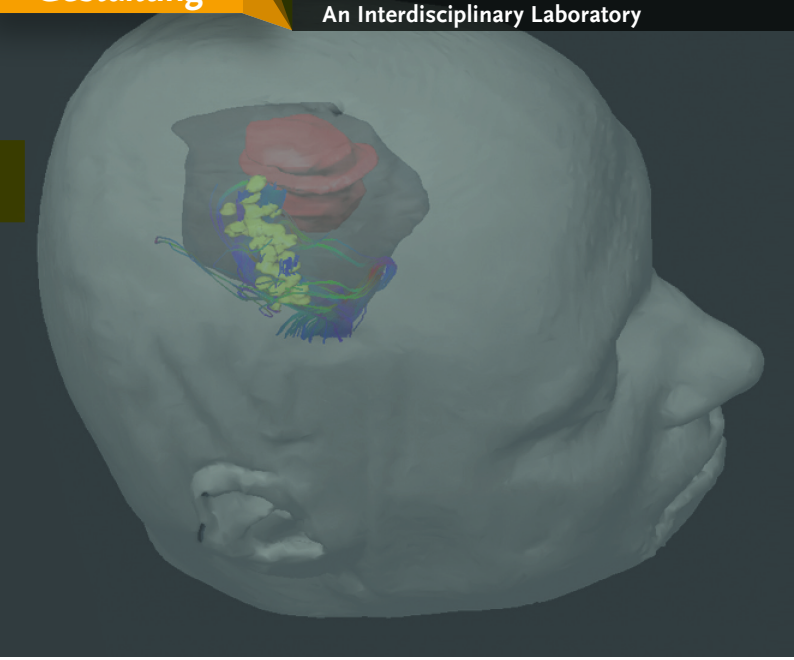
Image
Knowledge
Gestaltung

An Interdisciplinary Laboratory



IMAGING AND INTERACTION IN MEDICAL PRACTICE

An Interdisciplinary Workshop
on Image-guided Clinical Settings

27–28 February 2015

Sophienstr. 22a, 10178 Berlin

www.imagingandinteraction.com

Information

Organisation
Kathrin Friedrich, Moritz Queisner, Anna L. Roethe

Press Contact
Claudia Lamas Cornejo: *bwg.publicrelations@hu-berlin.de*

Registration
at *www.imagingandinteraction.com*

www.interdisciplinary-laboratory.hu-berlin.de

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About the Workshop

The evolution of medical imaging has significantly changed clinical practice and applications in the past decade. Improvements in computer technology, tracking and registration devices have put forth new types of interventions, in which the interaction between doctor and patient is increasingly shaped by visual media. This transformation significantly affects clinical workflows and a wide range of settings including software interaction, operating-room architecture and intraoperative navigation. Besides the rapidly growing number of technological innovations and the ongoing debate about their medical benefits, the methodological and practical implications of these developments are not yet adequately integrated into medical research and education. In this context, the workshop analyses the epistemic and pragmatic visual settings of image-guided interventions with regard to the question how images govern medical decisions and actions. It will address the methods and discuss the problems that go along with the shifting modalities of interaction in medical planning, monitoring and treatment. By assembling interdisciplinary perspectives, ranging from medicine, engineering and computer science to media studies, philosophy and design, the workshop intends to identify an applied visual knowledge that corresponds to the transformation of interaction in image-guided medical practice. A second and important goal will be a new approach to »Image Guidance« as an integrative concept that is based in medical practice as well as academic research and education.

