# Computational Surgineering

## Preliminary meeting

# Tutors

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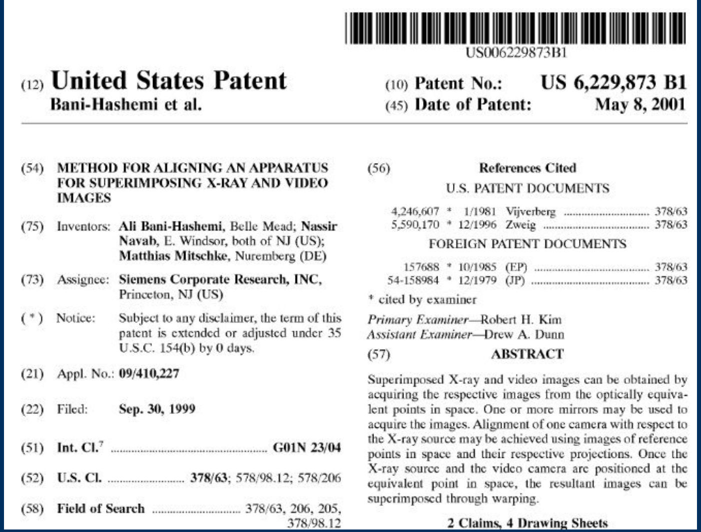
# Motivation

“My main failure in life is having not brought more of my inventions to patients”



US006229873B1

(12) **United States Patent**
**Bani-Hashemi et al.**

(10) **Patent No.: US 6,229,873 B1**
(45) **Date of Patent: May 8, 2001**

(54) **METHOD FOR ALIGNING AN APPARATUS FOR SUPERIMPOSING X-RAY AND VIDEO IMAGES**

(75) Inventors: **Ali Bani-Hashemi**, Belle Mead; **Nassir Navab**, E. Windsor, both of NJ (US); **Matthias Mitschke**, Nuremberg (DE)

(73) Assignee: **Siemens Corporate Research, INC**, Princeton, NJ (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/410,227**

(22) Filed: **Sep. 30, 1999**

(51) **Int. Cl.**[7] ........................ **G01N 23/04**

(52) **U.S. Cl.** ........................ **378/63**; 578/98.12; 578/206

(58) **Field of Search** ........................ 378/63, 206, 205, 378/98.12

(56) **References Cited**

U.S. PATENT DOCUMENTS

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5,590,170 * 12/1996 Zweig ........................ 378/63

FOREIGN PATENT DOCUMENTS

157688 * 10/1985 (EP) ........................ 378/63
54-158984 * 12/1979 (JP) ........................ 378/63

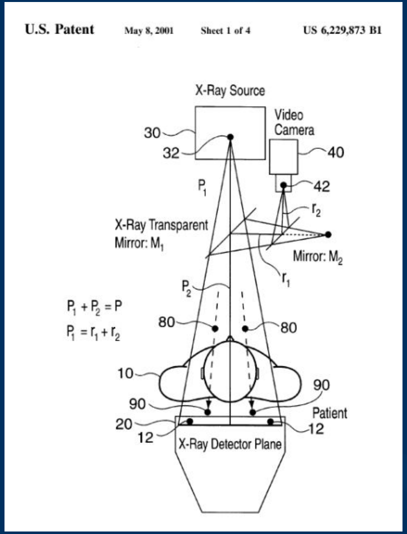
* cited by examiner

*Primary Examiner*—Robert H. Kim
*Assistant Examiner*—Drew A. Dunn

(57) **ABSTRACT**

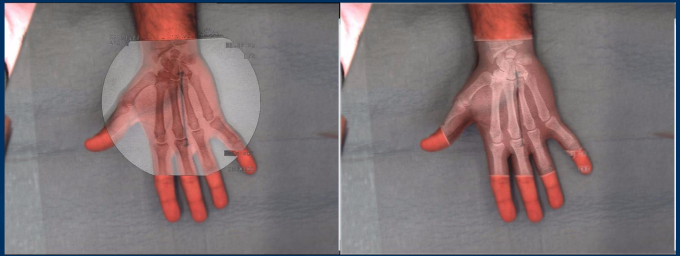
Superimposed X-ray and video images can be obtained by acquiring the respective images from the optically equivalent points in space. One or more mirrors may be used to acquire the images. Alignment of one camera with respect to the X-ray source may be achieved using images of reference points in space and their respective projections. Once the X-ray source and the video camera are positioned at the equivalent point in space, the resultant images can be superimposed through warping.

