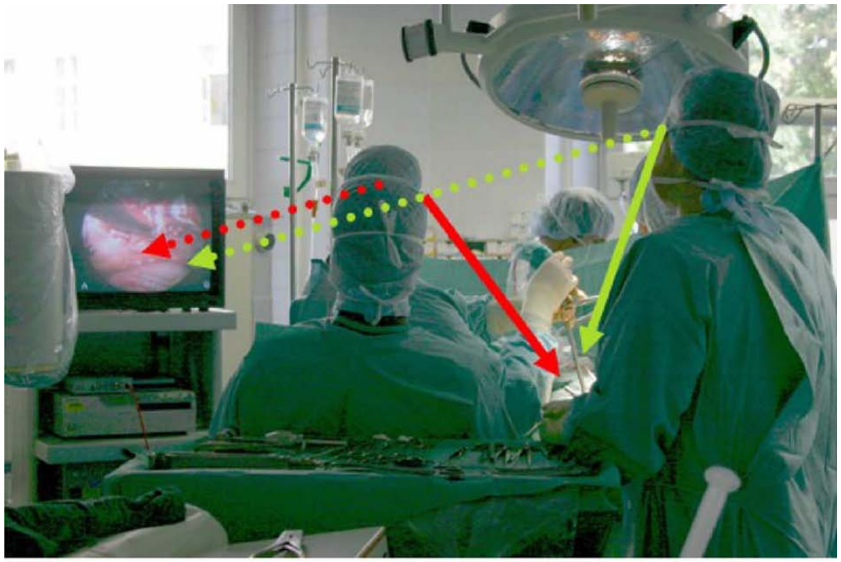
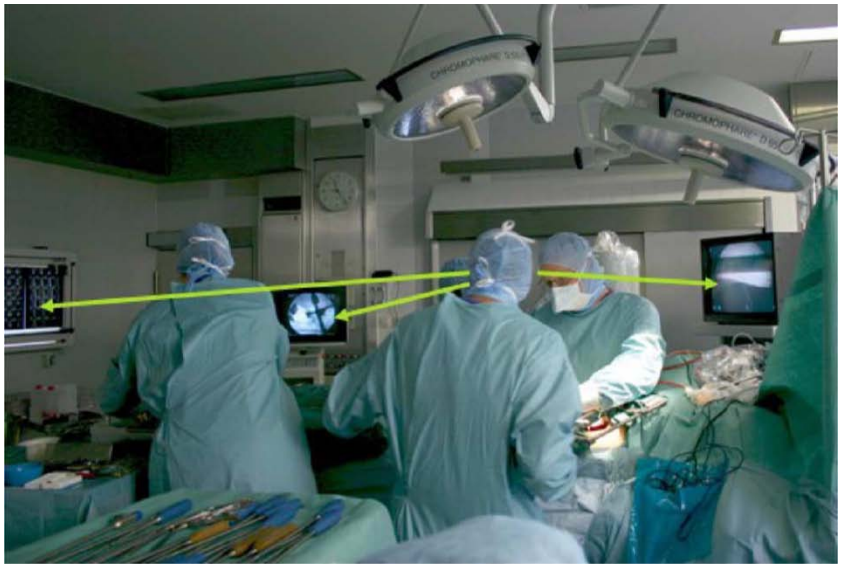
Tutorial Syllabus

Surface Visualization - Marching Cubes and its improvements - Smoothing of surface visualizations	(30 min.)
Direct Volume Visualization - Ray casting and texture-based approaches - Projection methods	(30 min.)
3D Vessel Visualization	(30 min.)
Virtual Endoscopy	(30 min.)
Augmented Reality and Intraoperative Visualization	(20 min.)
Medical Training and Surgical Planning	(20 min.)

Augmented Reality and Intraoperative Visualization





Sielhorst 2008

- Augmented Reality:
  - Overlay of real data („patient“) and virtual data (geometric patient model)
  - AR in Intraoperative Visualization:
    - **Live-data (Op-Video) combined with pre-op. Patient model**

- Prerequisites:
  - Appropriate dataset (not too old)
  - Preprocessing (Segmentation, …)
  - Registration (Mapping: Pre-Op – Intra-Op.)
  - Tracking of surgical instruments
  - Update during surgery
  - Appropriate output devices

- Brain shift and tissue deformation:
  - Due to influence of surgical instruments and forces exercted on the tissue deformations occur
  - Brain shift: Movement of (parts of the brain) after the skull is opened
  - Initial registration is still valid in some portions of the brain.

