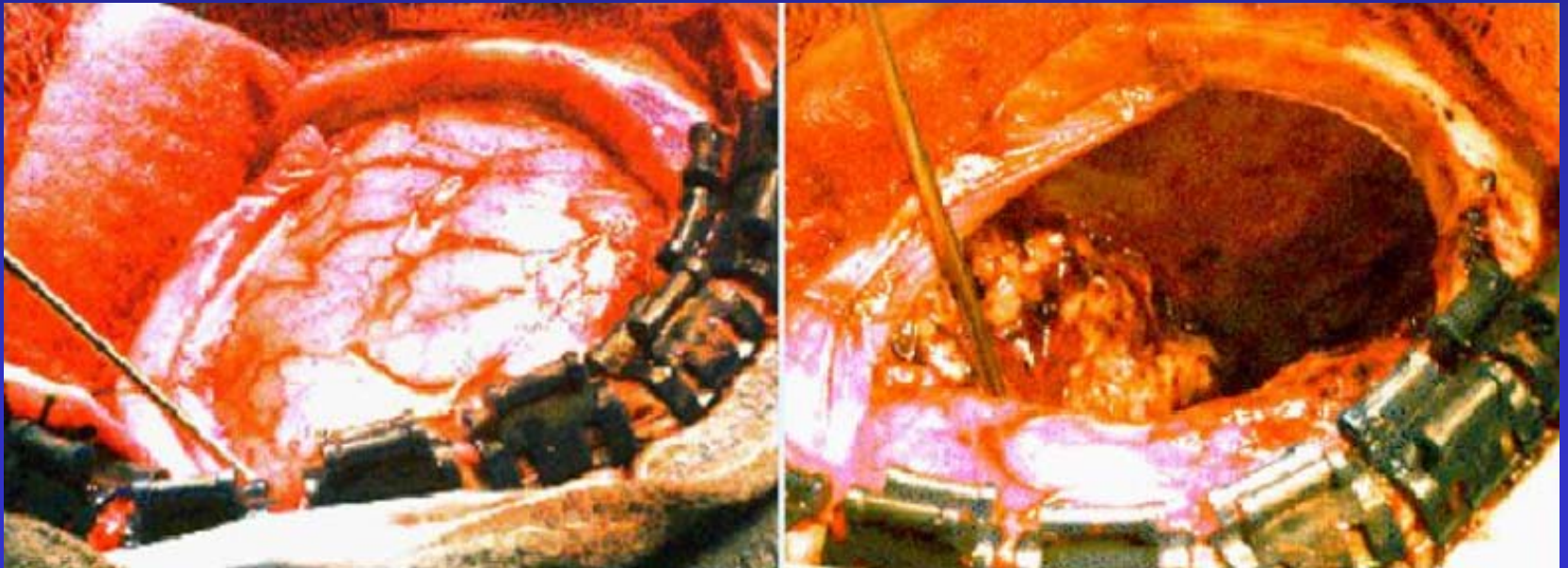# IMAGE-GUIDED SURGERY (IGS)

CongCong Yu

Yu Ning

What is Image-Guided Surgery

- Surgical procedures that combine imaging instruments in real time such as computed tomography (CT scans), magnetic resonance imaging (MRIs) and light emitting diode cameras (LEDs)
- Allow surgeons to navigate their way through body with the help of three-dimensional images.
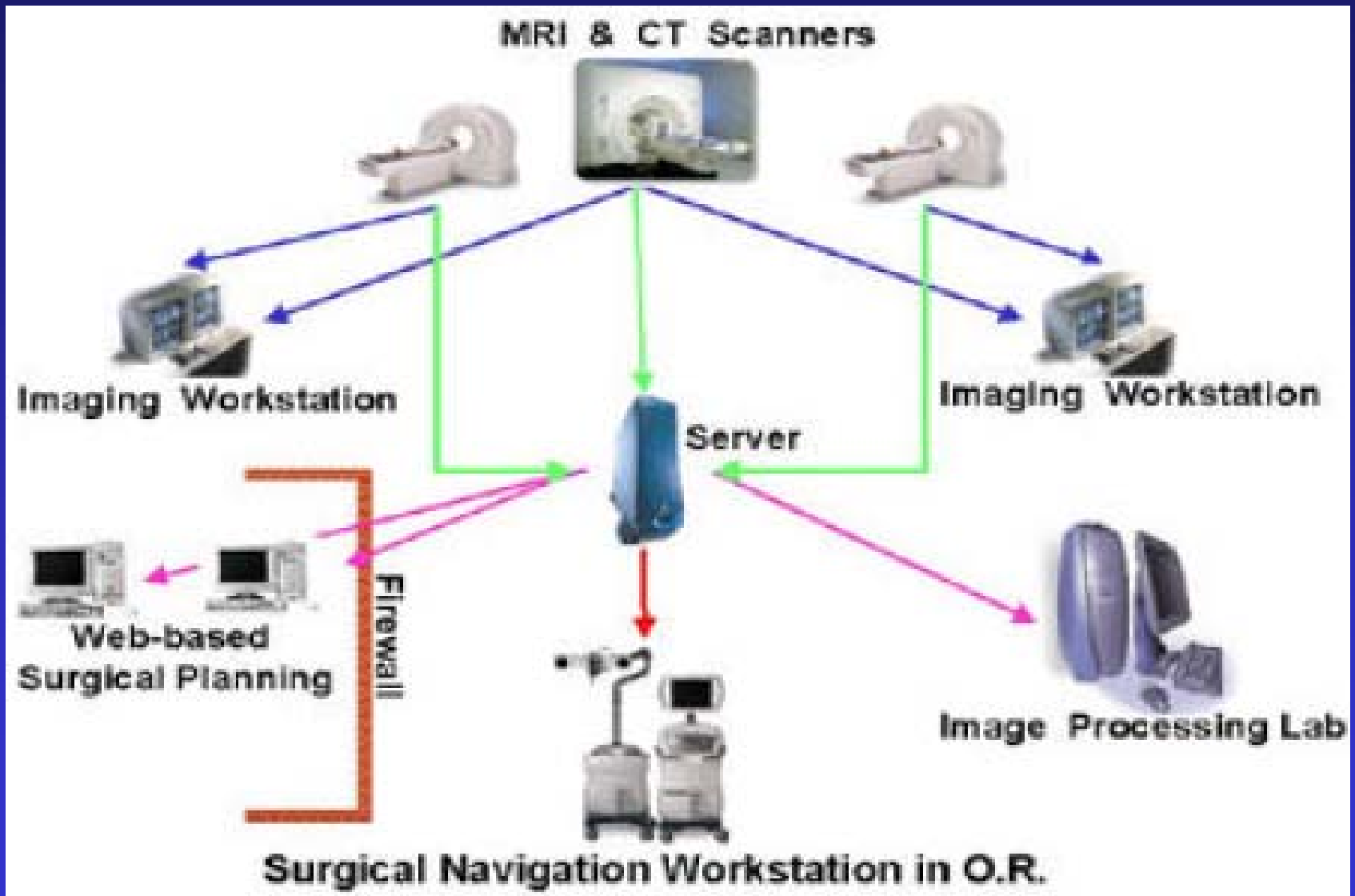
Conventional Surgery