**2 Claims, 4 Drawing Sheets**




https://www.youtube.com/watch?v=Bv6nW48a8Zo - 2000 version

2014 version



# Presentation Outline

- C(o)urse Structure
- Team Formation
- Grading
- Support and Infrastructure Provided by the Chair
- Registration Requirements
- Overview of the Potential Projects

# C(o)urse

# General aspects

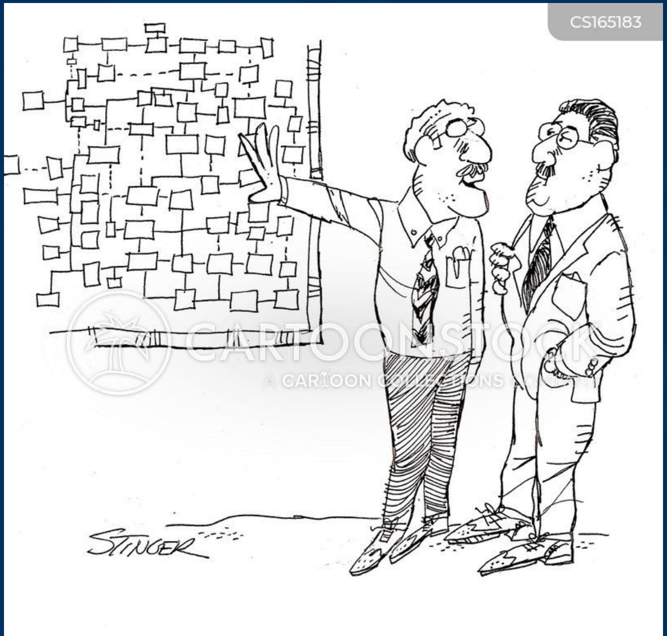
- Practical Course (every semester)
  - Biomedical Computing (Master) → elective in module Software Engineering and Programming
  - Informatics (Master)
  - Robotics, Cognition, Intelligence (Master)
  - Computational Science and Engineering (Master)
  - Biomedical Engineering and Medical Physics (Master)
- 6 SWS / 10 ECTS
- 18 students (working in groups of 3)
- Prerequisites
  - Required: Python and/or C++ experience
  - Ideally: CAMP 1, CAMP 2, IGS or equivalent

# Learning outcomes

- **Use** a subset of **common software development tools** for medical image processing and computer-assisted interventions
- **Consider regulatory constraints** needed to be taken into account when developing medical software
- **Understand the daily clinical routine** within one specialty/clinical department
- **Refine a clinical solution** for an unmet clinical need to be able to **generate a prototype**
- **Analyze one clinical application** in order to generate a requirement specification for the chosen clinical challenge
- **Develop a clinical prototype** (mainly software, if applicable also involving hardware) and demonstrate it on phantoms, ex-vivo, or using retrospective data
- **Present the work** in front of an audience of medical technologists and clinicians

# Structure of the Course

- Lectures - first 3 weeks
  - 1 obligatory
  - 4 depending on your previous courses
- Hospitation at the clinical partner’s department for at least one week - starting week 3
- Presentation Requirements specification - presented to doctors - week 4
- Weekly reviews - starting in week 5, every week
- Prototype demonstration - presented to the doctors - end of the semester




“We’ve reorganized so many times we are now one of our own subsidiaries.”

# Lectures

- Introduction - week 1
- OR training (for students who missed that training in IN2286, together with IGS students) - week 1
- Tools and methods for software development for medical image processing and computer-assisted interventions (for students who missed that training in IN4136, together with PMSD) - week 2
- Introduction to regulatory aspects of medical software development (for students who missed that training in IN2286, together with IGS students) - week 3

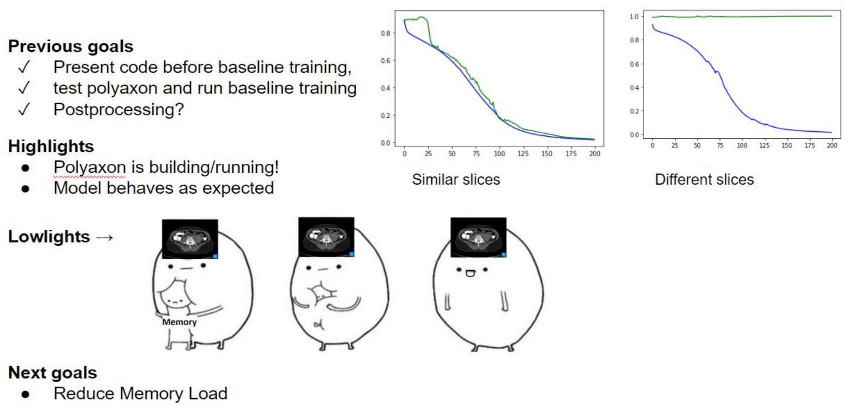
# Hospitation (planned)