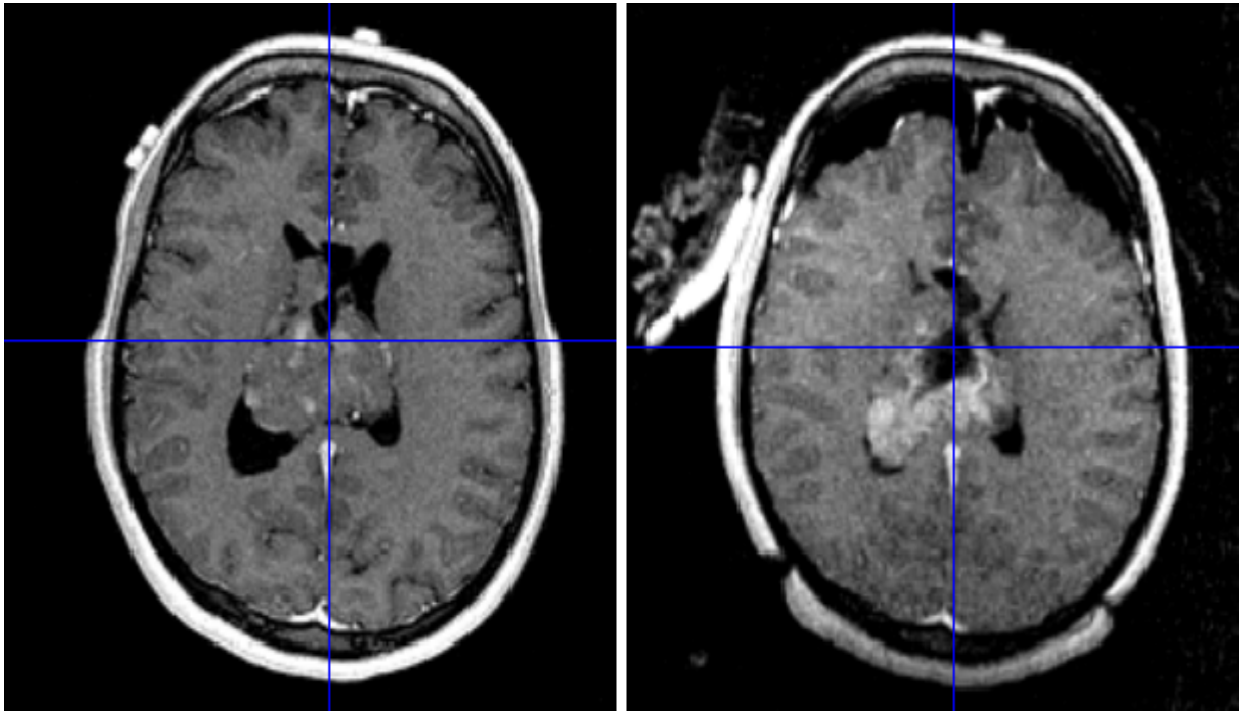


Image Courtesy Peter Hastreiter, Univ. Erlangen

- Registration:
  - Mapping of patient data to intraoperative position/orientation
  - Optimization process guided by landmarks
    - **Anatomic landmarks (difficult to locate them reliably and precisely)**
    - **Fiducial markers attached to the patient at known positions**
    - **Point cloud of the skin derived with a laser pointer**
  - Fiducial markers enable highest accuracy
  - Point cloud sufficiently precise for a variety of interventions

