MEDICAL IMAGE COMPUTING & COMPUTER ASSISTED INTERVENTIONS

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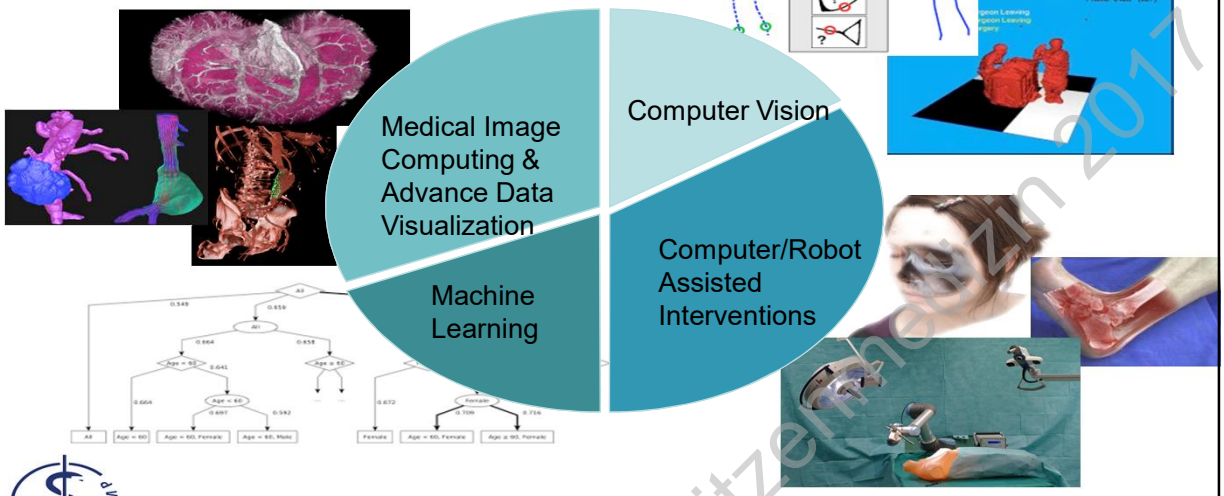
Technische Universität München + Johns Hopkins Whiting School of Engineering

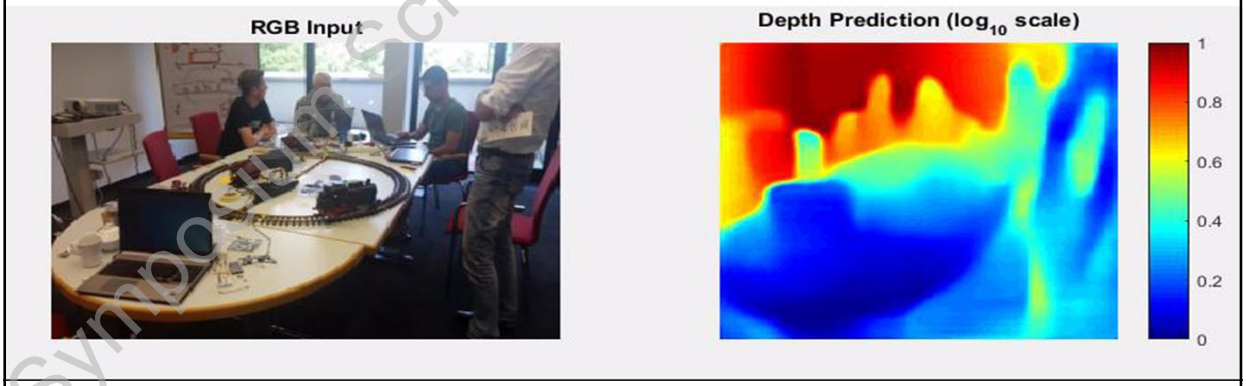
CAMP

More information: http://campar.in.tum.de

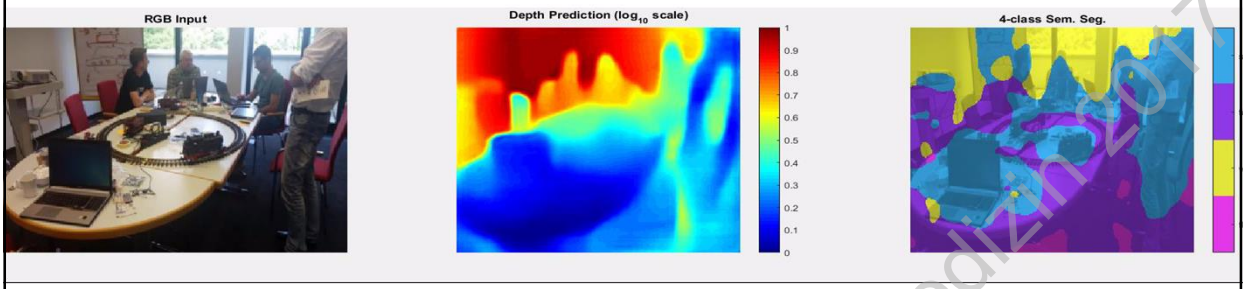
CAMP Research …



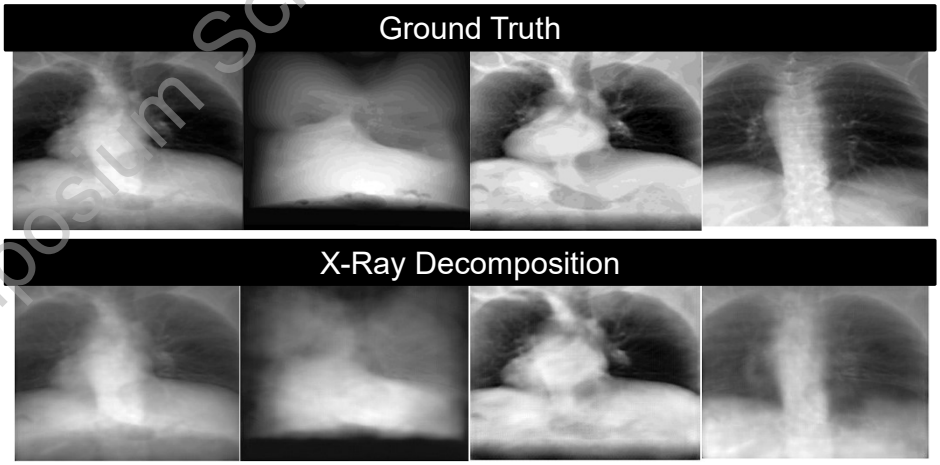
Deep Learning for Depth from one single image!