See the surface

IMAGE-GUIDED SURGERY

See under the surface

IGS NETWORK

MRI & CT Scanners

Imaging Workstation

Imaging Workstation

Server

Web-based Surgical Planning

Firewall

Image Processing Lab
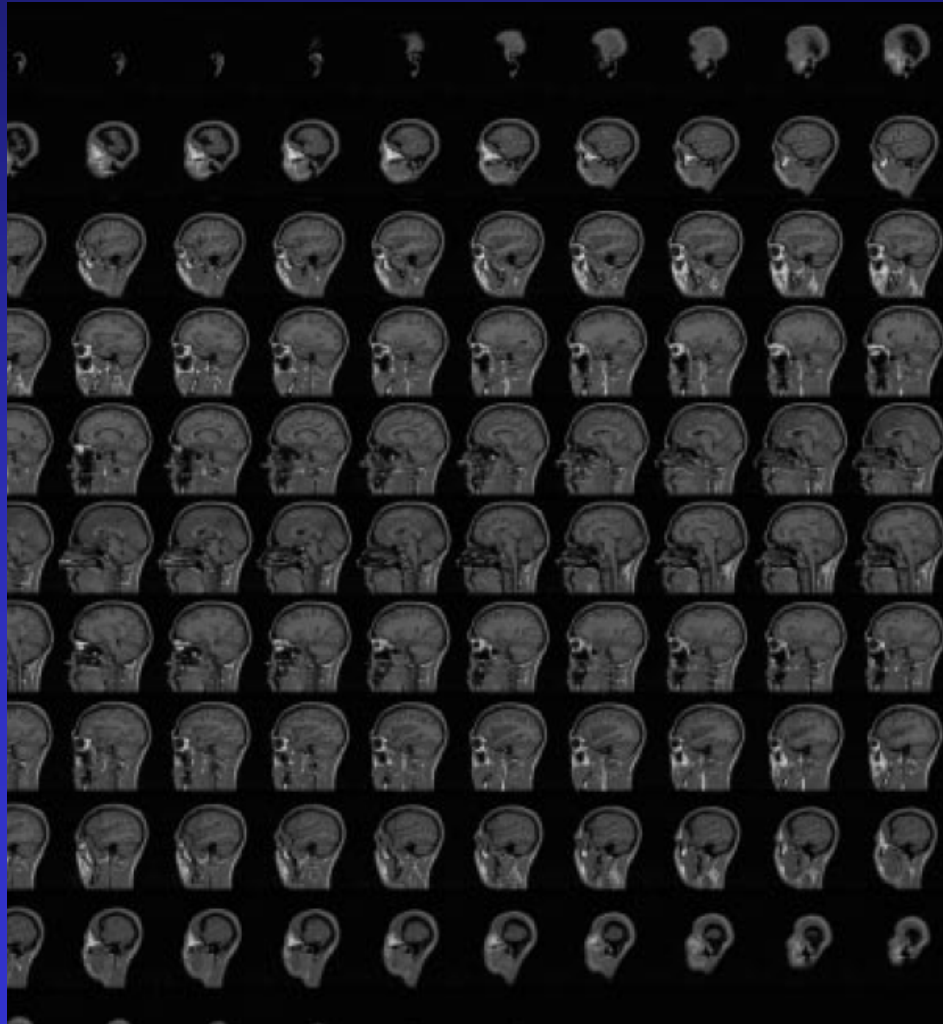
Surgical Navigation Workstation in O.R.
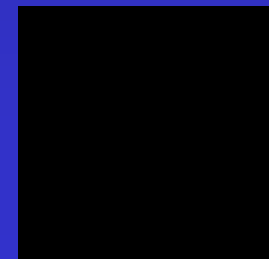
Flowchart for IGS
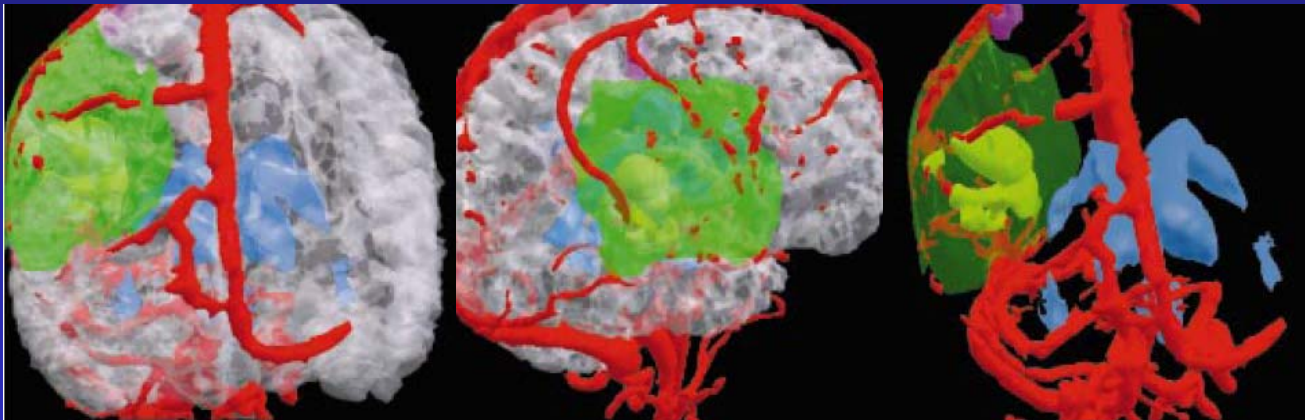
Pre-operative image construction