- You will play the “shadow” of medical doctors and technologists in the hospital division related to your project
- You wear a white coat and learn the daily work of clinicians
- You will analyse their routine and get a better view of reality in a hospital
- You probably will attend ORs, participate in patient visits/examinations, get to know the personnel

# Weekly meetings



- You will participate in weekly meetings with 1-3 of the tutors and possibly other students working in related projects
- You will report on the status of the project
- You will get supervision, help with bug fixing, an advisor for administrative stuff, connections to experts
- Documentation using an ever-growing Google Slide
  - Previous goals
  - Lowlights of the week
  - Highlights of the week
  - New goals



# Project / Group / Grading

- You will post your preferences of topics from list of previous projects of IGS
- The tutors will try to optimize wishes with know-how needed for the said projects
- First milestone
  - Understand clinical application and proposed solution by former IGS students
  - Update solution and generate a user requirement specification
- Final milestone
  - Present your implementation to clinical partners and Chair members
  - Software/Hardware demo highly recommended
- Grading
  - Individual grade for each team member
  - Grade based on code, demo (if possible), weekly reports (incl. attendance) and two presentations

# Available (shared) infrastructure

- Access to:
  - one of our GPU clusters inside Klinikum rechts der Isar
  - anonymized data from Klinikum rechts der Isar and internal Chair databases
  - robots (da Vinci telemanipulator, Franka, and KUKA arms)
  - instrument tracking technologies (optical and electromagnetic)
  - an x-ray C-Arm (only under supervision) - not yet installed
  - several ultrasound machines
  - 3D printer
- Licenses of a medical image analysis software, e.g., ImFusion Suite

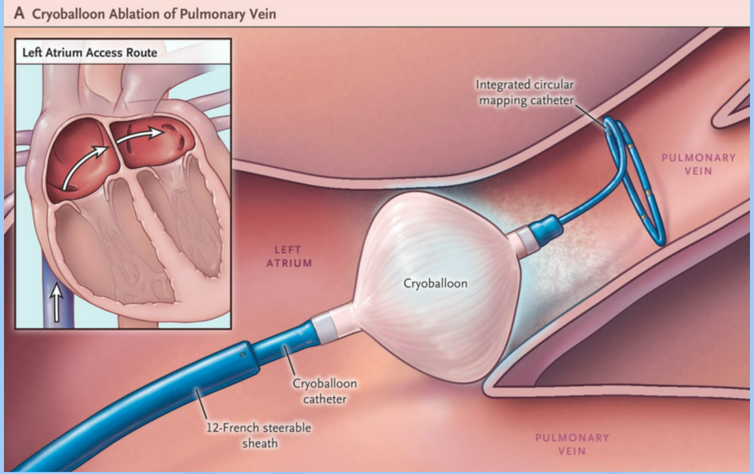
# Registration requirements

- Registration over TUM's matching system
- Submission of CV and motivation letter to tutors
  - Include previous experiences, mainly in the topics of IGS:
    - Programming
    - Computer Vision / Augmented Reality / Sonification
    - Robotics
    - Medical Image Analysis / Machine Learning
- Former students of IGS will be given priority
- CAMP 1 and CAMP 2 are strongly recommended, lacking both (without any additional medical computer science) will reduce your chances to get a place

# Potential Projects

# 1. Computer game to learn catheter ablation of the heart

- Atrial fibrillation (AF) is one of the most common types of arrhythmia
- Catheter ablation is a non invasive surgery to ablate muscle tissue, so that arrhythmic electrical currents do not interfere with the sinus rhythm of the heart
- **Problem**: Success rate and duration of the surgery depend (partially) on knowledge of doctor
- **Project**:
  - Identify the trickiest parts of the surgery
  - Create a simulation and learning app that trains doctors to analyze interventional images and make decisions
- **Tools**:
  - Visualiation/Graphics Framework
  - Desktop/Mobile/Web based