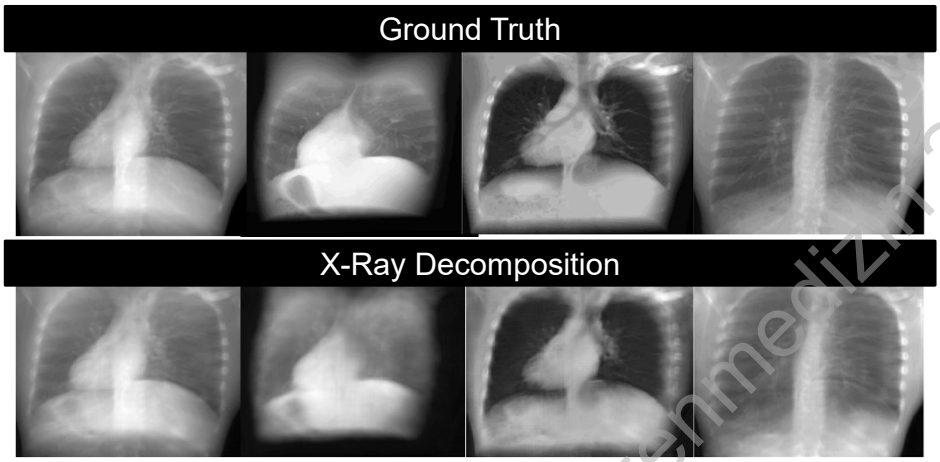
Deep Learning for Depth + Semantic segmentation from one single image!



Deep Learning for X-ray In-Depth Decomposition!



Deep Learning for X-ray In-Depth Decomposition!



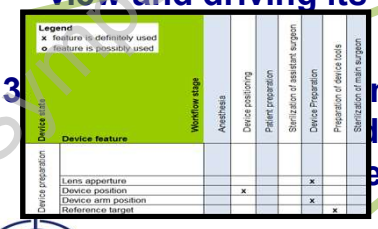
IMAGING & VISUALIZATION FOR COMPUTER ASSISTED INTERVENTIONS

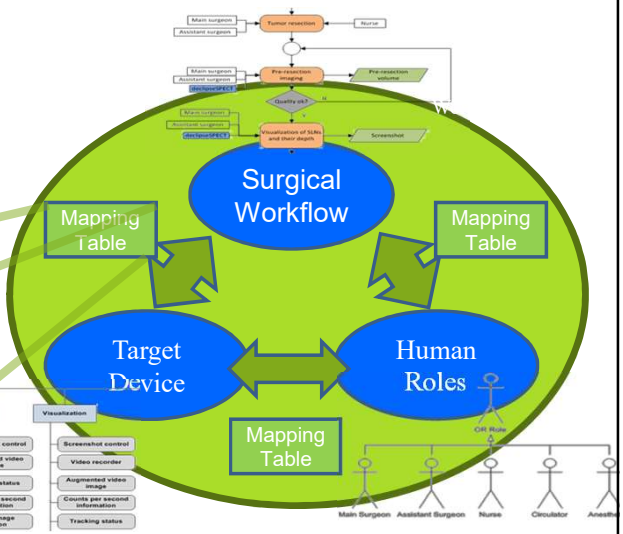
Technische Universität München + Johns Hopkins Whiting School of Engineering

http://www.ncigt.org/pages/AMIGO

Surgical Data Science

1. Decompose the domain into its sources of complexity modeled as distinct views
2. Select a proper modeling technique to represent each view and driving its
3. nnection
   l views
   ements





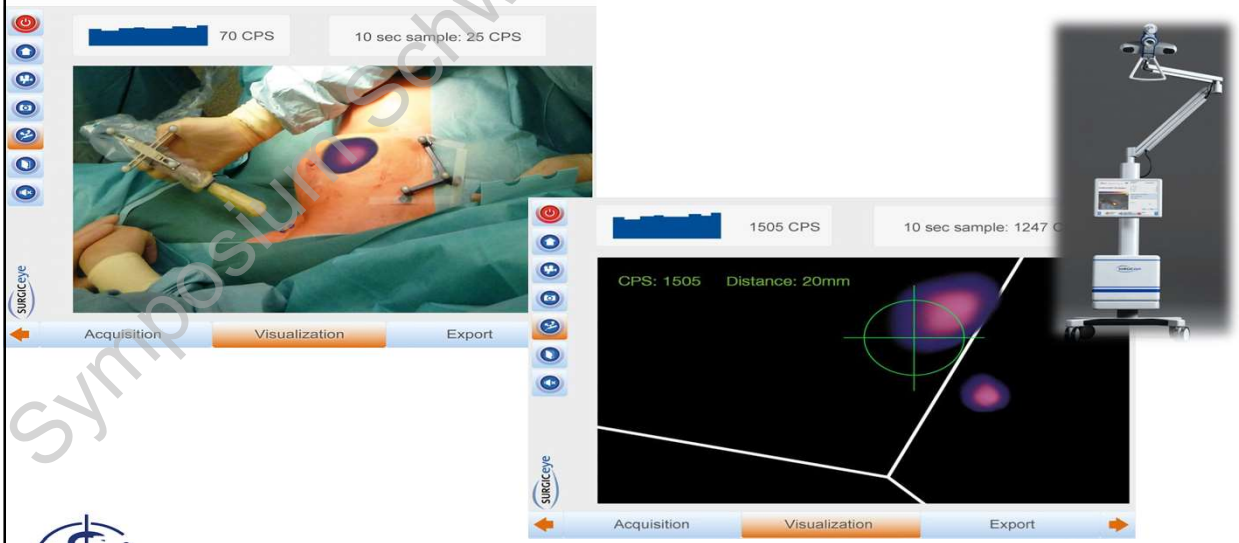
OR Domain Model

Patient and therapy specific imaging

Requirements

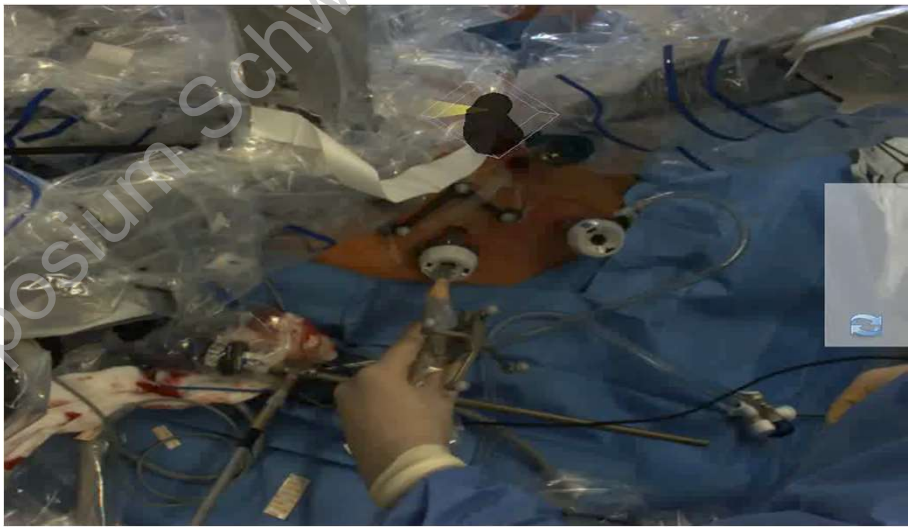
- Relevance
- Speed
- Flexibility
- Reproducibility
- Reliability
- Usability
- Safety