Schedule on Friday, 27 February 2015

09.30 ARRIVAL, REGISTRATION / COFFEE & TEA

09.45 Introduction

10.00 PANEL 1: SOFTWARE INTERACTION
Introduction: Kathrin Friedrich
Comment: Rebekka Lauer

- Morana Alac
  Department of Communication, University of California, San Diego
  fMRI Brain Scans as Fields for Interaction
- Dietmar Frey
  Department of Neurosurgery, Charité University Hospital, Berlin
  Surgical Planning for Brain Tumor Patients based on Navigated Transcranial Magnetic Stimulation
- Markus Kufeld
  Charité CyberKnife Center, Berlin
  Integration of Navigated Transcranial Magnetic Stimulation (nTMS) Information into Radiosurgical Treatment Planning

12.00 LUNCH

13.00 PANEL 2: INTRAOPERATIVE CONTROL
Introduction: Anna L. Roethe
Comment: Thomas Picht

- Alexandra Golby
  Department of Neurosurgery, Brigham and Women's Hospital, Harvard Medical School, Boston
  Multi-Modality Image-guided Neurosurgery in the AMIGO Suite
- Aud Sissel Hoel
  Department of Art and Media Studies, Norwegian University of Science and Technology, Trondheim
  Navigating the Brain
- Jörg-Christian Tonn
  Department of Neurosurgery, University Hospital of Munich
  Intraoperative Structure Update to Provide Information for Adaptive Hybrid Surgery

15.00–18.00 EXCURSION

19.00 DINNER

Schedule on Saturday, 28 February 2015

09.30 PANEL 3: CLINICAL APPLICATIONS HANDS-ON
Introduction: Moritz Queisner

- Michael Müller
  German Cancer Research Center (DKFZ), Heidelberg / mbits Steinbeis Transferzentrum (STZ)
  Tablet Computers in the OR: Gadget or Innovation?
- Anna Maria von der Heide
  Klinik für Allgemeine, Unfall-, Hand- und Plastische Chirurgie, München
  Innovative Surgical Applications Using Medical Augmented Reality

11.00 COFFEE

11.30 PANEL 4: SURGICAL ARCHITECTURES
Introduction: Moritz Queisner
Comment: Wolfgang Schäffner

- Wolfgang Freysinger
  Medical Physics, 4D Visualization Lab, Univ ENT Clinic Innsbruck Medical University
  Image-based Medicine and Medical Education: Nothing New under the Sun?
- Helena Mentis
  Department of Information Systems, University of Maryland
  Surgical Practices in Referencing Images in Collaboration and Instruction

13.00 LUNCH

14.00 PANEL 5: COMMUNICATING SURGICAL PRACTICE
Introduction: Kathrin Friedrich
Comment: Matthias Bruhn

- Ericka Johnson
  Department of Thematic Studies – Technology and Social Change, Linköping University
  Attaching the Uterus. Stringing Together Pelvic Bones, Internal Organs and Pressure Sensitive Diodes
- Christina Lammer
  CORPOrealities, Vienna
  SONO OPERATORE – Sensory Explorations in the Operating Theater

15.30 CONCLUSION/FUTURE PLANS

PANEL 1: SOFTWARE INTERACTION

The application of software has become fundamental both for the diagnosis of abnormalities and for the planning of therapeutical interventions. In today's radiation surgery, for example, procedures can only be carried out on the basis of a permanent interacting with dedicated computer programs. Diagnostic image data gathered by CT or MRI scanners is digitally processed and visualised to interactively mark tumours or critical areas as well as to calculate the intensity of radiation. In this respect, software applications do not only enable data processing and technical networking but constitute operative and epistemic possibilities for surgical interventions.

Nevertheless, several issues arise both in design and application of image-guided planning software. On a conceptual level, the gap between user and scenario models and the pragmatic contexts of application causes disruptions that often result in work-arounds instead of adaptable and dynamic workflows. On the level of visualisation, the integration of different data sources leads to often incomprehensible images in respect to viewpoint, 2D and 3D overlay or visual information overload. Furthermore, modes of software interaction need to relate to other forms of clinical interaction and practical knowledge in order to address an »embodied« form of medical expertise and thinking.

The panel will explore possibilities and problems of software applications and software-based interaction in clinical contexts to evaluate their impact on planning and conducting surgical interventions.