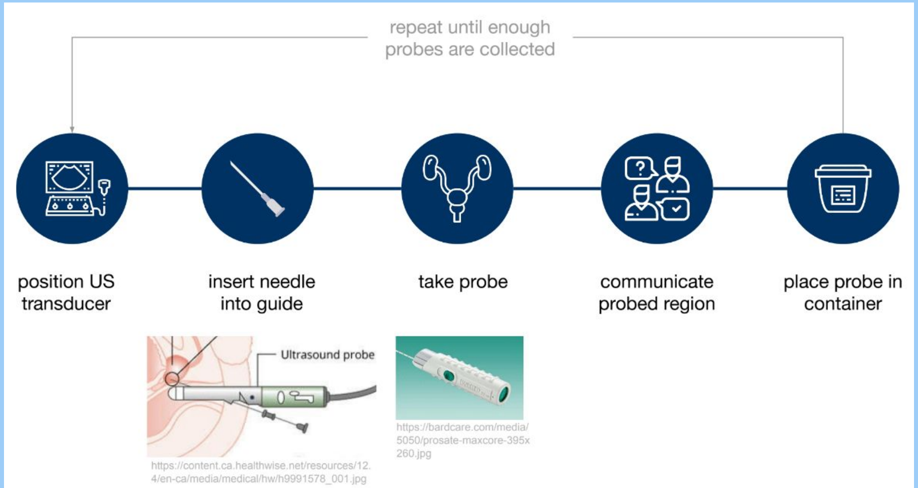



https://www.nejm.org/doi/10.1056/NEJMoa1602014


Catheter Ablation. Bonauer, David; Ries, Annika; Szeimies, Lara

# 2. Prostate Biopsy needle detection for optimized documentation

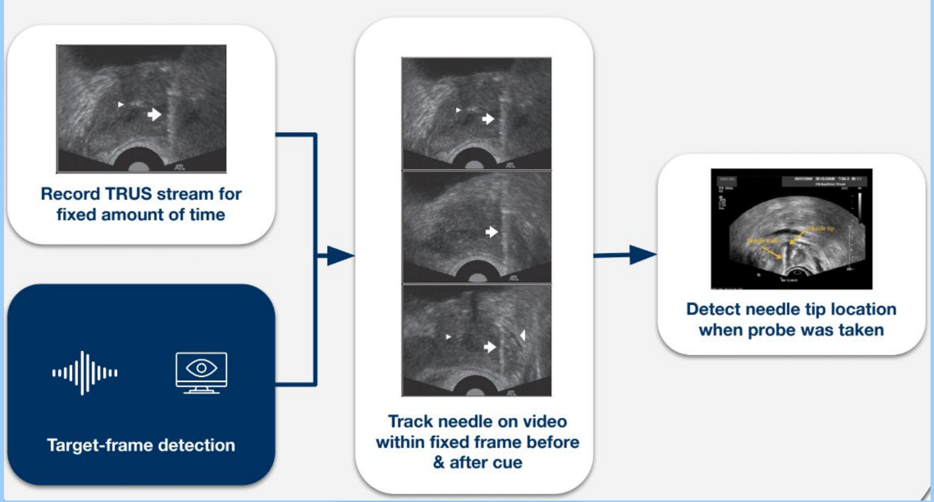





**Application:** Prostate biopsy of men suspected to have cancer.

**Problem:** Imprecise assignment of biopsies to region of prostate.

**Solution:** Combination of acoustic, (haptic,) and image-based detection of needle and automatic assignment to region.

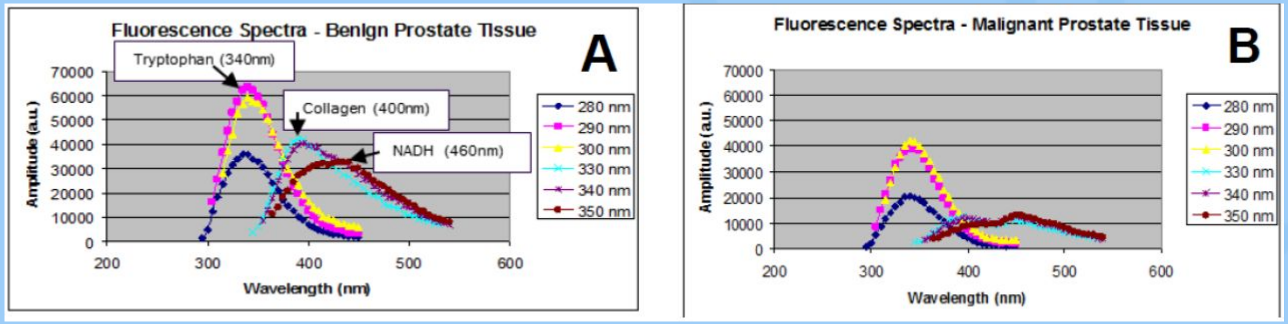



Left Slide from IGS final presentation S. Misatian, V. Sutedjo and V. Markova

Right Slide from IDP final presentation V. Markova and E. Shishniashvili

# 3. Multispectral specimen analysis of prostate cancer

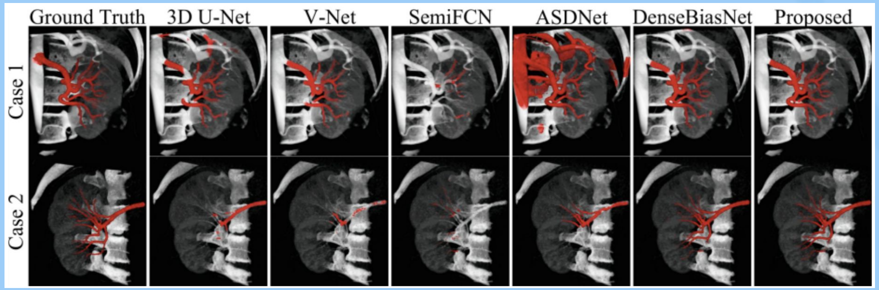
- Upon prostate removal, a histological test of the prostate is carried out. This determines if the cancer has spread and where - dealy surgery ~30mins
- Idea is find a method that could determine where the cancer has spread, in vivo
- The idea makes use of the Fluoroscopic properties of prostate tissue when excited with Ultraviolet light
- Develop an optic system that allows to excite tissue with UV-light and then measure the reflectance of the tissue

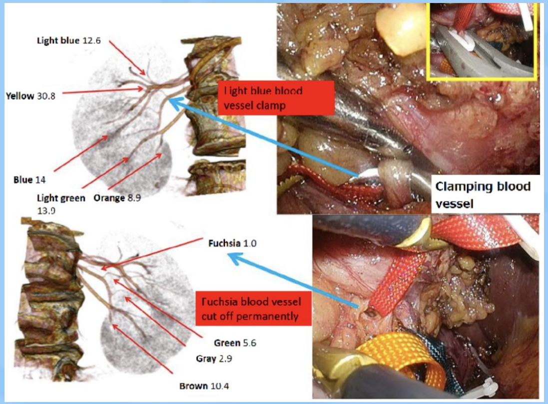


# 4. Kidney blood supply anomaly detection



- **Goal**: safe kidney tumor removal
- **Problem**: number of renal arteries can vary, identifying all vascular branches is challenging