DeclipseSPECT: Clinical Application



Using the laparoscopic gamma probe to generate a 3D image

Generation of a laparoscopic freehand SPECT image



Video: Courtesy of F. W.B. van Leeuwen

- in-patient SPECT: drop-in gamma detector held by da Vinci

Data Analysis

Pre-incision Data

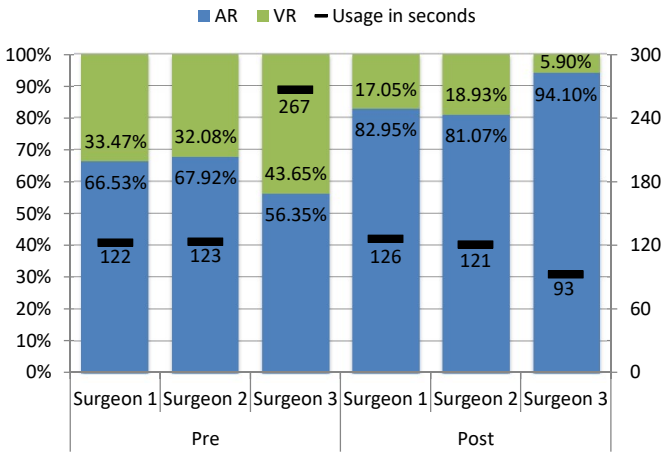
- 52 acquisitions in total
  - Average: 64.0% AR - 36.0% VR (Stdev 25.8%)
  - Average usage time: 3.15 minutes
- VR usage:
  - 41 of 52 – used (78.8%)
  - 11 of 52 – not used (21.2%)
- Threshold setting:
  - 51 of 52 – AR (98.1%)
  - 3 of 52 – VR (5.77%)
- Need for AR in VR:
  - 35 of 41 with VR (85.4%)
  - 35 of 52 total (67.3%)

Aslı Okur et al. IEEE ISMAR 2011

Post-excision Data

- 48 acquisitions in total
  - Average: 86.4% AR - 13.6% VR (Stdev 23.0%)
  - Average usage time: 1.56 minutes
- VR usage:
  - 16 of 48 used (33.3%)
  - 32 of 48 not used (66.7%)
- Threshold setting:
  - 12 of 48 – not needed (25%)
  - 36 of 48 – needed (75%)
- Need for AR in VR:
  - 13 of 16 with VR (27.1%)
  - 13 of 48 total (81.3)
- Comparison with pre-incision scan:
  - 29 of 48 – used (60.4%)
    - 27 in AR
    - 1 in VR
    - 1 in both

Data Analysis



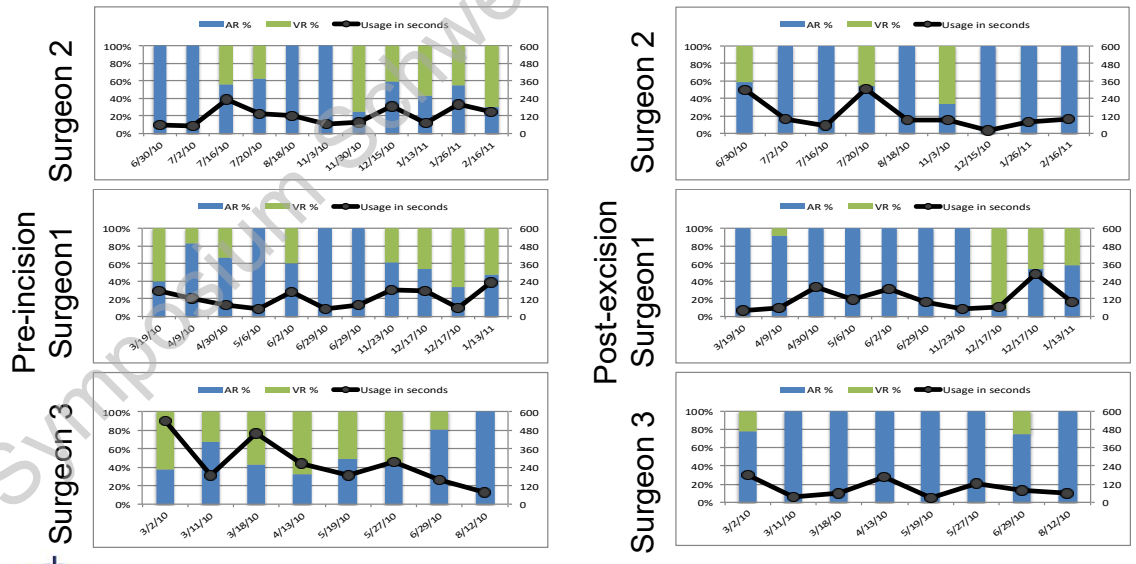
14 different main surgeons were involved in total

- Different characteristics of teams led by different main surgeons
- Actual usage time and type depends on the decision maker (the main surgeon)

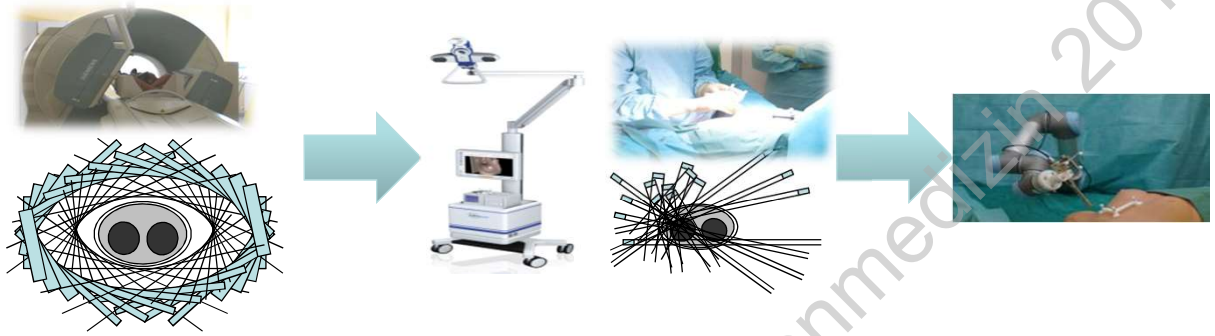
Analysis for three major users

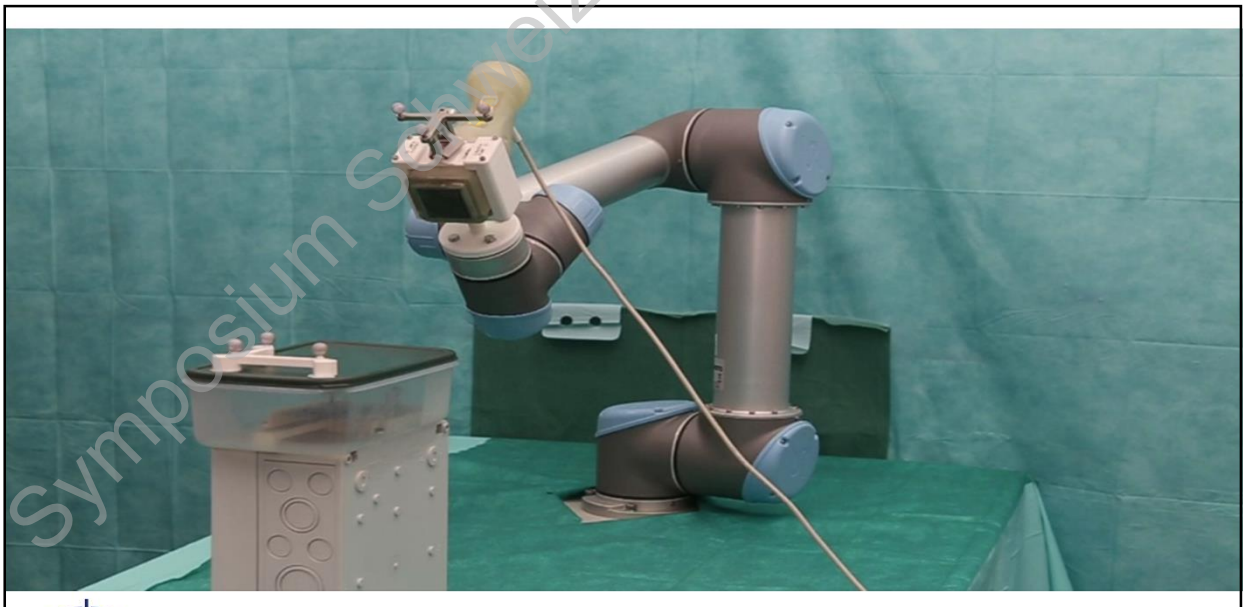
Different usage tendencies:

