistance in head and neck tumor therapy. 13th Research Festival for Life Sciences; 2014; Leipzig.

Meier J, Neumuth T. Recognition of clinical workflow steps from patient-specific information. 13th Research Festival for Life Sciences; 2014; Leipzig.

Rockstroh M, Lippert S, Glaser B, Neumuth T. Approach for a web-based anesthesia documentation. 13th Research Festival for Life Sciences; 2014; Leipzig.

Schreiber E, Franke F, Neumuth T. Generic estimation of predictors and their impact on surgical processes. 13th Research Festival for Life Sciences; 2014; Leipzig.

Schreiber E, Sommer G, Liebmann P, Meier J. Cross-Enterprise Model Sharing. 13th Research Festival for Life Sciences; 2014; Leipzig.

Stoehr M. A model of the decision-making process for tumor boards: therapy of laryngeal cancer. International Congress of Computer Assisted Radiology and Surgery (CARS); Fukuoka, Japan; 2014.

Stoehr M. Modeling and support of therapeutic decision-making processes on the example of laryngeal cancer; Annual Meeting of the German Society of Oto-Rhino-Laryngology, Head and Neck Surgery; Dortmund; 2014.

von Sachsen S. Computer Aided Defect Classification for Model-based Therapy of Cervical Spinal Stenosis; International Conference on Biomedical Engineering and Systems (ICBES); Prague, Czech Republic; 2014; 126.1- 126.6.

von Sachsen S, Groll MJ, Meixensberger J, Leimert M. Application of the openEHR approach to support an innovative defect classification for patients with cervical spinal canal stenosis. 13th Research Festival for Life Sciences; 2014; Leipzig.

SCIENTIFIC EVENTS 2014 ORGANIZED BY ICCAS

Girls' Day 2014
27 March 2014, ICCAS, Leipzig

OR.NET-Workshop on sub-project 6 – Demonstrators in OR.NET
29-30 July 2014, ICCAS, Leipzig

Workshop »Models for surgical decision support« at the Virtual Physiological Human Conference (VPH) 2014
09-12 September 2014, Trondheim, Norway

ICCAS Digital Operating Room Summer School (DORS) 2014
22-26 September 2014, ICCAS, Leipzig

OR.NET – Meeting Industry
06 October 2014, ICCAS, Leipzig

1st »Standards and Model Guided Medicine« Workshop
10 October 2014, ICCAS, Leipzig

ICCAS COLLOQUIUM

03 March 2014 | ICCAS | Leipzig
Prof. Dr. med. Andreas Melzer, Director of the Institute for Medical Science and Technology, University of Dundee, St. Andrews, Scotland
Presentation on »Clinical Decision Support by Medical Imaging – personalised image guided therapy by modelling and simulation: FUSIMO«

05 March 2014 | ICCAS | Leipzig
Lucas Koch, Department of Computer Science and Communication Systems, Hochschule Merseburg – University of Applied Sciences
Presentation on the latest knowledge about utilizable and user friendly interface development towards international standardization

26 March 2014 | ICCAS | Leipzig
Sara Hiller (M.Sc. Psychology), Bielefeld University
Presentation on »Learning, knowledge acquisition and study design«

02 April 2014 | ICCAS | Leipzig
Dr. Brett Bell, ARTORG Center for Biomedical Engineering Research, Image-Guided Microsurgery, University of Bern
Presentation on »Inroads to Minimally Invasive CI Surgery«

05 June 2014 | ICCAS | Leipzig
Dr. med. Patrick Dubach, Head of the University Outpatient Clinic, ENT Department, University Hospital Bern, Research fellow at ICCAS
Presentation on »Planning and Visualization Tools for Middle Ear Implantology – Final results from a German and Swiss Two Center Study«

PUBLIC EVENTS 2014 WITH ICCAS PARTICIPATION

FameLab Sachsen
06 March 2014, Leipzig

Long Night of Sciences Leipzig
27 June 2014, Leipzig

Leipzig Corporate Run
04 June 2014, Leipzig

Leipzig Research Festival 2014
18 December 2014, Leipzig

INVITED LECTURES

19. Dresdner Palais-Gespräch
24 January 2014, Dresden, Germany
Lecture: Prof. Dr. Heinz U. Lemke »Mit substantiellen IT-Innovationen zur modellbasierten Medizin«
Lecture: Prof. Dr. med. Gero Strauß »Zur Zukunft der Technik in der Medizin«