Morana Alac
Department of Communication, University of California, San Diego

fMRI Brain Scans as Fields for Interaction

In this presentation I will talk about my ethnographic study of fMRI practices in university laboratories of cognitive neuroscience, and will illustrate how I combine this well-established approach with videotaping of actual interactions with brain scans. Engaging the scans in this manner provides an opportunity to describe how their digital materiality is articulated in practice, and suggests that labeling them as »visual representations« is limiting. Instead, I propose that they are fields for interaction.

With this idea I refer to the following features of the scans: first, their understanding in the laboratory is rooted in multiparty engagements; second, they do not mean on their own but gradually achieve their visibility through a coupling with the bodies of those who read them; third, the objects they »show« are hybrids of digital and physical semiotic matter.

This has consequences for the design of the technology and conceptual claims in cognitive neuroscience.

Dietmar Frey
Department of Neurosurgery, Charité University Hospital, Berlin

Surgical Planning for Brain Tumor Patients based on Navigated Transcranial Magnetic Stimulation

Background: Neurological and oncological outcomes of motor eloquent brain-tumor patients depend upon the ability to localize functional areas and the respective proposed therapy. We set out to determine whether the use of navigated transcranial magnetic stimulation (nTMS) had an impact on treatment and outcome in patients with brain tumors in motor eloquent locations.

Methods: We enrolled 250 consecutive patients and compared their functional and oncological outcomes to a matched pre-nTMS control group (n = 115).

Results: nTMS mapping results disproved suspected involvement of primary motor cortex in 25.1 % of cases, expanded surgical indication in 14.8 %, and led to planning of more extensive resection in 35.2 % of cases and more restrictive resection in 3.5 %. In comparison with the control group, the rate of gross total resections increased significantly from 42 % to 59 % (P< .05). Progression-free-survival for low grade glioma was significantly better in the nTMS group at 22.4 months than in control group at 15.4 months (P<.05). Integration of nTMS led to a nonsignificant change of postoperative deficits from 8.5 % in the control group to 6.1 % in the nTMS group.

Conclusions: nTMS provides crucial data for preoperative planning and surgical resection of tumors involving essential motor areas. Expanding surgical indications and extent of resection based on nTMS enables more patients to undergo surgery and might lead to better neurological outcomes and higher survival rates in brain tumor patients. The impact of this study should go far beyond the neurosurgical community because it could fundamentally improve treatment and outcome, and its results will likely change clinical practice.

Markus Kufeld
Charité CyberKnife Center, Berlin

Integration of Navigated Transcranial Magnetic Stimulation (nTMS) Information into Radiosurgical Treatment Planning

Background: Radiosurgical treatment of brain lesions near motor or language eloquent areas requires careful planning to achieve the optimal balance between effective dose prescription and preservation of function. Navigated transcranial magnetic stimulation (nTMS) can be used to map functionally essential areas presurgically.

Objective: To evaluate the efficacy of nTMS data integration into the radiosurgical environment and to analyze the influence of nTMS data on the radiosurgical treatment planning for lesions near or within motor or language eloquent areas of the brain.

Methods: This study prospectively collected data of 10 patients eligible for radiosurgical treatment with brain lesions in eloquent location mapped with nTMS. The radiosurgical team prospectively classified the ease of the data transfer as well as the influence of the nTMS results on the radiosurgical treatment planning.

Results: The integration of the nTMS data into the radiosurgical treatment planning environment was flawless and rated as easy in all cases. The influence of nTMS on the radiosurgical treatment planning was as follows: added awareness of high-risk areas in 100 %, modified dose prescription in 3 cases; radiosurgical indication or target contouring have not been influenced in any of the cases by nTMS information.

Conclusions: Integration of nTMS information raised awareness of areas carrying essential function. The additional functional data showing the spatial relationship between the lesion and the functionally essential areas can influence the radiosurgical treatment planning process and may thus improve the safety for radiosurgical treatments of eloquently located lesions.