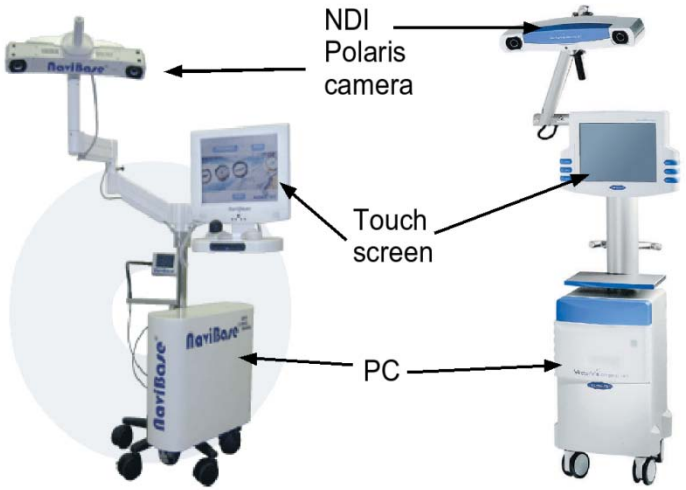


Image Courtesy NDI

- ICP-based registration of a point cloud

Image Courtesy Jürgen Hoffmann, Univ. Tübingen

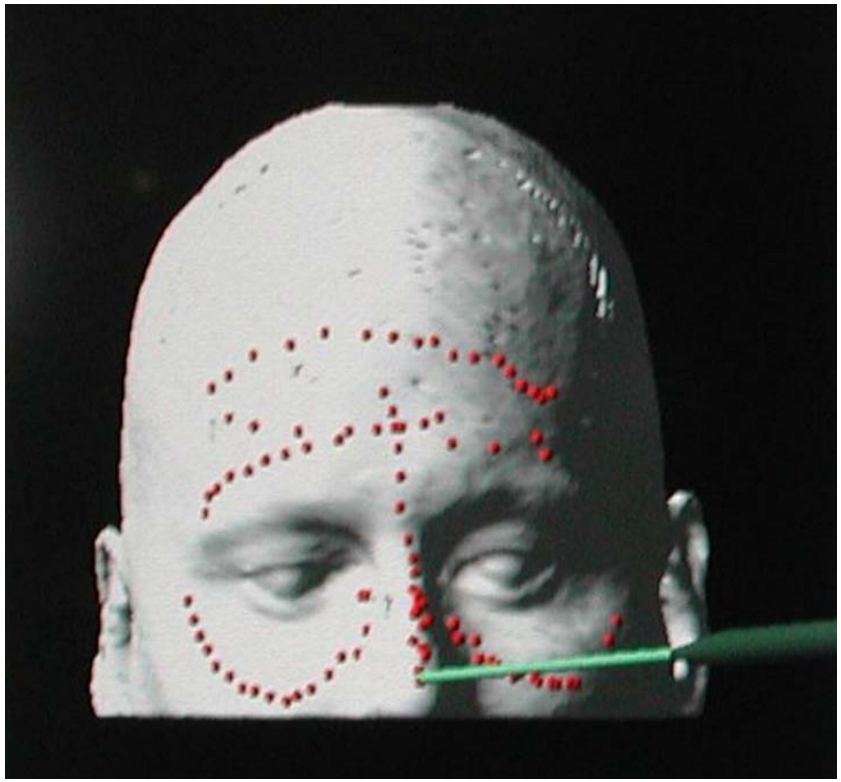
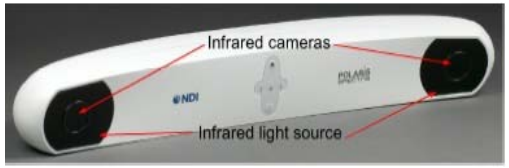


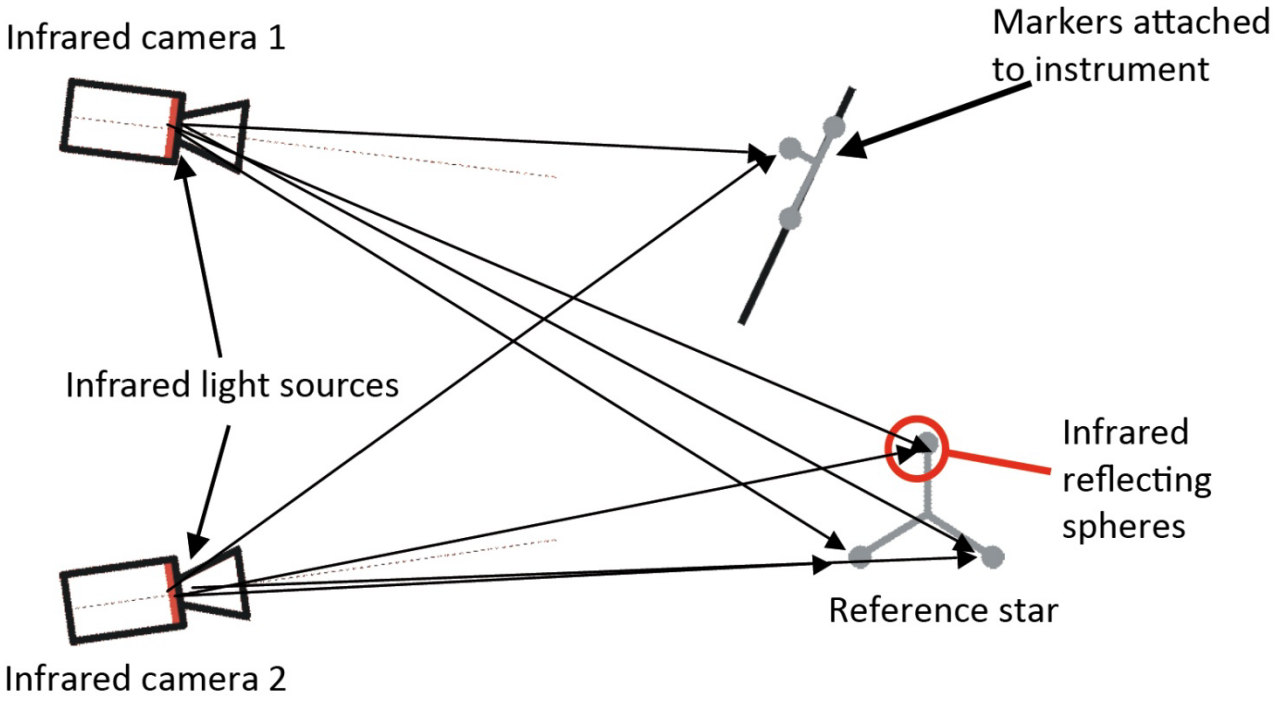
Image Courtesy BrainLab AG Feldkirchen

- Optical tracking (e.g., infrared)
  - Instruments attached with reflective spheres
  - Instruments are seen by two cameras.
  - Requires direct line of sight



Optical tracking with the Polaris Spectra

Image Courtesy NDI



- Tracked pointer tool to identify fiducial positions. A reference star is connected to the forehead.