- Surgeon 1 and 2: confirmation of radioactivity before excision over the anatomy (more AR usage)
- Surgeon 3: image-guided excision (more VR usage)



From general diagnostic imaging to flexible, reproducible and reliable patient and therapy specific imaging

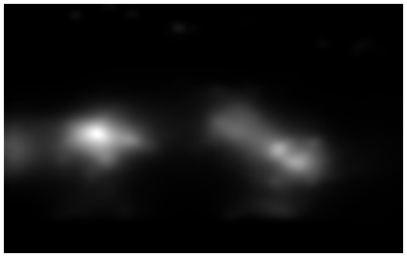




Decay compensation experiment

3 spheres loaded with ~1MBq of ^{99m}Tc, scanned 18 hours (3 half lives) after show the effect of the compensation in the reconstruction.

Reconstruction with compensation



Reconstruction without compensation

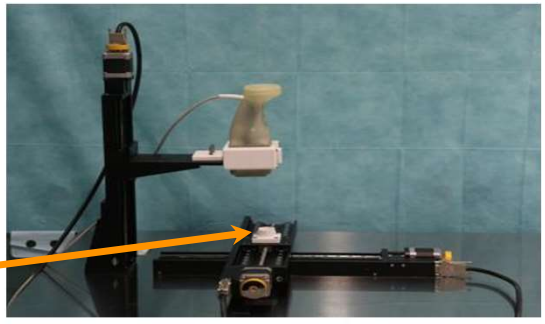
Gardiazabal et al. (2012), ***First flexible robotic intra-operative nuclear imaging for image-guided surgery***. IPCAI

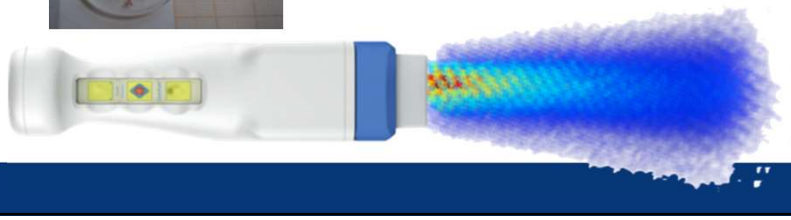
Robotic Gamma camera modeling

- 15 x 15 x 15cm^3
- 1mm^3 spacing
- 41^3 = 69k points

Experiment

- Box-phantom with 3 radioactive spheres
- Optically tracked camera and phantom
- 6 images from 2 orthogonal directions

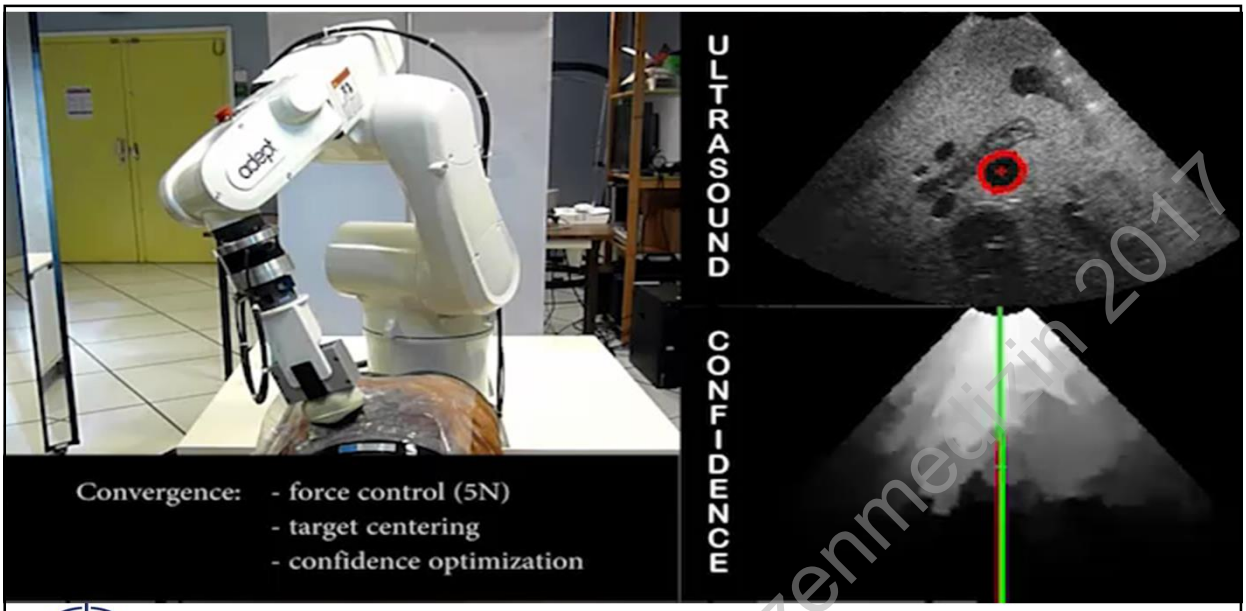




Towards personalized interventional SPECT-CT imaging

MICCAI 2014 submission #155
(supplementary material)

Robotic US (Optimal Acquisition), Collaboration with INRIA in Rennes



Chatelaine, Krupa, Navab, ICRA 2015

Automatic Force-Compliant Robotic Ultrasound Screening of Abdominal Aortic Aneurysms

Salvatore Virga[1,2], Oliver Zettinig[1], Marco Esposito[1], Karin Pfister[3], Benjamin Frisch[1], Thomas Neff[2], Nassir Navab[1,4], Christoph Hennersperger[1]

[1]Chair for Computer Aided Medical Procedures, Technische Universität München
[2]KUKA Roboter GmbH, Augsburg, Germany
[3]Vascular and Endovascular Surgery, University Medical Center Regensburg
[4]Computer Aided Medical Procedures, Johns Hopkins University

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IEEE IROS 2016
October 9-14, Daejeon, Korea