V. Joint-Meeting der Brasilianischen und Deutschen Gesellschaft für Neurochirurgie
21-23 Februray 2014, Sao Paulo, Brasilia
Lecture: Prof. Dr. med. Jürgen Meixensberger »Advanced intraoperative ultrasound imaging in brain tumor surgery«

131. Kongress der Deutschen Gesellschaft für Chirurgie
25-28 March 2014 Berlin, Germany
Lecture: Prof. Dr. Heinz U. Lemke »Mit substantiellen IT-Innovationen zur Modellbasierten Chirurgie«
Lecture: Prof. Dr. med. Gero Strauß »Der digitale OP«

OP-Management Kongress
10 April 2014, Bremen, Germany
Lecture: Prof. Dr. med. Gero Strauß »Die Innovationen gestalten die Organisation«

Ghamra Military Hospital
11-13 May 2014, Kairo, Egypt
Lecture: Prof. Dr. med. Gero Strauß »Navigation and Distance Control in FESS Surgery«

10th Asian Conference on Computer Assisted Surgery (ACCAS 2014)
25 June 2014 Fukuoka, Japan
Lecture: Prof. Dr. Heinz U. Lemke »Machine intelligence for therapy decision making using model based methods«

Tutorial on Medical Workstations and Model-guided Medicine
25 June 2014 Fukuoka, Japan
Lecture: Prof. Dr. Heinz U. Lemke »The Digital Operating Room: Functions, Infrastructures and Standards«

IFCARS/ SPIE/ ISCAS / EuSoMII Joint Workshop on Surgical PACS and the Digital Operating Room
27 June 2014 Fukuoka, Japan
Lecture: Prof. Dr. Heinz U. Lemke »IHE surgical integration profiles, implementation and approval issues«

National Institute for Health Innovation (NIHI) New Zealand
22 July 2014, Auckland, New Zealand
Lecture: Dr. Kerstin Denecke »ICCAS and the Digital Patient Model«

Paranasal Sinus and Skull Base Surgery (PSSB 2014)
05-06 September 2014, Bern, Switzerland
Lecture: Prof. Dr. med. Gero Strauß »Automation and assistance systems for transnasal surgery«

VDE MedTech 2014
08 September 2014, Hannover, Germany
Lecture: Prof. Dr. med. Gero Strauß »Die HNO-/Kopfchirurgie als Anwendungsfeld im vernetzten Krankenhaus«

13th Annual Conference of the German Society for Computer and Roboter-Assisted Surgery (CURAC 2014)
12 September 2014, Munich, Germany
Lecture: Prof. Dr. med. Gero Strauß »Aktive Prozesssteuerung im chirurgischen Cockpit: Chancen und Risiken aus der Perspektive der HNO-Chirurgie«

Leadership in Health Care
19 September 2014, Berlin, Germany
Lecture: Prof. Dr. med. Gero Strauß »Der automatisierte OP Saal – Navigation und Autopilot für den Chirurgen«

EANS 2014 – 15th European Congress of Neurosurgery
12-17 October 2014, Prague, Czech Republic
Lecture: Prof. Dr. med. Jürgen Meixensberger »Intraoperative advanced ultrasound imaging in brain tumor surgery«
Lecture: Prof. Dr. med. Jürgen Meixensberger »Neurosurgical training: Impact of novel phantom–based training systems«

RWTH Aachen University
Colloquium co-organzied by IEEE- Engineering in Medicine and Biology Society
29 October 2014, Aachen, Germany
Lecture: Dr. Kerstin Denecke »Modell- und evidenzbasierte Medizin durch digitale Patientenmodelle«

Rhinology Unites
22-24 November 2014, Dubai, UAE
Lecture: Prof. Dr. med. Gero Strauß »The influence of Procedure Point Navigation to FESS and related procedures, Transnasal procedures under Instrument Surgery Conditions with the help of SMGS«

35th National Congress of Radiology, Turkish Society of Radiology
14 November 2014, Antalya, Turkey
Lecture: Prof. Dr. Heinz U. Lemke »Invention and Evolution of PACS«
Lecture: Prof. Dr. Heinz U. Lemke »Towards intelligent IT supported infrastructures and clinical processes for the Digital Operating Room«

Augsburger Perspektiven
04 December 2014, Augsburg, Germany
Lecture: Prof. Dr. med. Gero Strauß »Automatisierung im chirurgischen Cockpit: Chancen und Risiken aus der Sicht der HNO-Chirurgie«

2nd Annual Symposium »Advances in Practical Medical Imaging« of the German Cancer Research Center (DKFZ)
16 December 2014, Heidelberg, Germany
Lecture: Dipl.-Inf. Bernhard Glaser »What about the scrub nurse?«

HONORS AND AWARDS

Mario Cypko (DPM) received a poster award for outstanding scientific achievements in the field of Medicine and Life Sciences at the 12th Leipzig Research Festival for Life Sciences in December 2013.