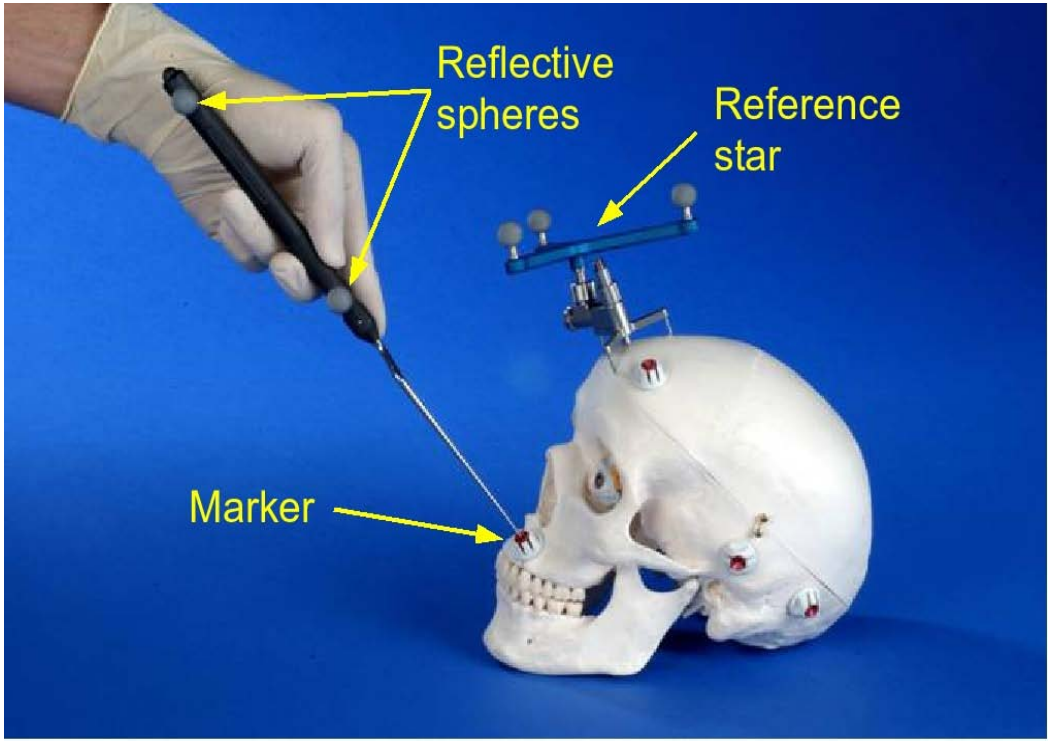


Image Courtesy Jürgen Hoffmann, Univ. Tübingen

- Electromagnetic tracking
  - No direct line of sight required
  - Lower accuracy compared to optical tracking
  - Magnetic field must not be disturbed
  - Small tracking volume

Electromagnetic Tracking with NDI Aurora,

Image Courtesy NDI

- Videotracking
  - Low accuracy
  - Requires direct line of sight
  - Simple Setup

Courtesy of Zein Salah, Univ. Magdeburg

- Intraoperative visualization options:
  - Projection on a special fixed monitor
  - Projection on a small flexible, tracked display in the surgeons hand
  - Included in the endoscope view
  - Projection directly onto the patient