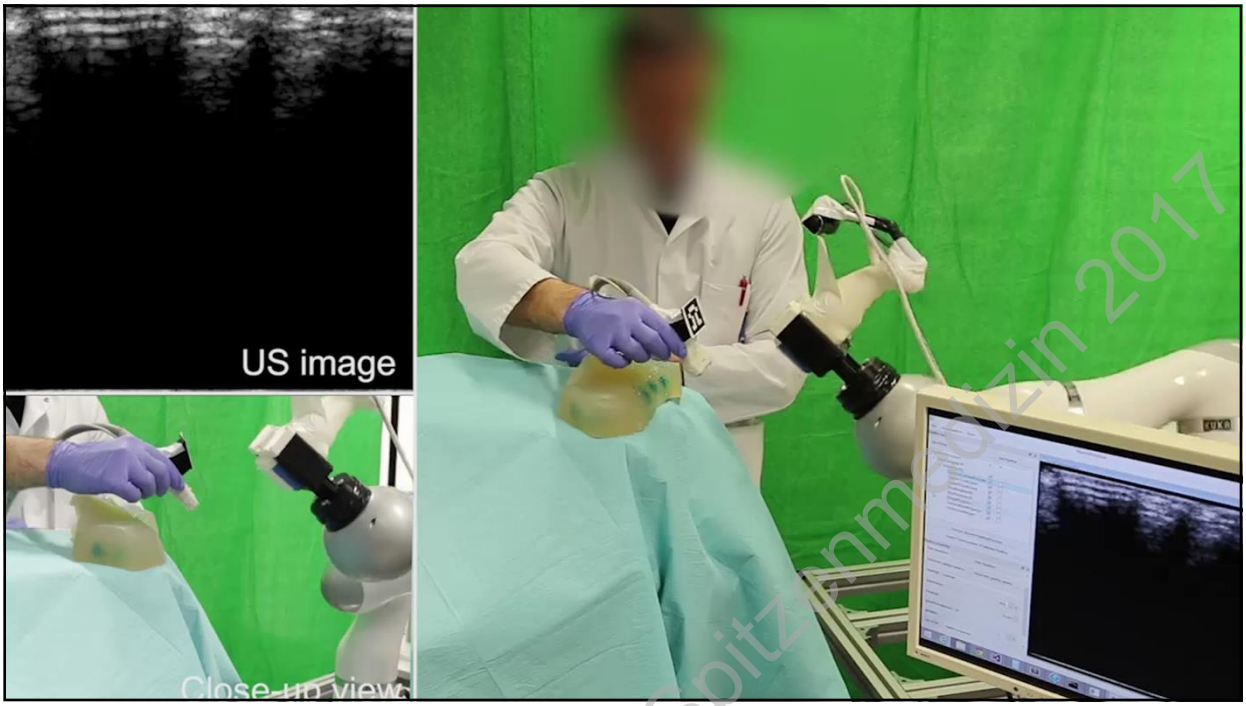
'*Desired-views*' for Automatic C-arm positioning

shift the paradigm

- clinician only communicates the desired outcome of imaging.
- based on DRRs, pre-operative CTA data, and inverse kinematics

Fallavollita P, Winkler A, Habert S, Wucherer P, Stefan P, Mansour R, Ghotbi R, Navab N. *Desired-view controlled positioning of angiographic C-arms.* **(MICCAI 2014)**

Patient fhSPECT Acquisition



Challenges – Adoptive, intuitive and interactive visualization

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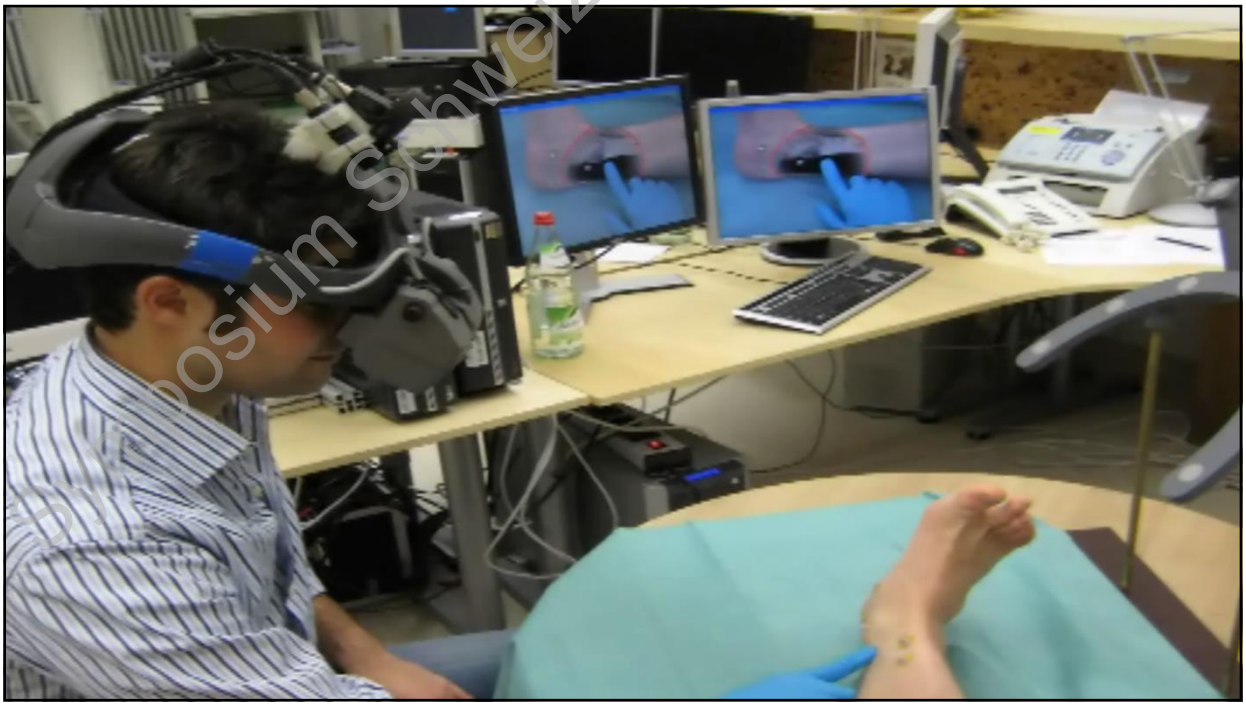
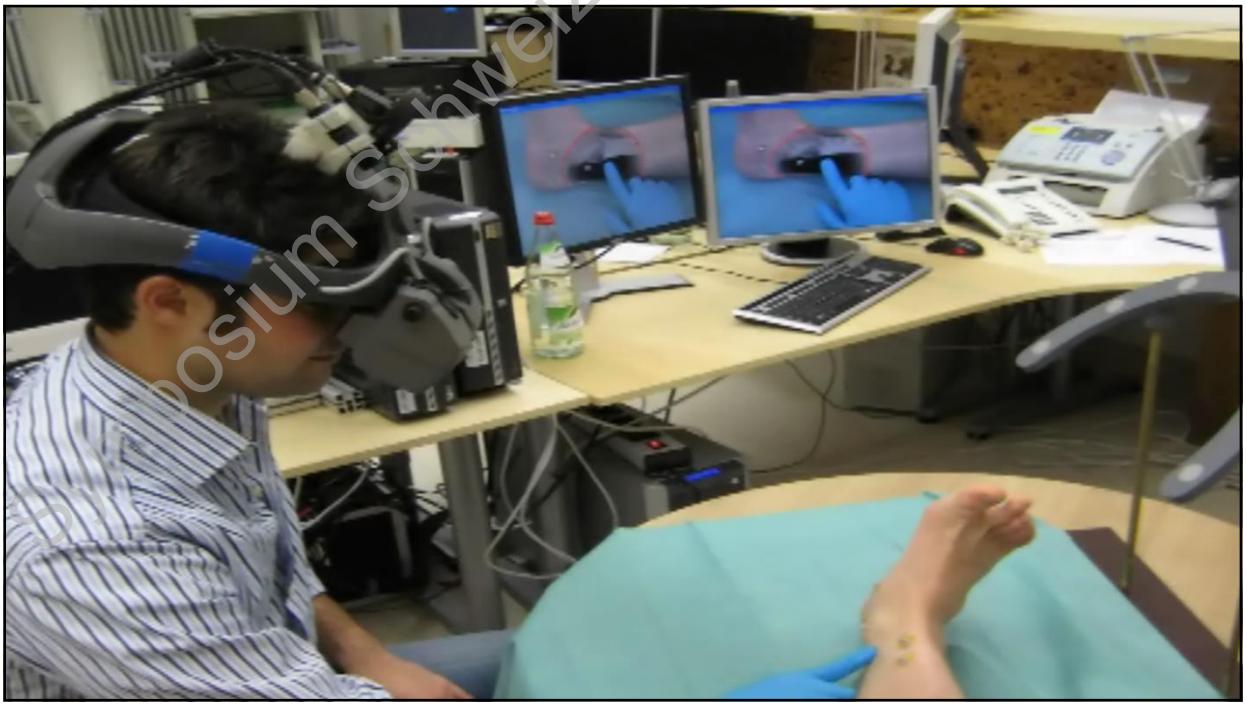
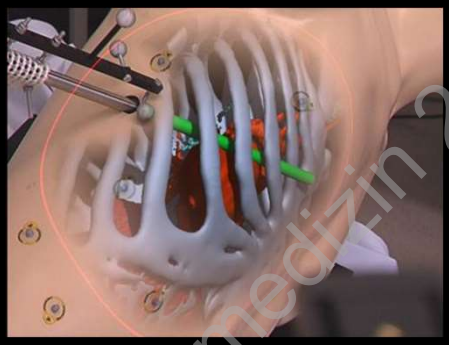
Is
Augmented Reality
only about
3D image overlay?