Mario Cypko (DPM) won the poster prize of the NextMed / MMVR21 Conference 2014 for his contribution »3D++ visualization of MEBN graphs and screen representations of patient models (PIXIE II)« in February 2014.

Jens Meier (MAI) was awarded the »Innovationspreis-IT - Best of 2014« in the category Health IT for his project oncoflow. The IT Innovation Awards were presented by Initiative Mittelstand in March 2014.

The International Reference and Development Center for Surgical Technology (IRDC) was awarded the »Innovationspreis-IT- Best of 2014« in the category E-Health for its solution »The Patient Instruction Video«. The IT Innovation Awards were presented by Initiative Mittelstand in March 2014.

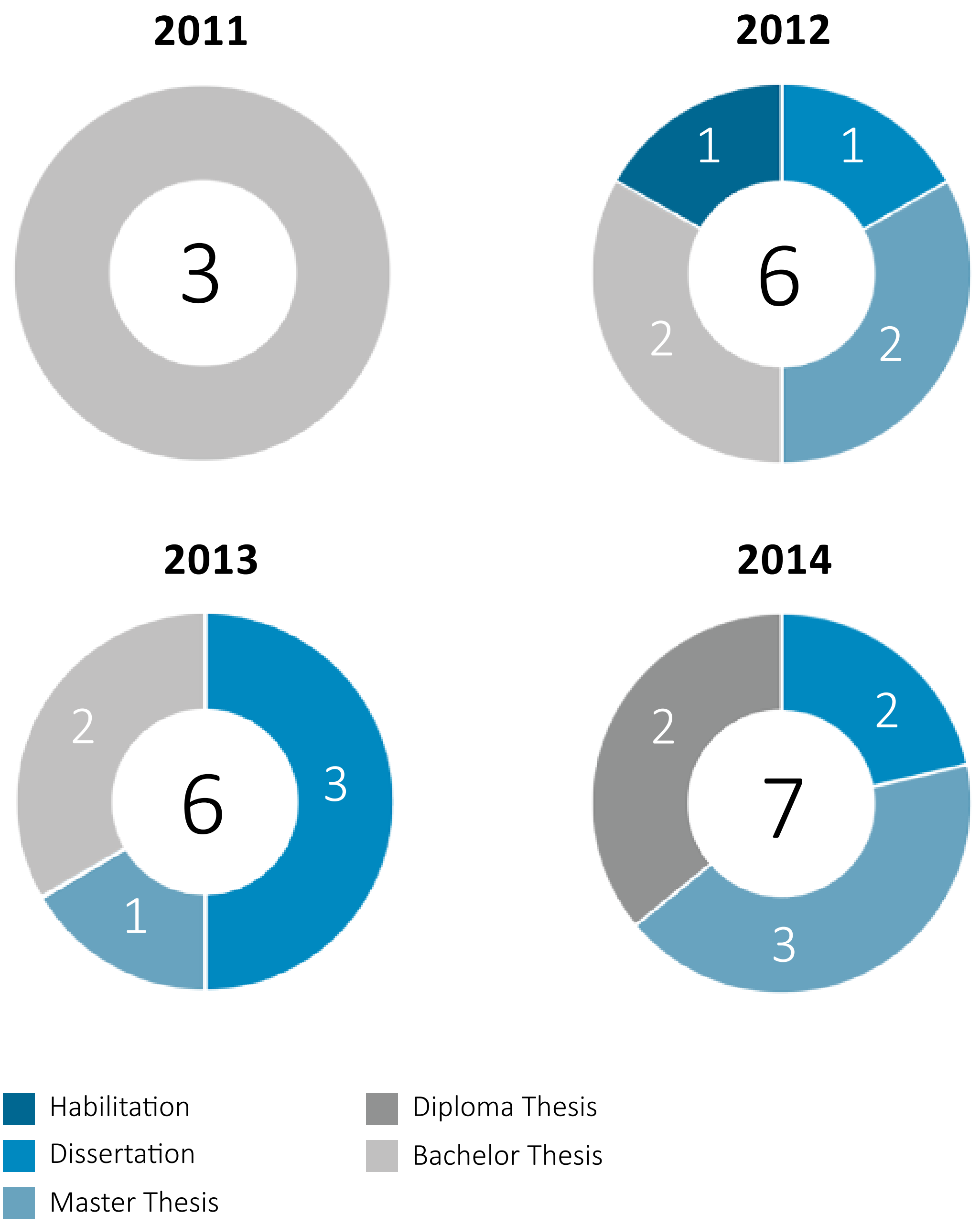
Prof. Dr. med. Andreas Dietz (ENT-Department, Leipzig University Hospital) has been appointed member of the »Board of Directors« in the International Federation of Head and Neck Oncologic Societies (IFHNOS) in August 2014.