1. Internal scan from MRI and CT to obtain anatomical structure

   Combine serial MRI scans to create the 3 dimensional volume

Pre-operative image construction

2. Perform segmentation (label individual voxels in the volumetric scan by tissue type)
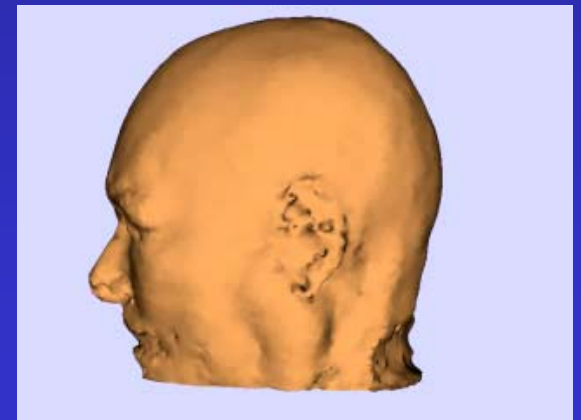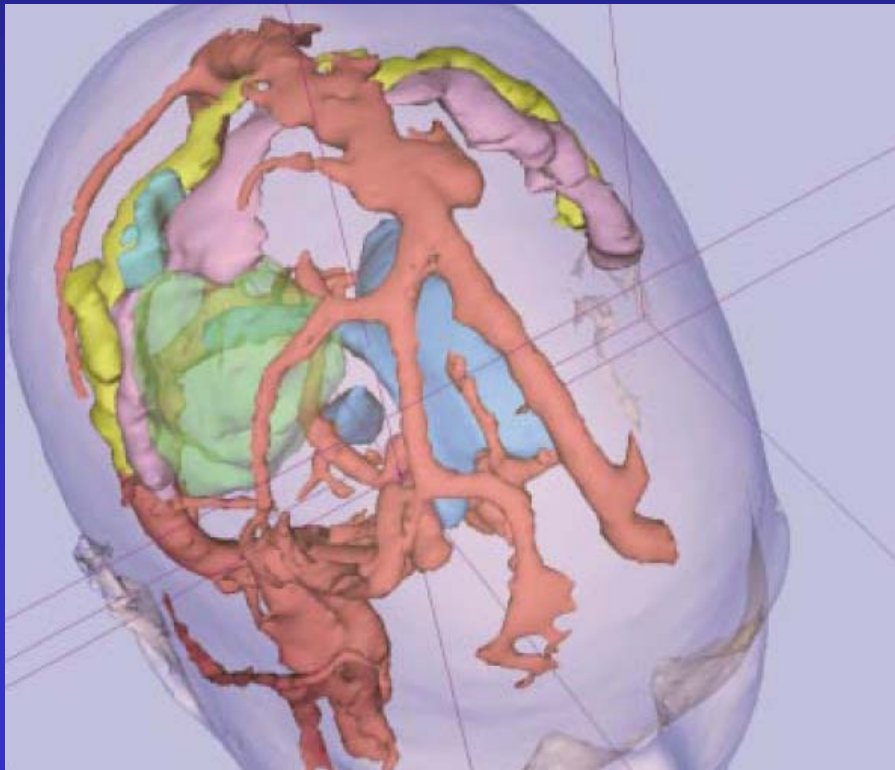

Different tissues emit different amounts of energy in response to MIR pulse and recorded as different brightness in MRI scan

Pre-operative image construction

3. Construct 3D surface from the segmented MRI structures using surface rendering techniques

Setup in operating room

Articulated Arm

Laser-Calibrated Video Camera

Sun UltraSPARC Workstation

Flashpoint Controller

Laser Scanner Hardware

Laser on a Stepper Motor

Flashpoint Bar

Author

What is image registration

- Establish spatial relationship thus allowing 3D locations within pre-operative data to be unambiguously associated with the corresponding anatomical location on the actual patient in the operating room, and vice-versa

- Relate the measurement made in one coordinate system to those of another

Instruments calibration
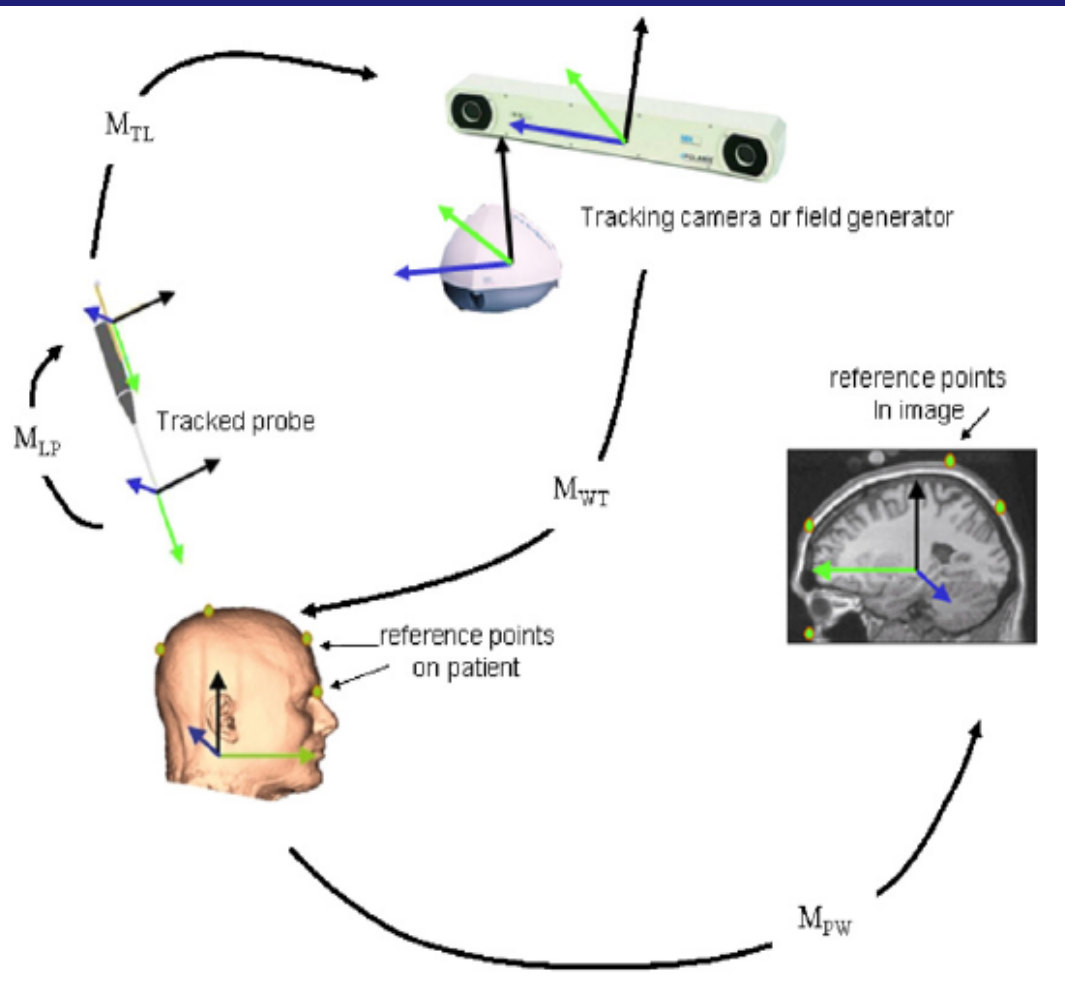
- Spatial transformation among tracking device, patient position and the image on the screen
- Enable image to show the patient from the surgeon's vantage