PANEL 2: INTRAOPERATIVE CONTROL

In the course of surgical interventions, preoperative diagnostic imaging and treatment planning regularly require subsequent strategies of visual data provision, registration, tracking, real-time actualisation, and monitoring, all of which are ideally integrated into a seamless, trouble-free workflow. Issues of real-time control in particular have been the subject of numerous approaches to implement suitable imaging modalities (such as intraoperative ultrasound, iMRI, or iCT) in the OR setting. In order to improve the accuracy of access, resection or therapeutic implantation and to minimise potential risks for the patient, established preoperative tools such as functional mapping in neurosurgery (for instance, fMRI or navigated brain stimulation) are already being used successfully for purposes of navigation while still lacking satisfactory possibilities to update the measured data during surgery. The panel seeks to discuss current arrangements of visual intraoperative success control, their specific multimodality (e.g. image fusion of MRI and CT, or MRI and ultrasound, comparison of non-invasive functional mapping with intraoperative electrophysiological monitoring), as well as their limitations and future potential.

Alexandra Golby
Department of Neurosurgery, Brigham and Women's Hospital, Harvard Medical School, Boston

Multi-Modality Image Guided Neurosurgery in the AMIGO Suite

Neurosurgical resection of brain tumors is safer and more effective thanks to numerous technological advances over the last few decades, particularly improvements in imaging and visualization. Pre-operative advanced imaging including functional imaging with fMRI and diffusion tensor imaging (DTI) allow surgeons to make a detailed surgical plan which takes into account individual functional and structural anatomy as well as the configuration of the lesion. Navigation allows a precise alignment of the pre-operative plan with the intra-operative patient configuration. Intra-operative treatment monitoring with intra-operative MRI allows the surgeon to accurately deploy surgical tools as well as monitor the progress of the intervention with particular attention to avoiding unnecessary tumor residuals.

At Brigham and Women's Hospital, image-guided approaches to brain surgery were pioneered including navigation, functional imaging, and most notably intraoperative MRI. Over 1000 craniotomies were performed in the world's first intra-operative MRI at BWH. More recently, our group has developed the Advanced Multi-Modality Image-Guided Operating (AMIGO) suite at BWH. This suite allows intraoperative image using all contemporary imaging modalities. In AMIGO, we have active clinical programs in brain tumor resection and biopsy, laser hyperthermia ablation, transphenoidal pituitary resection, skull base tumors, and functional neurosurgery. Laser hyperthermia provides an example of true image guided neurosurgery in which imaging forms the basis of treatment targeting and monitoring.

We have also broadly deployed functional imaging modalities to map individual brain function including fMRI for pe-operative brain mapping in over 750 patients since 2003. Over 450 patients have had white matter mapping with diffusion imaging and analysis with advanced tractography algorhythms. Integration into clinical navigation systems for multi-modality functional navigation has been performed in the majority of cases. The indication for awake craniotomy has been narrowed to the small subset of patients requiring this challenging technique. Moreover, we have found that pre-operative fMRI/DTI can be very useful even in cases in which awake surgery is pursued; in approximately 25 % of awake surgeries, mapping is either aborted, inconclusive or incomplete and having the non-invasive functional maps can allow the surgeon to proceed with more confidence.

Another challenge in brain tumor surgery results from the progressive deformation of anatomy that takes place during the surgical intervention (brain shift), making preoperative images and associated neuronavigation increasingly inaccurate. We are working with several approaches to measuring and compensating for brain shift which could be applied without intraoperative MRI. Together, these methods allow the evaluation of surgical risks, selection of the best method of intervention, and planning of the safest surgical approach.

Aud Sissel Hoel
Department of Art and Media Studies, Norwegian University of Science and Technology, Trondheim
Navigating the Brain

Advanced imaging technologies are currently transforming operating rooms into sophisticated augmented reality studios that explore recent developments in computer visualization, navigation applications, and robotic systems. The new imaging methods promise to increase precision and improve health outcomes. However, as medical diagnosis and therapy grow more dependent on images, the status and roles of these images become increasingly controversial. In image-guided surgical procedures images take on a new and more active role that calls for a new theoretical and methodological basis for handling the impact of these images and assessing their controversial aspects.