- **Solution**: Tool to detect and segment all arteries using preoperative CT data to avoid ischemia
- **Task**:
  - Implement segmentation and visualization framework for renal arteries
  - Employ state-of-the-art DL segmentation networks
- **Tools**: Python and Visualization tool-kit (e.g. ImFusion)



# 5. Robotic ultrasound of the liver

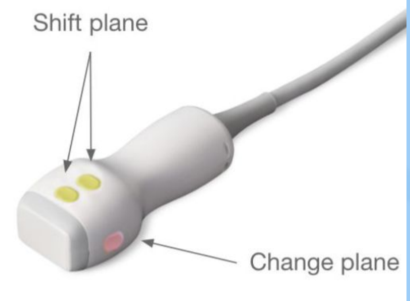
- Transcatheter arterial chemoembolization (TACE) is performed to restrict the tumor’s blood supply by injection of chemotherapy microspheres in the artery that feeds the tumor.
- A catheter is inserted through the leg/arm and guidance is performed using fluroscopy.
  - ➡ Exposure to radiation for the patient and the medical staff
- **Idea**: lowering the use of ionizing radiation and chemical substances by integrating ultrasound imaging (radiation-free imaging modality).
- **Project**: Robotically-guided ultrasound system to detect and track the catheter
  - Visualize catheter movement in real time

Catheter guidance

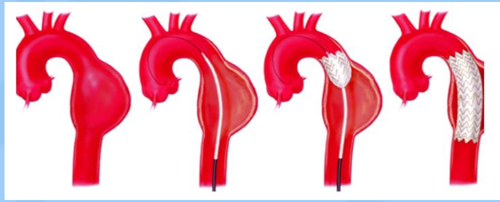
# 6. 3D ultrasound of the brain



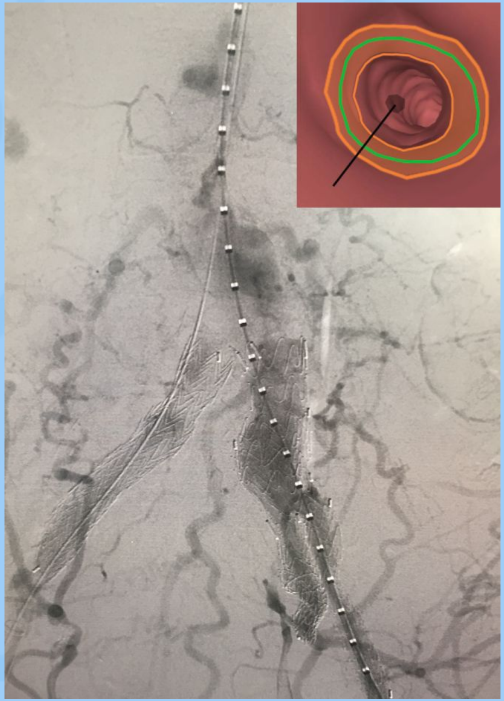
- Issues in brain tumor resection surgery are
  - brain shift from craniotomy and resection,
  - identification of residual tumor
- Main idea is to improve the visualization and user experience with 3D iUS navigation during brain tumor resection surgeries
- Use current tracking and reconstruction methods to create 3D images from 2D iUS scans, an added visualization tool allowing the surgeon to control of the data visualized on the neuronavigator directly from the probe