Early approach : fiducial marker-based registration
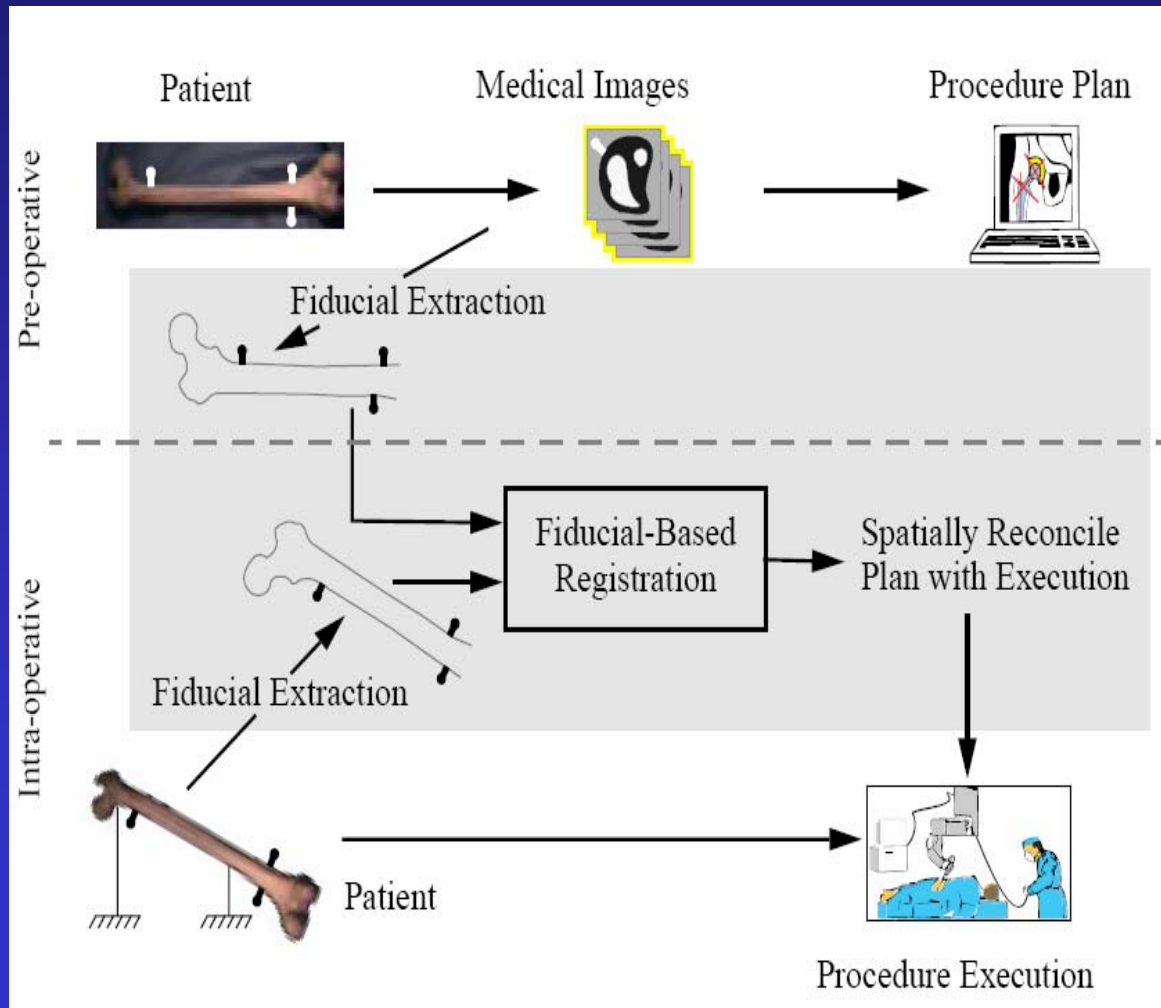
- Intra-operatively, fiducial makers are physically exposed and tracked by intra-operative sensing device
- Given the 2 sets of the corresponding fiducial makers locations, spatial transformation is performed