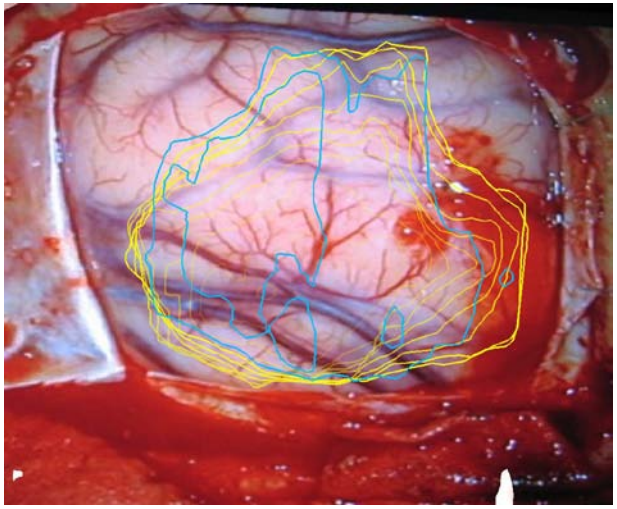
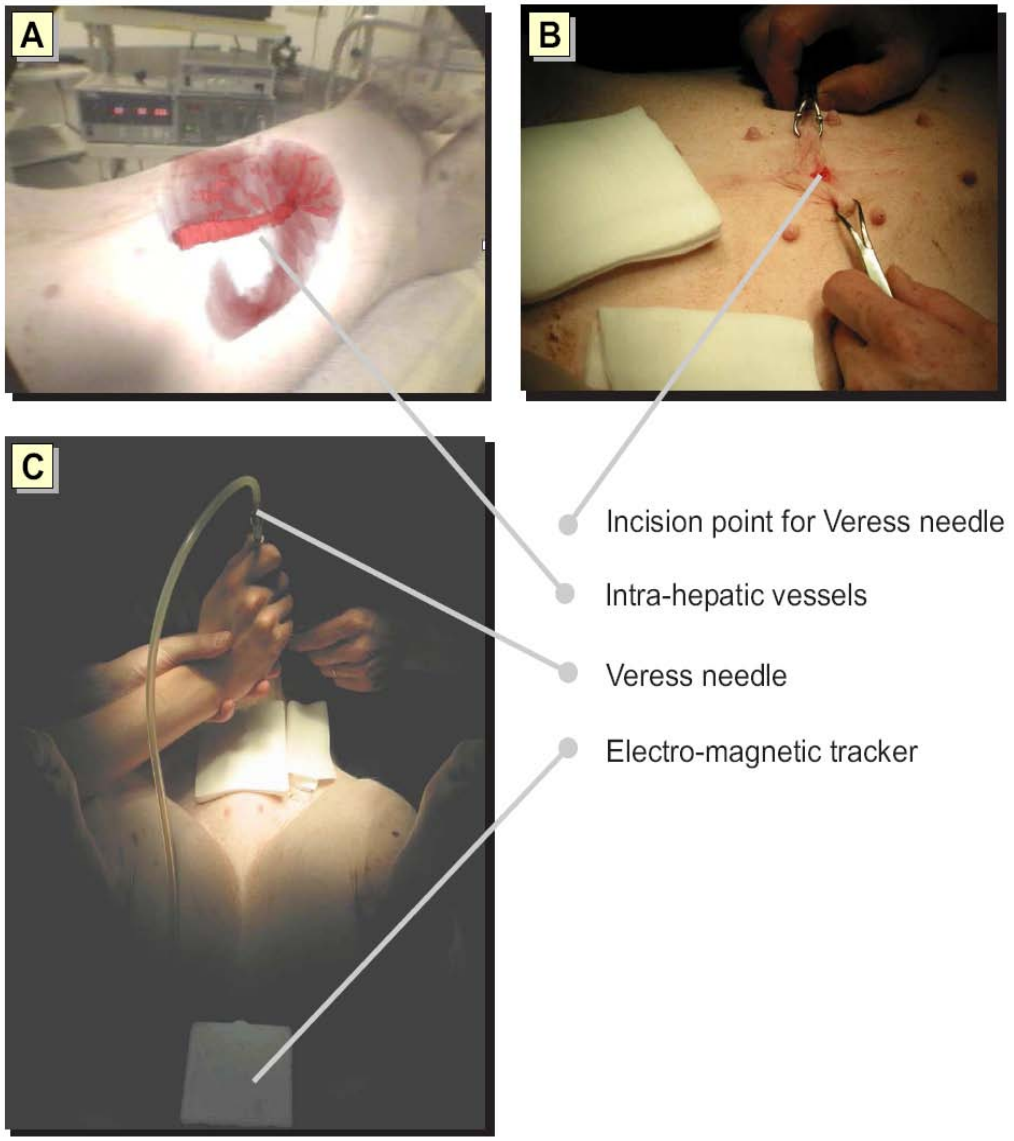


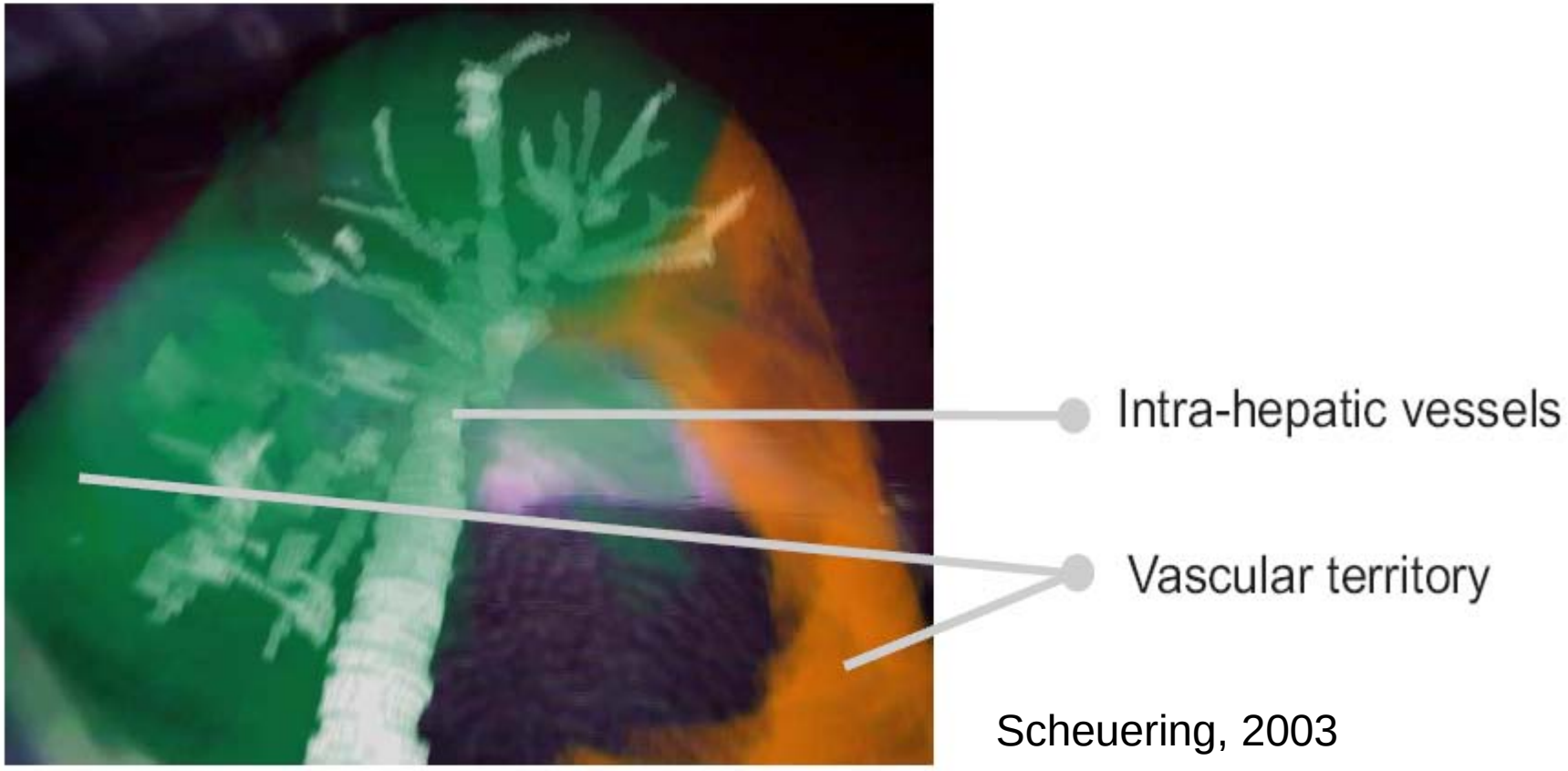
Image Courtesy Zein Salah
Univ. Magdeburg