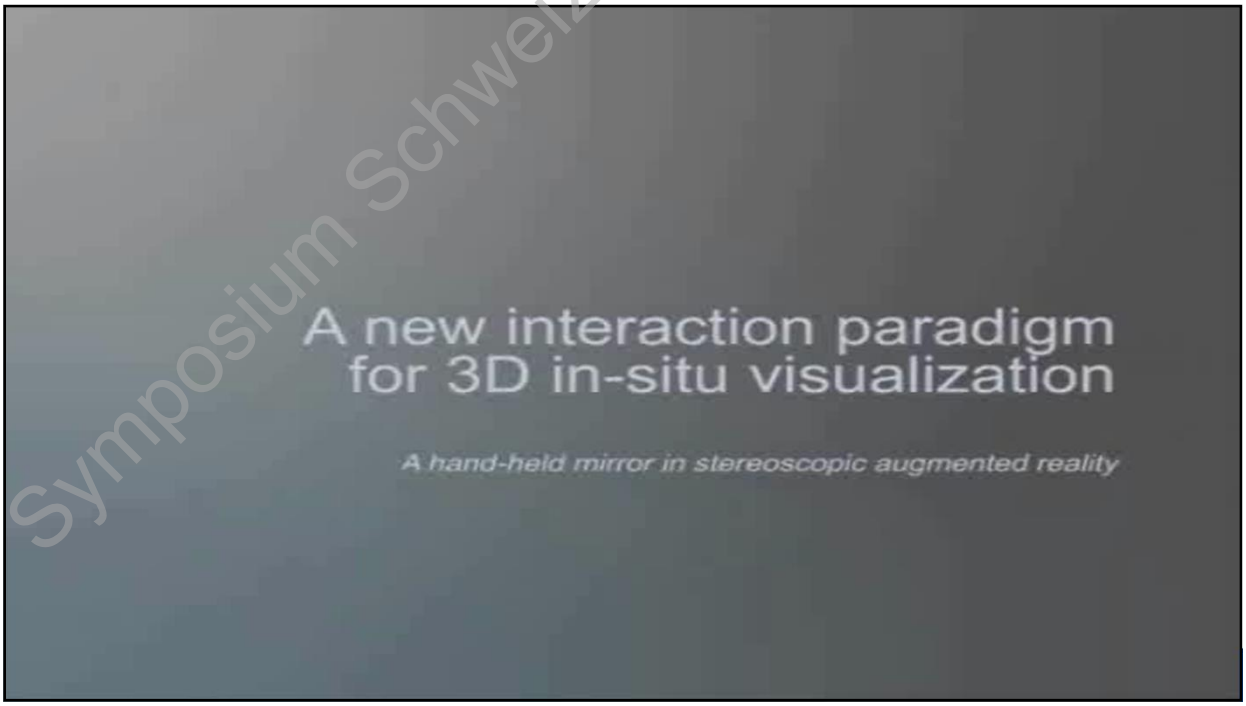
Can
we improve/fool
our
visual perception?



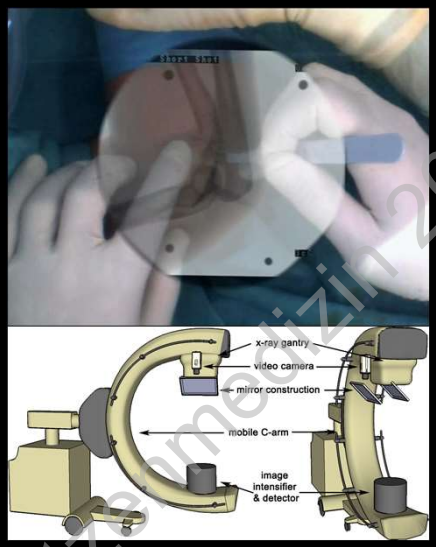
How to enforce coexistence of Real & Virtual?