13

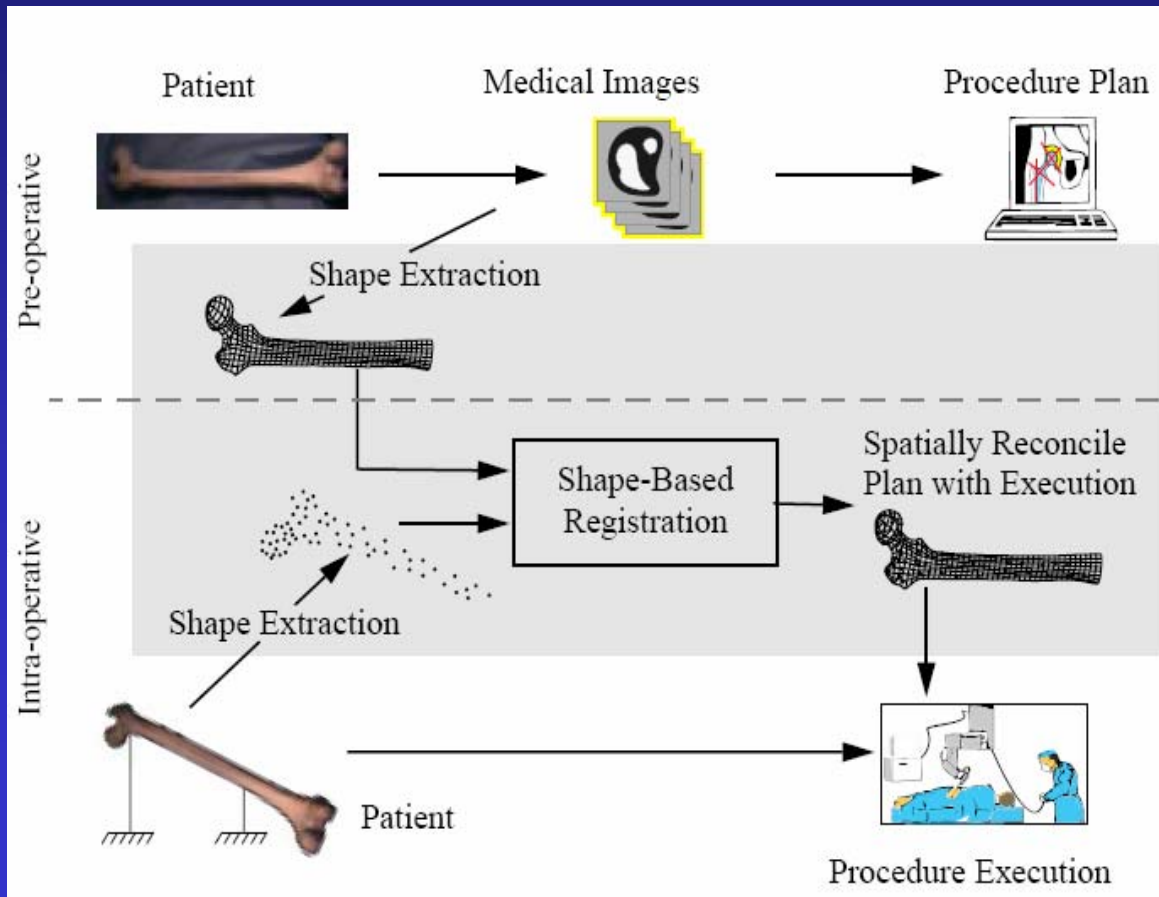# Pros and cons of fiducial marker-based registration
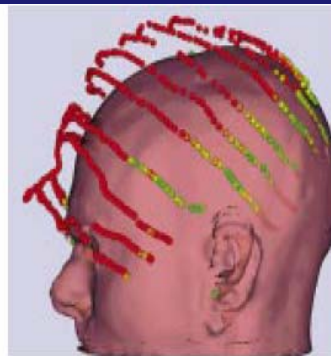
Pros:

- Simple

Cons:

- Inconvenient, patients keep them attached between imaging and surgery
- Poor accuracy due to marker shifting
- Invasive if drill into the skull

New approach: shape-based registration

- No fiducial markers needed
- Intra-operative shape extraction using laser scanning

# Intra-operative laser scanning and registration
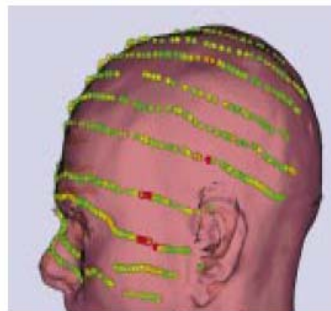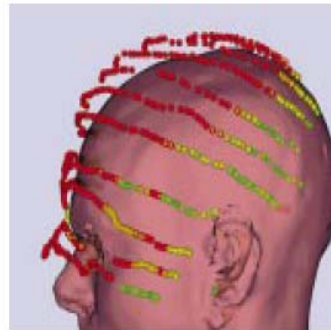
- With the laser 'cast' stored in the computer we rotate the virtual head till the face matches the contours of the laser lines