This presentation addresses the question of the active and shaping role of images in contemporary surgical practice by focusing on current neuronavigation systems that use ultrasound for intraoperative control. Neuronavigation is a set of methods that makes use of three-dimensional coordinate systems for frameless guidance, orientation, and localization of structures during brain surgery. Neuronavigation systems transfer multimodal image data into the surgical field, track surgical tools, and overlay the position of important instruments on medical image maps of the patient. A major challenge for neuronavigation is the shift in position of the brain anatomy as the operation progresses, commonly referred to as »brain shift«. To compensate for this shift, updated maps are acquired during the operation on the surgeon's request.
In a tumor removal that I observed, the navigation system included preoperative magnetic resonance images, live video images from a surgical microscope, intraoperative ultrasound images, and optical tracking of surgical instruments. At critical points in the operation (before, during, and after the removal of tumor tissue) ultrasound volumes were obtained to show the extent of brain shift.
Taking its point of departure from current uses of ultrasound for intraoperative control, the presentation proceeds to address the goals of the workshop: First, by sketching out a framework that can account for the entanglement of seeing and doing, and further, of images and measurement; and second, by considering the dual governing role of images in surgical settings, introducing the notion of styles of objectivity.

Jörg-Christian Tonn
Department of Neurosurgery, University Hospital of Munich
Intraoperative Structure Update to Provide Information for Adaptive Hybrid Surgery

Preservation of function is one of the key elements in skull base surgery. Especially in benign tumors, the concept of deliberately left remnants in order to maintain functional integrity has been shown to be associated with tumor control rates comparable to more aggressive approaches. To optimize the combination of microsurgery and focal (single shot or fractionated) irradiation, upfront agreement of the neurosurgeon and the radiosurgeon/radiation oncologist about the appropriate extent of resection and, conversely, the maximal size of the tumor remnant is necessary.

A software tool named adaptive hybrid surgery has been developed to update the information about the residual tumor volume during the process of surgery and to concomitantly calculate appropriate treatment plans for radiotherapy/stereotactic radiosurgery. In order to visualize the extent of resection online without intraoperative imaging, a navigated tool is used to »scan« the resection cavity intraoperatively and update a preoperatively segmented tumor object. Prerequisites are a 3D MRI data set with a segmented tumor object and a neuronavigation device. Practical evaluation of this system has been started and the graphic tools have been found to be of good accuracy concerning simulated extent of resection (compared to iCT/intra-OP MRI) with smooth integration into the surgical workflow.

PANEL 3: CLINICAL APPLICATIONS HANDS-ON

Image-guided applications enable the physician to establish a connection between locations in the medical image and the patient's body. This correspondence is usually achieved by linking the preoperative images of the operation field to the actual intervention, made possible by new means of registration and tracking. The setting results in an increased surgical complexity as the actual workspace of the surgeon is separated from visualisations appearing on the workstation's screen, which is often remote from the patient. The discussion panel is to look at latest developments of augmented reality applications that promise to diminish the difference, spatially and aesthetically, between image and action, by overlaying preoperative and intraoperative images. It examines the potential as well as the problems that go along with an image-based interaction that merges medical images with the patient's body.

Michael Müller
German Cancer Research Center (DKFZ), Heidelberg/mbits Steinbeis Transferzentrum (STZ)

Tablet Computers in the OR: Gadget or Innovation?

The challenging field of computer assisted surgery is still subject of ongoing research. While the industry already offers commercial solutions for surgical guidance, the available systems have not yet made a substantial break-through to the clinical routine – except for special disciplines like neurosurgery. An obvious reason for these circumstances is the usage of proprietary hardware, which is expensive and bulky along with complex software making them hard to integrate into the clinical workflow. In seeking a simple and elegant solution to these problems, tablet computers were used in different projects. This contribution will present the most recent projects including our own development »SurgeryPad«, which utilizes a tablet computer for augmented reality guidance during percutaneous nephrolithotomy. Furthermore, it will be discussed whether tablet computers have a real benefit for surgery or, respectively, under which circumstances they could improve patient outcome.