Schwald 2002

- Augmented Reality in Liver Surgery
- Animal Experiment (Scheuering, 2003)



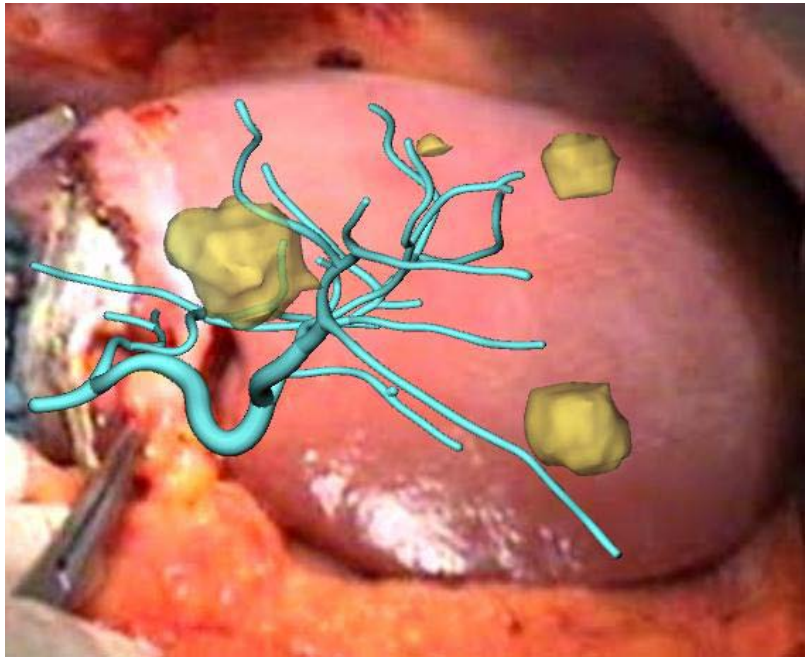
- Video overlay of a laparoscopic liver image with 3D renderings from pre-planning.