Optical tracking system

- Instrument must be tracked and related to the patient image
- Accounts for motion of patient relative to camera system
- Use mounted flashing infrared LEDS
- Permits real time, dynamically referenced location of patient anatomy and surgical instrumentation
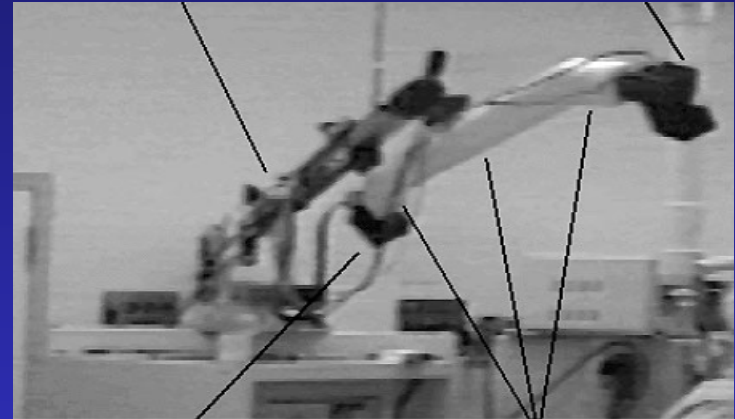
Optical tracking system
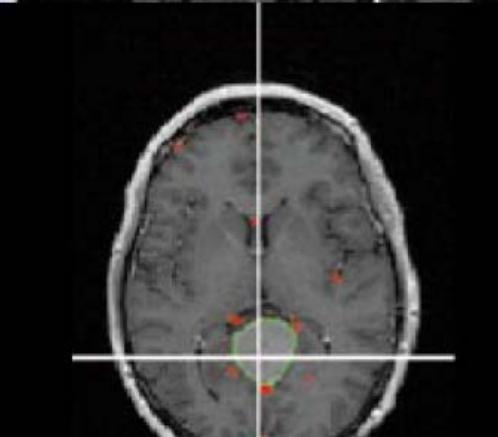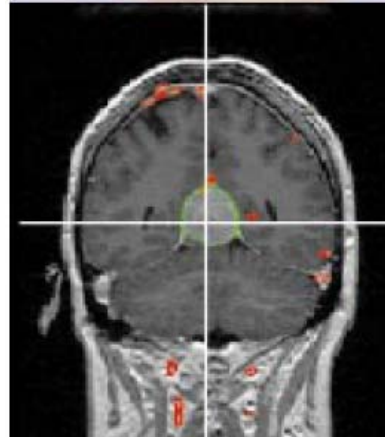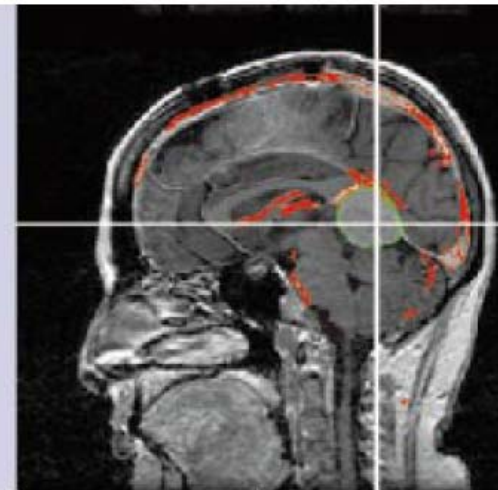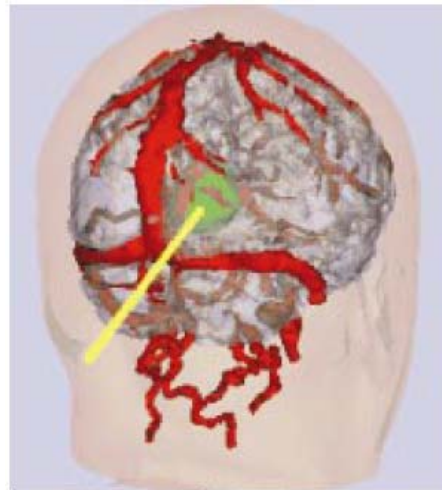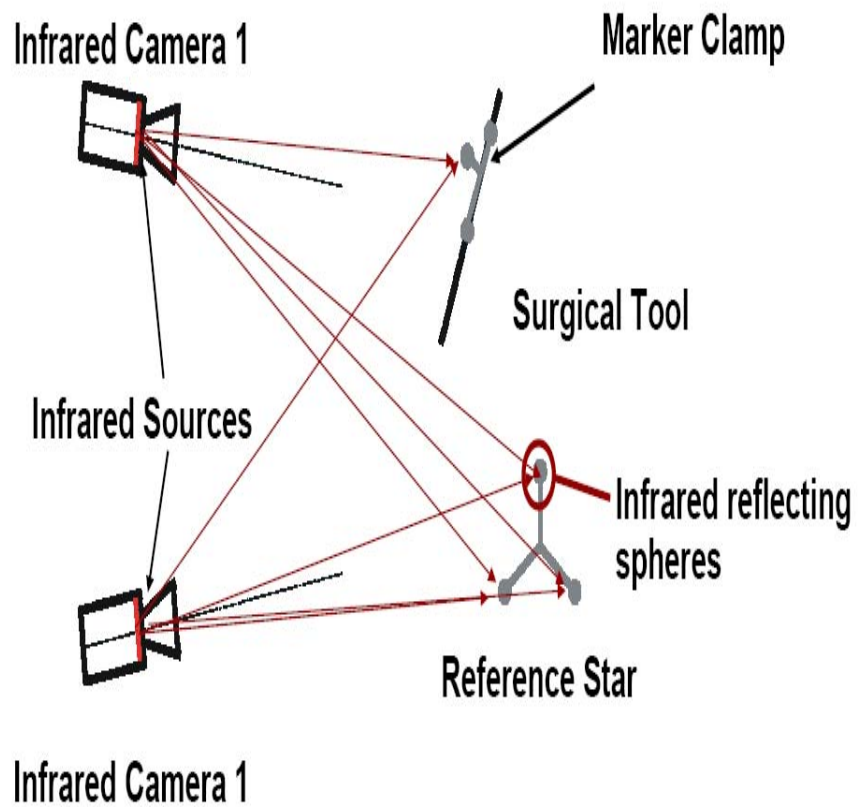
Surgical navigation

- Display method:

- Standard display plus video camera
- Head-mounted display

Standard display on monitor

- Enhanced reality virtualization of internal structures blended with a video image
- The live video image is to set up to duplicate the surgeon's point of view

Drawbacks of display on monitor

- Doesn't appear directly in the environment of the patient
- Surgeon must look at the computer monitor while planning the approach
- Very sensitive to parallax

Head-mounted display
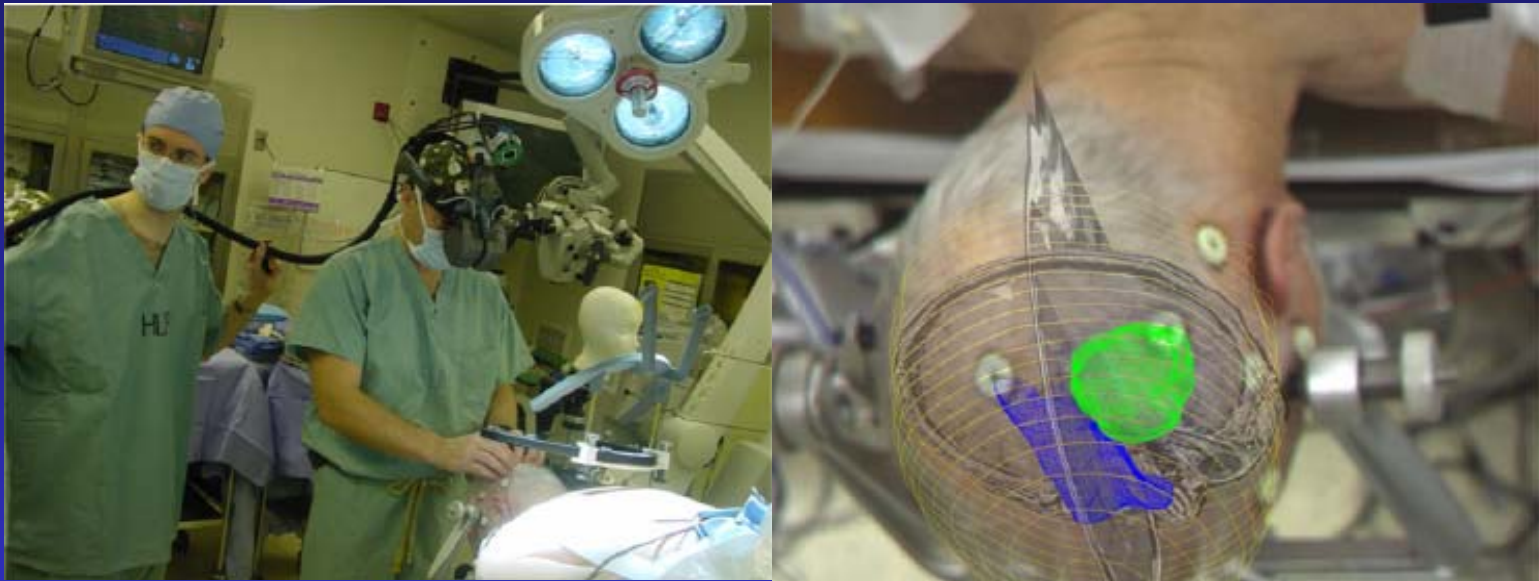
- With the virtual image projected on to the patient
- Surgeon doesn't need to look at the monitor to experience the virtualization