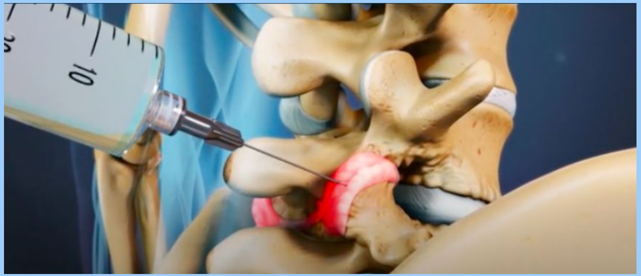
# 7. Planning of stent placement for abdominal aortic aneurysm (AAA)

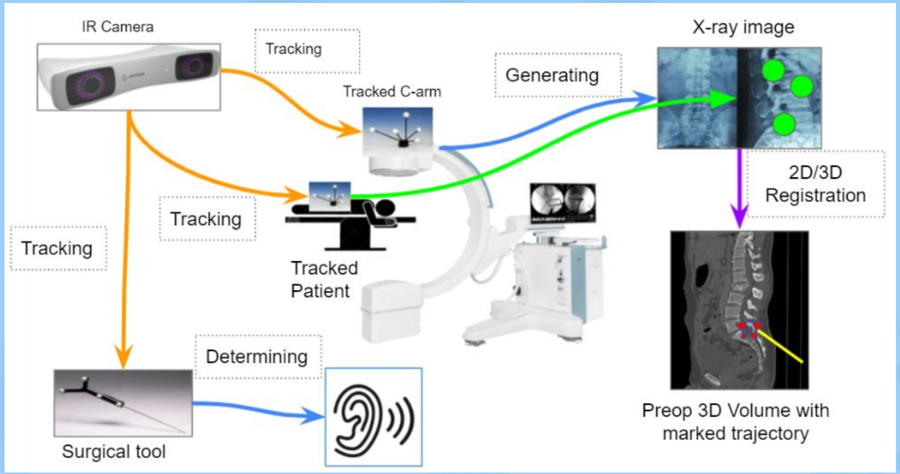


- Due to many factors the aorta can swell and dilate which is referred to as Abdominal Aortic Aneurysm (AAA)
- Endovascular repair (EVAR) is the surgery, where a stent graft called Endograft is placed into the aneurysm area. EVAR is the minimally invasive alternative procedure of open surgery
- General motivation: Improve the stenting procedure by more accurate position marking and providing additional views
- Improving the visualization by creating a virtual angioscopy view with a visual marking of the landing zone



# 8. Sonification of facet joint insertion



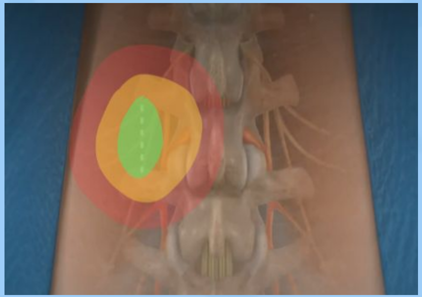


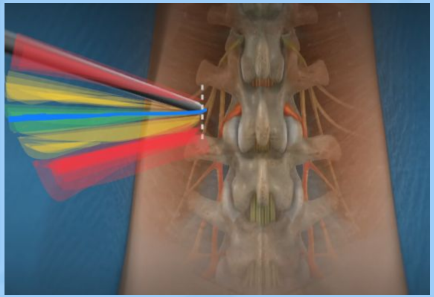

**Application:** Facet joint insertion.

**Problem:** Guidance only possible under fluoroscopy.

**Solution:**

- Marking of facet in 3D preop. Images
- 2D/3D registration
- Optical tracking of instruments and C-arm
- Guidance to facets
- Sonification