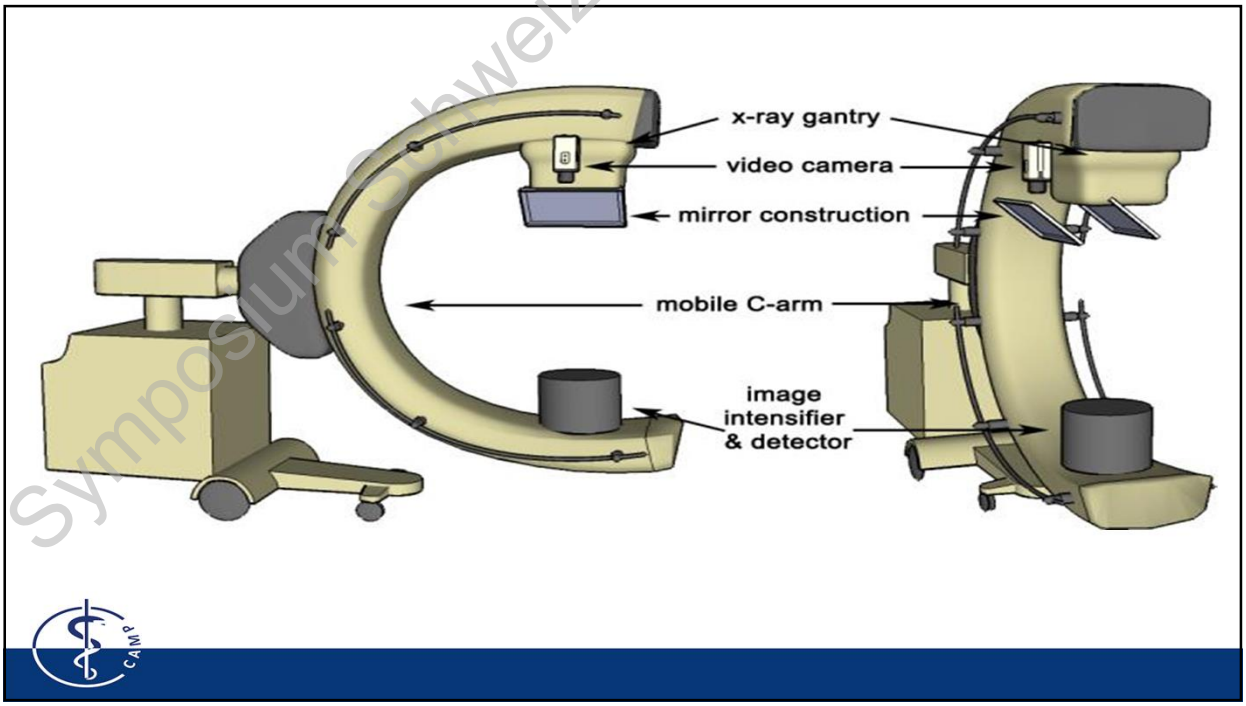


How to explore 3D data in Augmented Reality?

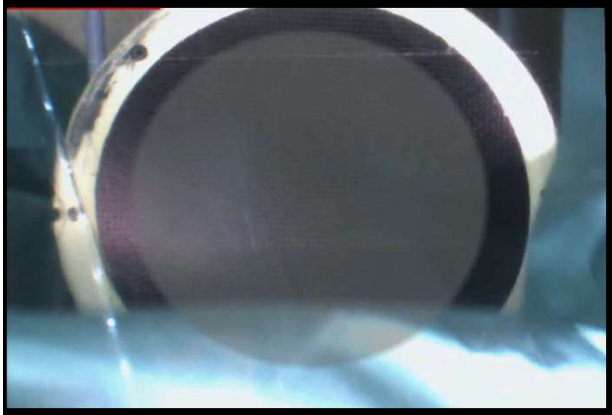


AR in OR
Relevance
&
Workflow
Integration

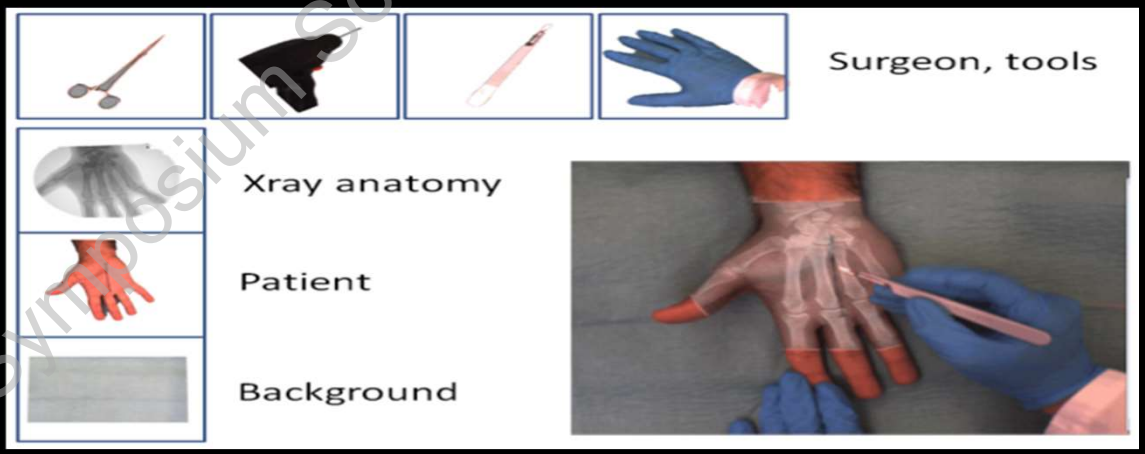




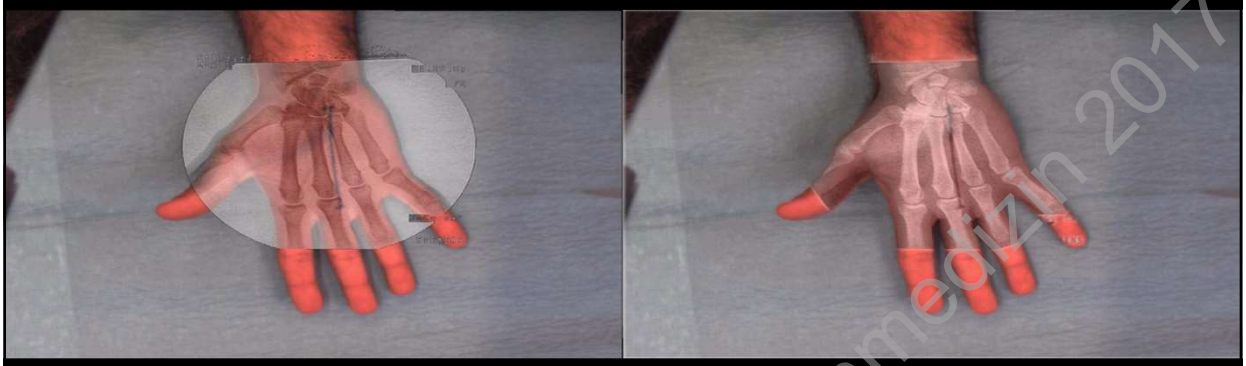
First uses of AR in Trauma Surgeries …



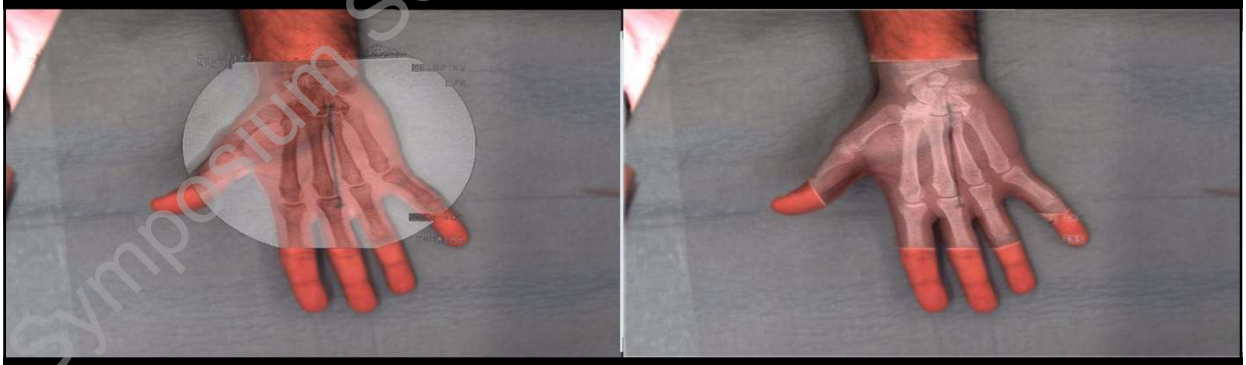
Machine Learning for Relevance based Imaging