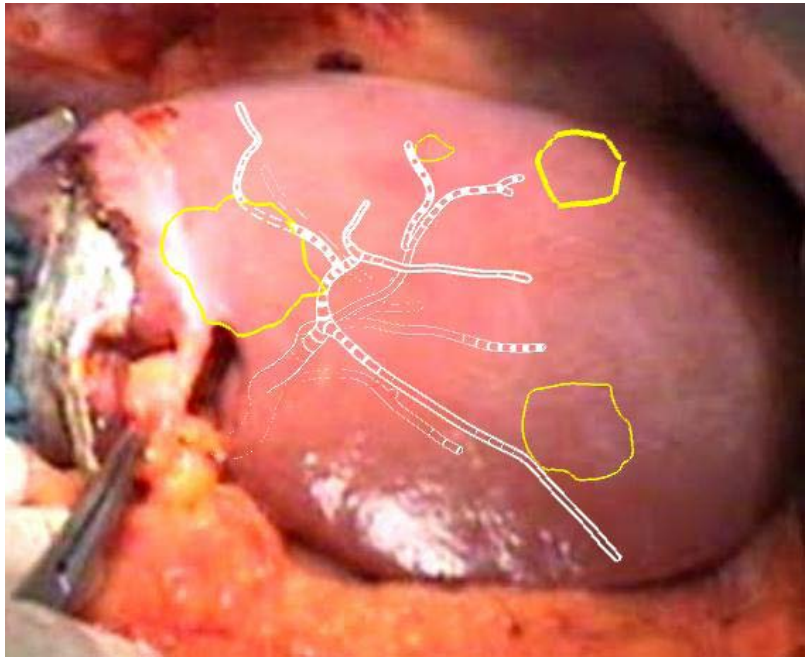


Scheuering, 2003

- Superimposed on video stream
  - may occlude video information

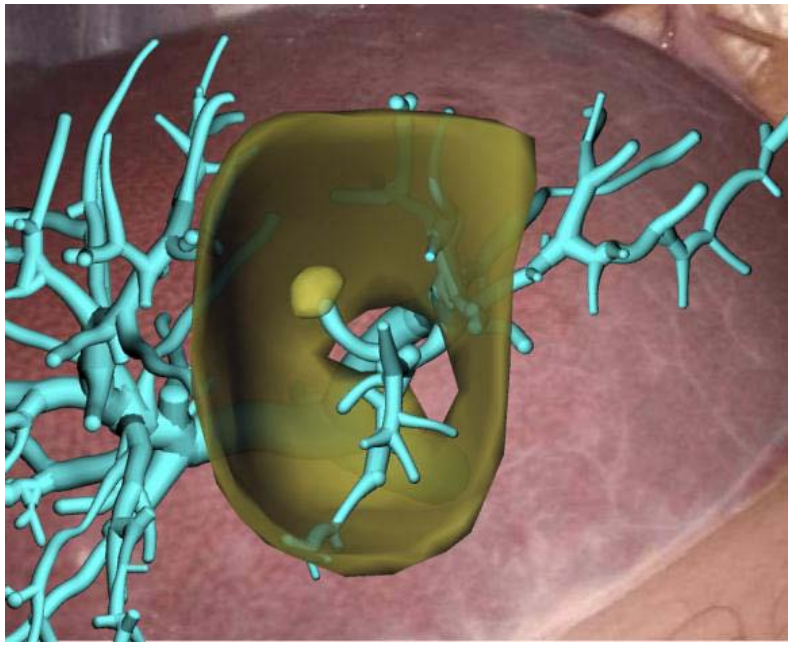
- Example: open liver surgery

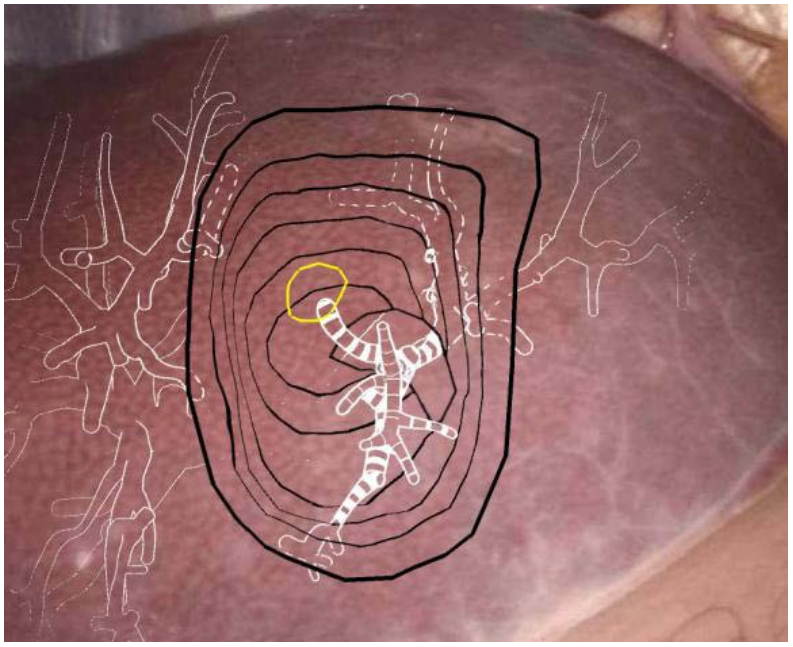




Hansen 2010

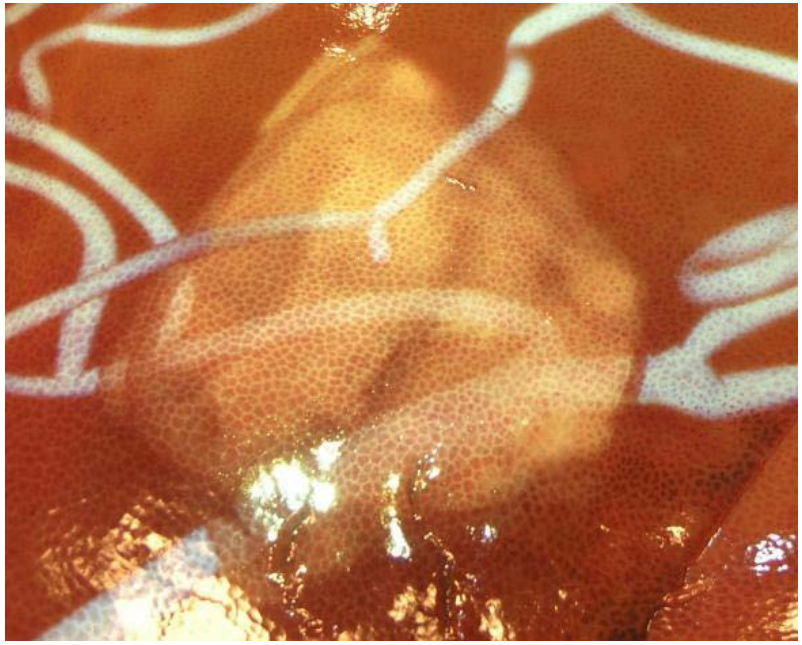
- Superimposed on laparoscopic view/camera
  - may occlude video information