Drawbacks of Head-mounted display

- The head of the surgeon needs to be tracked and the virtual image on the display can be updated to eliminate the parallax

- Too cumbersome and bulky for surgery

Issue deformation

- IGS typically depends on pre-operative data acquisition
- Depending on target area, significant deformations may take place(e.g. brainshift)
- Data is not up-to-date, or intra-operative imaging is required

Example for Brainshift

- **Drilled hole** in skull: significant deformations

- **Ventricular system**: negligible deformations
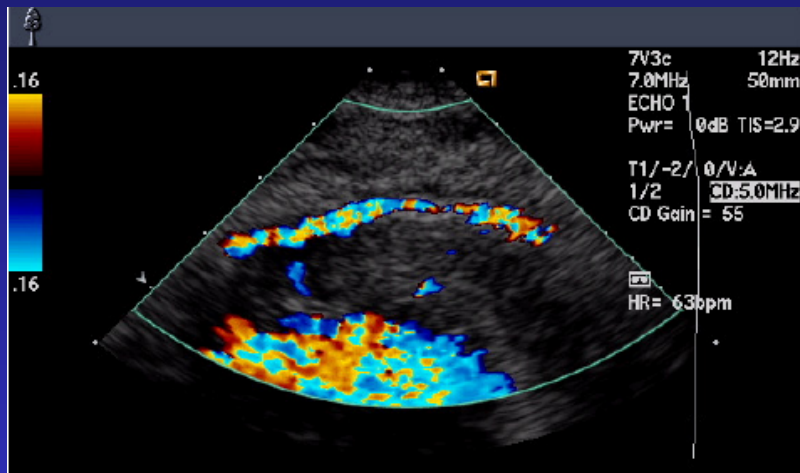
- After **ventriculostomy**: (still minor) deformations
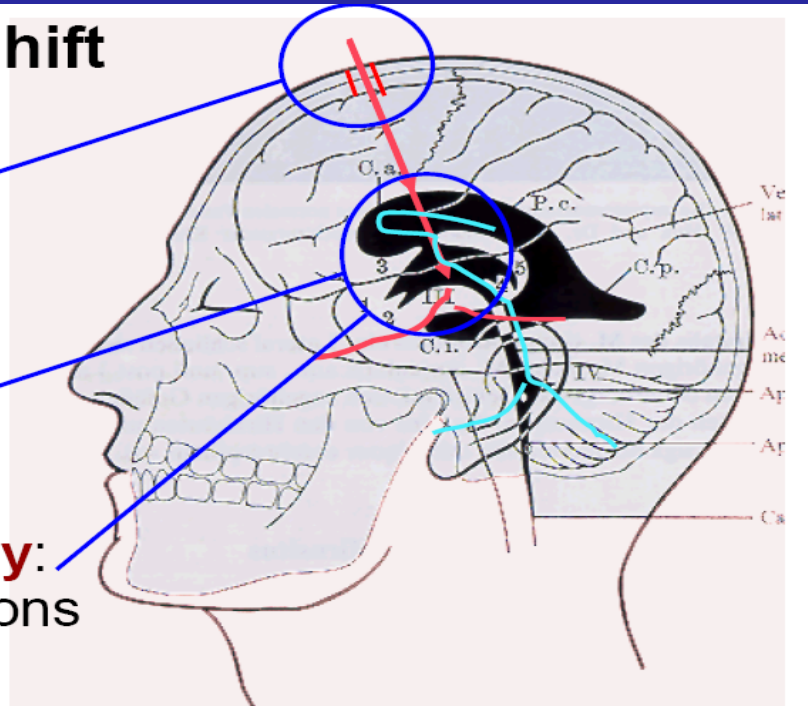
Intra-operative imaging Open MRI approach

Drawbacks:

- Limited access
- Low field scanner limited image quality
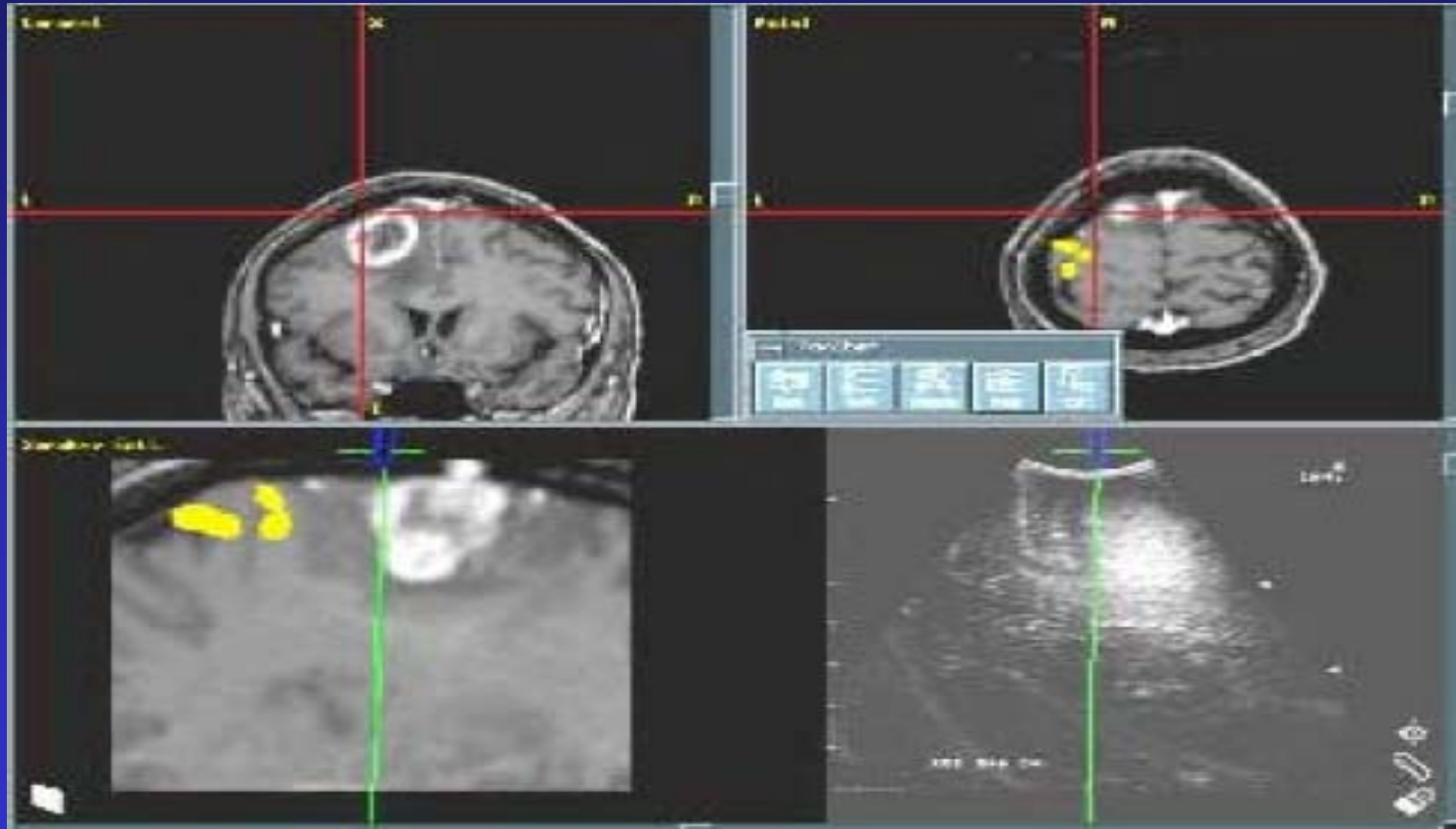- Require MRI suitable instruments and OR