Anna Maria von der Heide
Klinik für Allgemeine, Unfall-, Hand- und Plastische Chirurgie, München

Innovative surgical applications using medical augmented reality

We present the first augmented reality system deployed in surgical routine, known as the Camera augmented mobile C-arm (CAMC). It was tested on over 40 patients by surgeons at the Klinik für Allgemeine, Unfall-, Hand- und Plastische Chirurgie, Munich. Secondly, we will highlight the important role between surgeons and scientists that enable both sides to combine their expertise for a better patient care in areas such as medical anatomy teaching and rehabilitation.

PANEL 4: SURGICAL ARCHITECTURES

With the comprehensive employment of minimally invasive and robot-assisted surgical procedures, medical treatment gets into a predicament: on the one hand, there are possible benefits for the patient (such as a smaller risk of trauma, shorter hospitalisation, and an improved recovery process). On the other hand, these procedures involve fundamental difficulties for the surgeon, whose ability to access the operation field and to navigate the instruments is diminished in comparison with traditional open surgery. An increased surgical complexity results from the fact that in image-guided forms of intervention the patient's body needs to be accessed remotely with special instruments that have to be guided by real-time visualisation techniques instead of interventions within the range of the physician's hands and eyes. Performing surgery via screens or optical devices introduces a layer of iconicity between physician and patient that entails and demands a respective »iconic knowledge« in relation to clinical practices and technical solutions. The panel will address the problems and challenges that result from the particular visual architecture of surgical operations in order to evaluate how it shapes and governs decisions and actions.

Wolfgang Freysinger
Medical Physics, 4D Visualization Lab, Univ ENT Clinic Innsbruck
Medical University

Image-based Medicine and Medical Education: Nothing New under the Sun?

An image says more than a thousand words. Thus, images always played an essential role in medicine and medical education. From antique times on, pathologies, symptoms and surgical processes were integratively presented in images. In modern times, due to the progress in physics, high-resolution microscopes triggered a massive use of images in the medical field: pathological, histological and micro-anatomical drawinges emerged. The embracement of X-rays as a diagnostic and therapeutic tool was paradigmatic for all the new physical methods to arrive up to now.
Currently, both medical professionals and students, are digital natives concerning modern medical imagery in all potential facettes. Training and education of basic scientists and physicians is currently a reflector and an innovator of medicine ase a strongly image-based field.
The interplay of practical use and basic developments in image-based medicine will be shown on the experiences the PhD program Image-guided Diagnosis and Therapy at the Medical University Innsbruck.

Helena Mentis
Department of Information Systems, University of Maryland

Surgical Practices in Referencing Images in Collaboration and Instruction

Recent years have seen a growth in the possibilities of new imaging and interaction technologies for minimally invasive surgery; however our understanding of how imaging systems are integrated into surgical practice are wanted. With this talk I will discuss the productive and cross-referential nature of surgical practice and image use. I will present evidence of constructive and embodied image use in surgery in both collaboration as well as instruction of residents. Drawing on these observations, I will present two Kinect-based systems that were designed and built in response to these findings for interacting with images in minimally invasive surgery.

PANEL 5: COMMUNICATING SURGICAL PRACTICE

The inseparable entanglement of »seeing« and »doing« in image-guided intervention challenges both medical practice and education as well as their theoretical analysis alike. Screen-based training simulators for lifelike minimal-invasive surgery are to enrich text-based forms of instruction in order to grasp the dynamic, relational and embodied/manual qualities and modes of surgical operations. While video transmission and recordings have become common tools of examination, operation and surveillance, they are now also employed to extend the sensory interaction within surgical settings. With the growing complexity of workflows and procedures, new means of evaluation and dissemination of surgical skills are in demand. The panel will thus take a closer look at the application of surgical simulators and video as essential media of communicating surgical practices to different audiences.