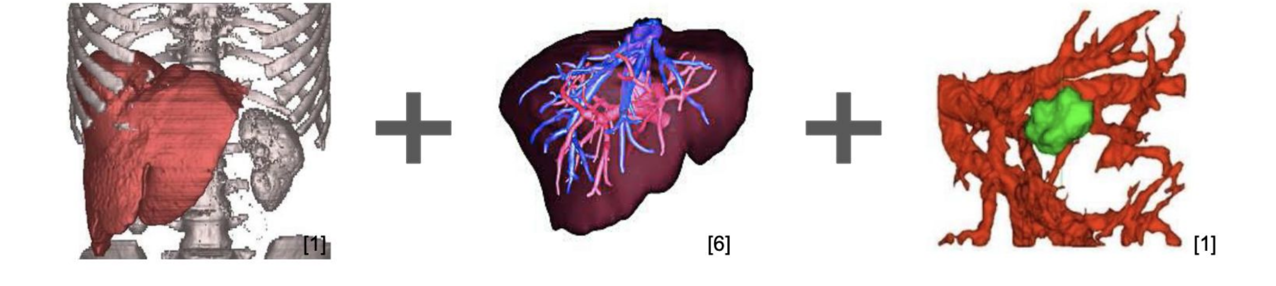




IGS final presentation of M. Gafencu, A. Kumar, D.A. Voutyrakou

# 9. Improved vessel segmentation for liver and kidney


- Transcatheter arterial chemoembolization (TACE) procedure
- Understanding of vessel structure and tumor location
  - find optimal position for chemoembolization
    - Save as much healthy liver tissue as possible
    - Block (all) blood supply to tumor
- Visualize of the relevant vessel tree at all times




- Volume Rendering of CT Scan **Visualization of Vasculature:** Tumor Segmentation:

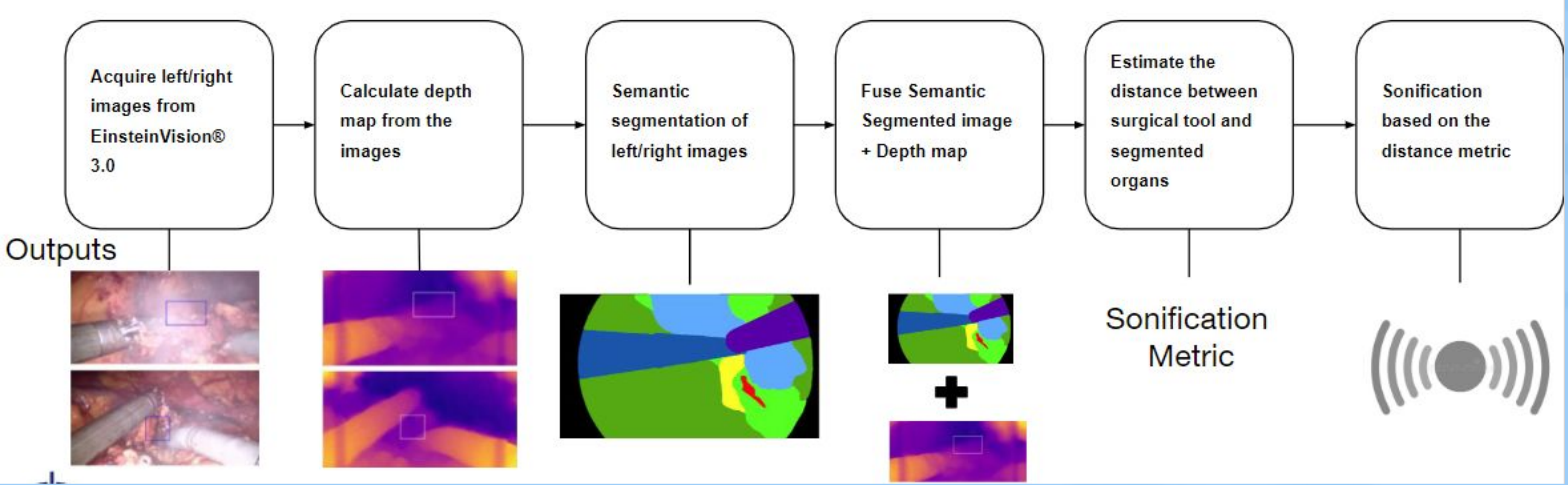
# 10. Depth+Segmentation of endoscopic images