Prof. Dr. med. Gero Strauß (IRDC) received the first Award of the Best Paper Session of the German Society for Computer and Roboter-Assisted Surgery (CURAC) for his outstanding scientific contribution on »Prozesssteuerung im Operationssaal« in September 2014.

ICCAS GRADUATIONS IN 2014

Sandra Schumann successfully defended her dissertation at the Faculty of Medicine, Universität Leipzig. For her doctoral work entitled »Evolution of distance measures for surgical processes« she received the grade magna cum laude.

Silvia Born successfully defended her dissertation entitled »Illustrative Flow Visualization of 4D PC-MRI Blood Flow and CFD Data« at the Faculty of Mathematics and Computer Science at the Universität Leipzig.



ACTIVITIES IN TEACHING

ICCAS is the leading research institution in Saxony which is committed to the interdisciplinary education in the field of computer assisted surgery for medicine and computer science studies at the Universität Leipzig. At the Faculty of Medicine ICCAS manages the elective subject Computer Assisted Surgery and offers a comprehensive course on this topic to medical students in the fifth year of study.

The lectures provide an interdisciplinary view on computer assisted surgery from the clinical perspective of various surgical departments as well as on engineering aspects that will be relevant to future surgeons. Additionally, within the Masters of Medical Computer Science a number of lectures and seminars in the field of computer assisted surgery are offered to computer science students at the Universität Leipzig.

Since 2012, ICCAS has been providing courses for students at the Faculty of Electrical Engineering and Information Technology at the Leipzig University of Applied Sciences (HTWK). The topics focus on project management and systems engineering.

ICCAS opens up numerous opportunities to students to get acquainted with the highly innovative research topic Computer Assisted Surgery, including bachelor and master theses as well as medical doctor’s theses and research internships.

Regular courses at the Universität Leipzig

Study course »Computer-assisted Surgery« (Master, Computer Science)

» Lecture »Medical Planning- and Simulation Systems«
» Lecture »Surgical Navigation, Mechatronics and Robotics«
» Internship »Computer Assisted Surgery«

Study course »Structured System Innovation for Medicine« (Master, Computer Science)

» Lecture »Structured System Innovation«
» Seminar »Applied Development of Medical Technology Systems«

Courses in Human Medicine

» Lecture »Computer Assisted Surgery«
» Practical course »Introduction to Careers in Medicine – Computer Assisted Surgery«

Regular courses at the Leipzig University of Applied Sciences (HTWK)

» Lecture »Project Management for Engineers«
» Lecture »Systems Engineering«

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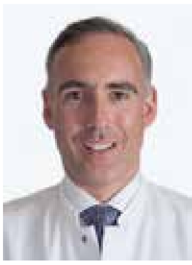

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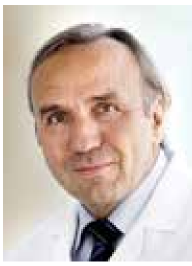

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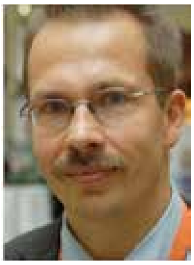

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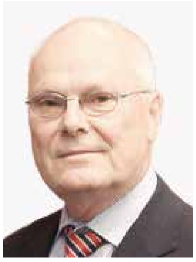

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