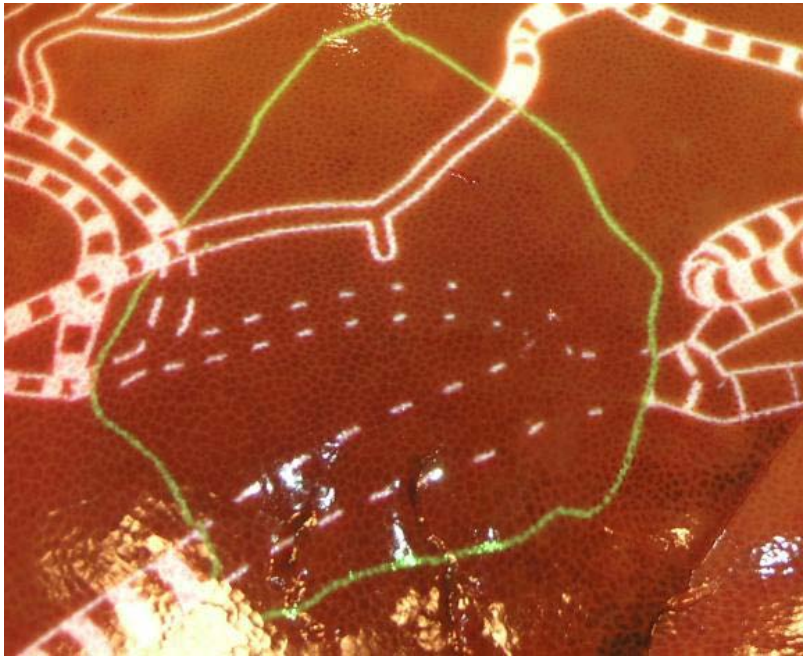




Hansen 2010

- Projector-based AR
  - Insufficient visual contrast
  - Loss of spatial information
  - AR-information may get occluded by objects between projector and projection area



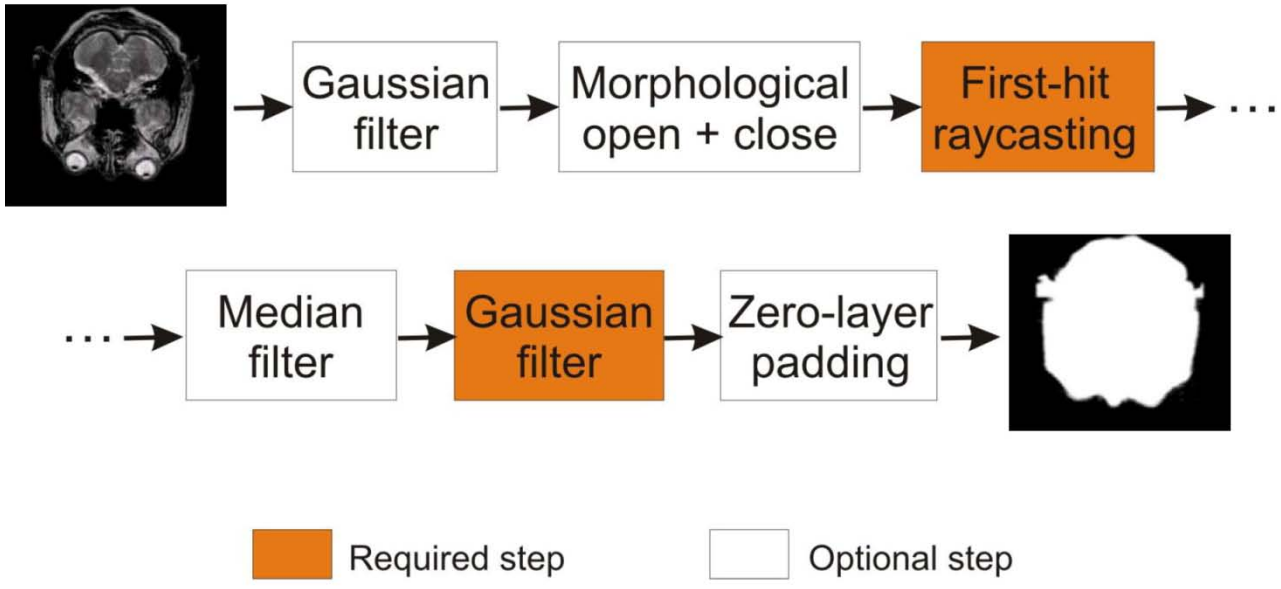


Hansen 2010

- Problem: Handling of depth (2d-video and 3d-VR)
  - Virtual objects occlude real objects
  - No correct depth perception
  - Virtual objects behind real objects…
    - **Draw them differently**
    - **Occlude them correctly**

Fischer, 2004

- Reconstruction of 3d depth information
  - Use the pre-operative dataset
  - Extract the geometry
    - **Simplification of the data might be necessary**
      - **Removal of invisible inner surfaces**
      - **Compute binary visual hull volume**
  - Render the data to the depth buffer



Fischer, 2004

Fischer, 2004

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