**Application:** Cholecystectomy or any laparoscopic surgery.

**Problem:** Display of organs at risk and warnings..

**Solution:** DL-based semantic segmentation and depth estimation as first step for intraoperative registration.

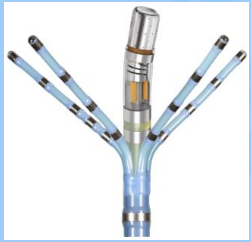


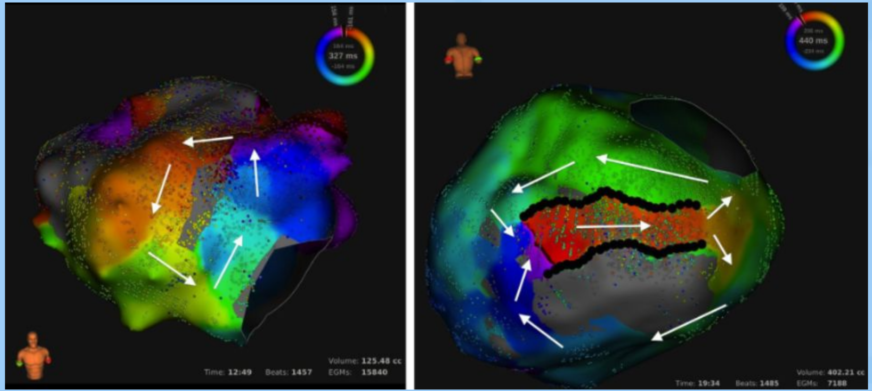

IGS final presentation of F.M. Karali, M. Kiray and L. Kreitner

# 11. Combined catheter for electrophysiology



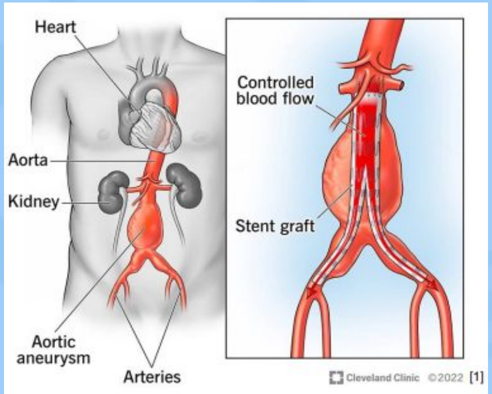
- Cure Arrythmia by ablating non properly functioning tissue
- Heart is mapped in the beginning of the procedure - no new mapping between each ablation → no information on changes
- Implement a real-time electrical heart signal mapping
  - Combination of a mapping and ablation catheters (first solution)
  - DL solution by simulating cardiac tissue behaviour (second solution)

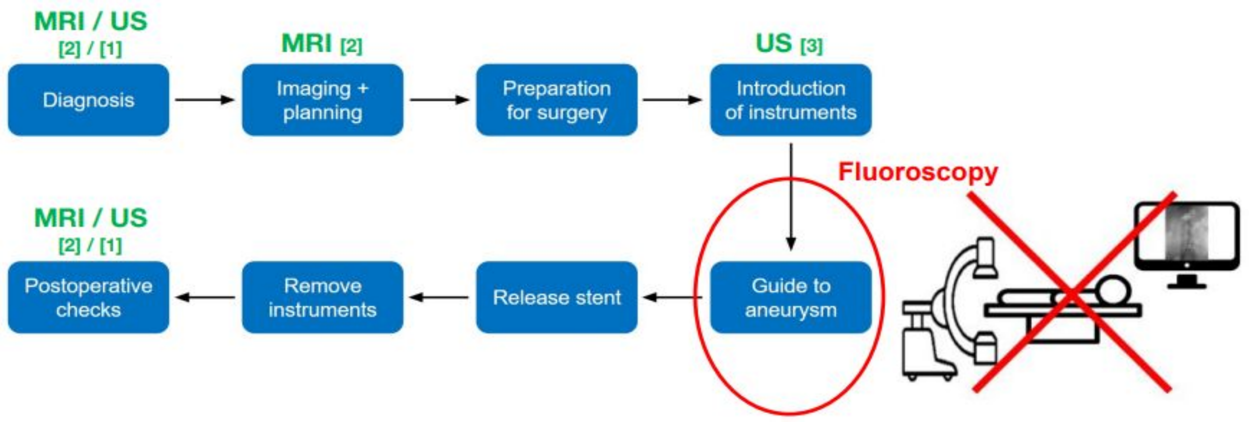


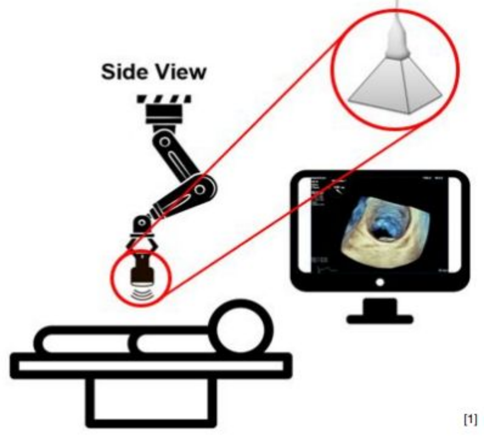


# 12. Robotic ultrasound for Endovascular aneurysm repair (EVAR)

- **Goal**: remove ionizing radiation from EVAR workflow
- **Project**: Replace Fluoroscopy by Ultrasound guidance
  - real-time 3D Ultrasound reconstruction + visualization
    - automated catheter tip following by the robot
    - tracking and visualization of catheter
    - collision avoidance, scan / path planning and control




IGS intermediate presentation of O. Tmenova, S. Steinmüller, L. Buess

# Questions ?