Johnson, Ericka
Department of Thematic Studies – Technology and Social Change, Linköping University

Attaching the Uterus. Stringing Together Pelvic Bones, Internal Organs and Pressure Sensitive Diodes

Medical training simulators simulate medical practice. This is true of virtual reality simulators as well as those that rely on tangible, physical models. Yet, to assert their legitimacy as training environments, we often rely on proof that they are realistic models of ontologically stable anatomies, meaning that the representations of the patient body they reify are objective and valid. But what if we were to unpack the knowledge practices used to create those anatomies? We would find that medical anatomy is medical practice. Thus, rather than simulating anatomical objects, our simulators are simulating the ways we know patient bodies.

Lammer, Christina
CORPOrealities, Vienna

SONO OPERATORE – Sensory Explorations in the Operating Theater

My presentation is inspired by Walter Benjamin's comparison of the surgeon and the cameraman, for both »penetrate« deeply into the body's realities. Was this connection in Benjamin's era largely metaphorical, are cameras and surgical procedures nearly inseparable in our times. »Sono operatore«, referring to Luigi Pirandello's novel Shoot: Of the Notes of Serafino Gubbio Cinematograph Operator (1916), I am an operator. Operating nothing. This is what I do. I observe operations in interventional radiology and plastic surgery in my role as ethnographer and artist. For this I am particularly interested in the empathetic relatedness of bodies, instruments and images. Interpersonal sensory aspects of surgery are in the center of my research interest. Thus I will discuss video footage that I created in the context of minimally invasive radiology. One of a series of three Hand Movies (Lammer 2012, HD video à 5 minutes) that has been produced in reconstructive surgery shall be presented. Furthermore I will share the video documentation of a collaborative work with four surgeons – entitled Anatomy Lessons – that was part of the 7th Berlin Biennale 2012. All of the aforementioned works frame the planned art based research Performing Surgery – Movement Research in the Operating Theater (2015–2018) that aims at exploring the operating theater as an intimate space and the surgeon's hand as feeling for the body of the patient.

Notes

Directions

Bhf. Hackescher Markt
S5 S7 S75
Tram M1 M4 M5 12

S-Bhf. Oranienburger Straße
S1 S2 S25

U-Bhf. Weinmeisterstraße
U8

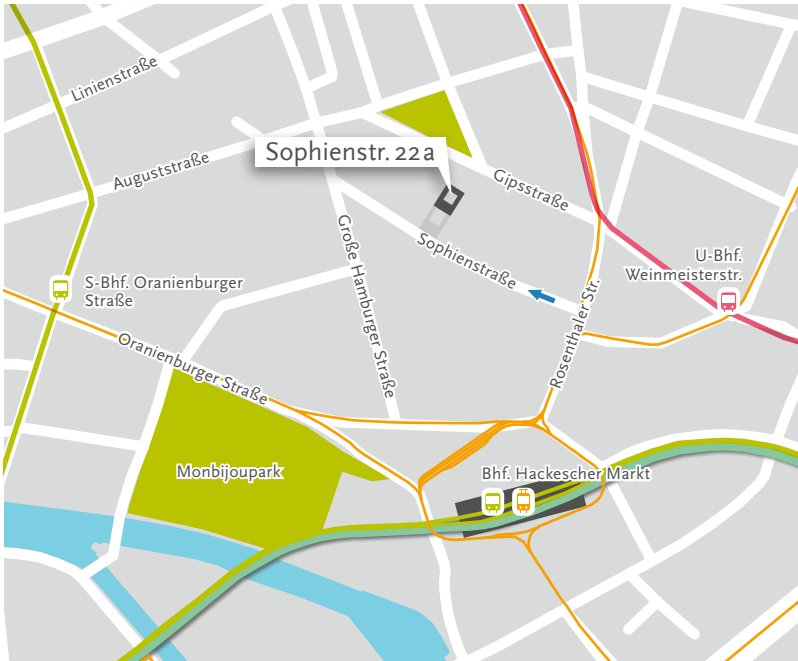

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Illustration: Thomas Picht, 2014