Intra-operative imaging Ultrasound approach

- Emits sound waves and record echo
- Very noisy
- Low virtualization

Intra-operative imaging
Co-register approach

Ultrasound (low right) acquired during surgery co-registered with MRI (low left) to update the tumor position and surrounding anatomy
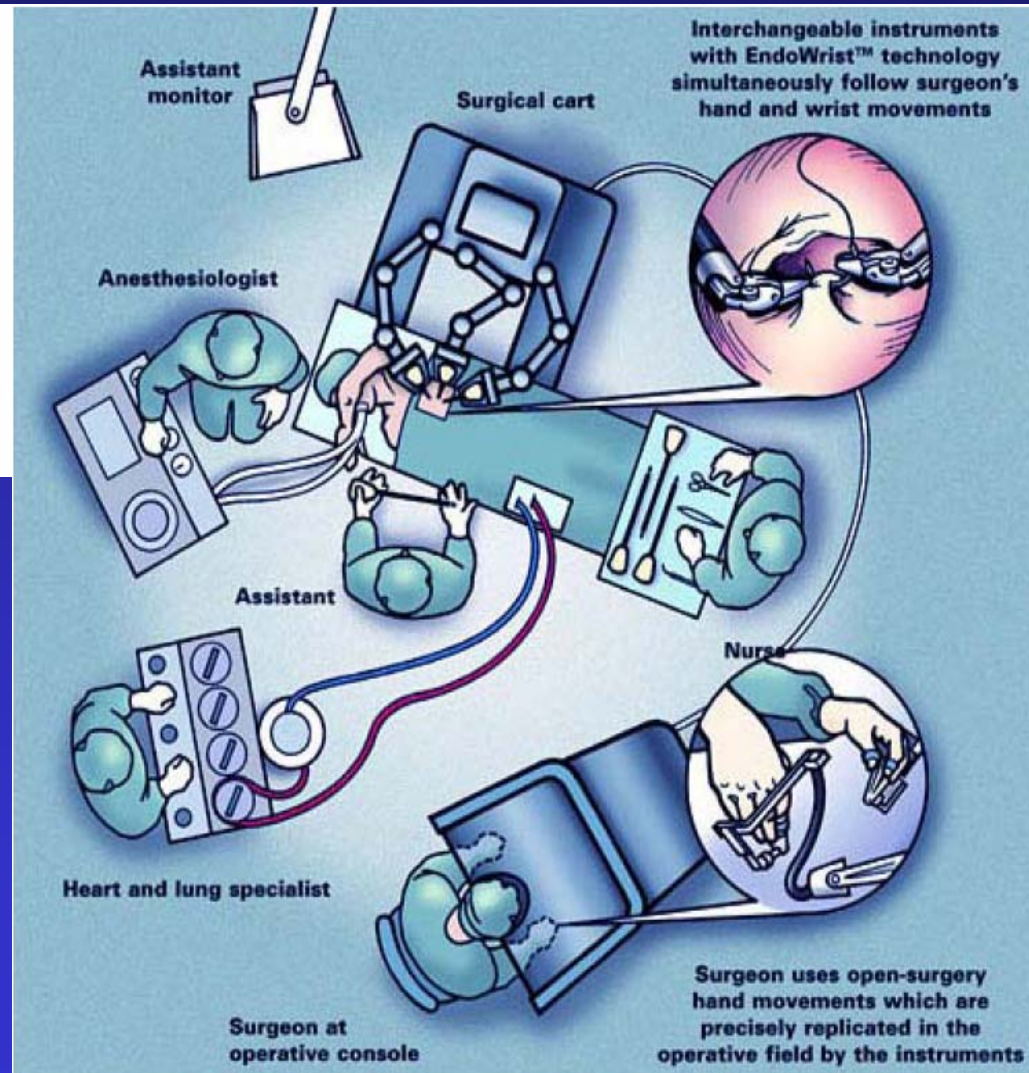
IGS application

- Orthopaedics
- Neurosurgery
- Spine surgery
- Cranio-facial surgery

Future: image-guided robotic surgery

- High precision
- No fatigue
- Increased dexterity
- Need intuitive surgeon-machine interface

Summary

- IGS uses tracking and registration to match patient dataset to patient on OR table
- Minimum invasive surgery
- The IGS system must not add time and complication to the procedure
- User friendly system interface needed
- Next revolution: image-guided robotic surgery to enable the automation of surgical procedure

Thanks Everyone
Any Questions?

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