Machine Learning for Relevance based Imaging



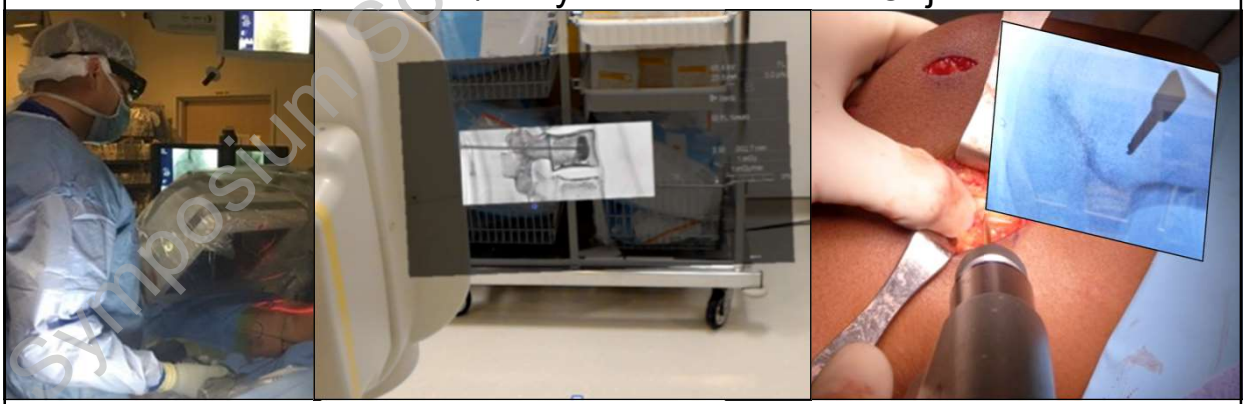
Machine Learning for Relevance based Imaging



Towards introduction & extensions of Real-world Laboratories

Taxonomy and Uses for 2D Medical Displays

Head Anchored | World/Body Anchored | Object Anchored



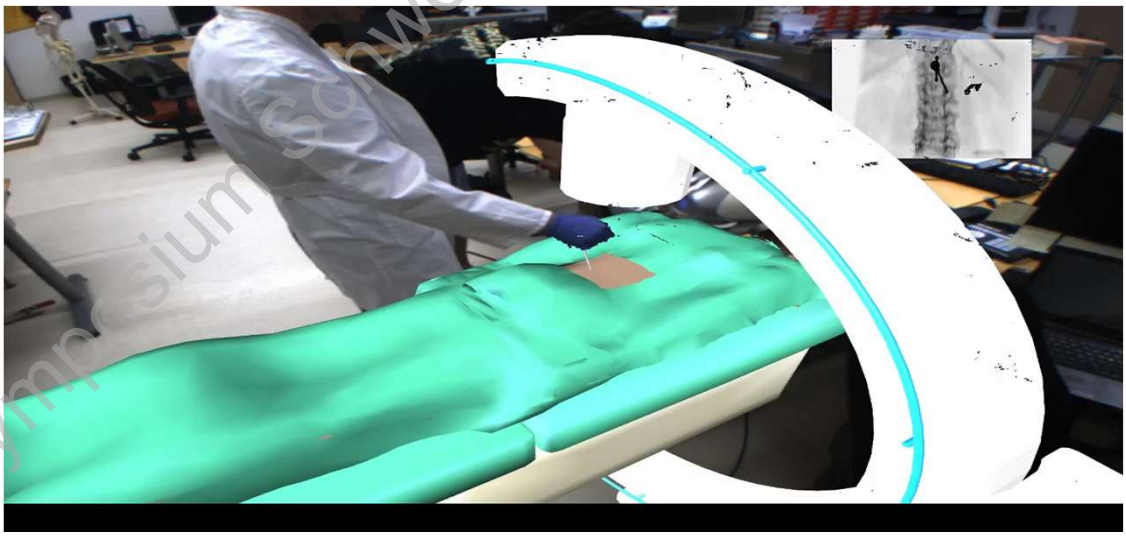
Kersten-Oertel M, Jannin P, Collins DL. DVV: a taxonomy for mixed reality visualization in image guided surgery. IEEE Trans Vis Comput Graph. 2012 Feb;18(2):332-52. doi: 10.1109/TVCG.2011.50. PubMed PMID: 21383411.

Computer Aided Medical Procedures Slide 55

Technical components of simulation environment with CT imaging

Computer Aided Medical Procedures Slide 30

We propose a realistic, radiation-free mixed-reality simulation system to address this problem for C-arm based surgery



Safety

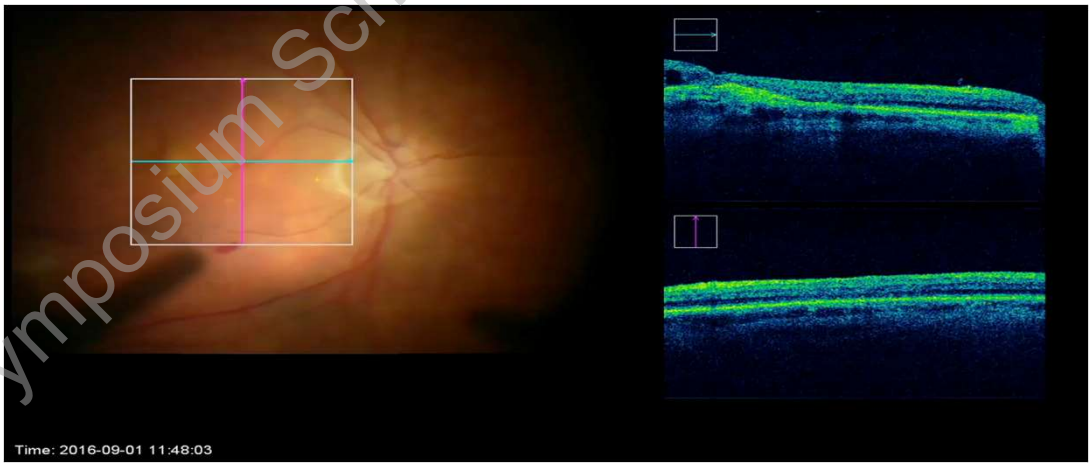
Safety

Habert ISMAR 2015, Padoy MICCAI 2015, Ladikos MICCAI 20110

Thanks

More information: http://campar.in.tum.de

Sonified Video Sequence from a Surgery



Surgery performed by Dr. Mathias Maier at *Rechts der Isar*, Munich