Augmented reality for CAMI

Principles and materials
Examples

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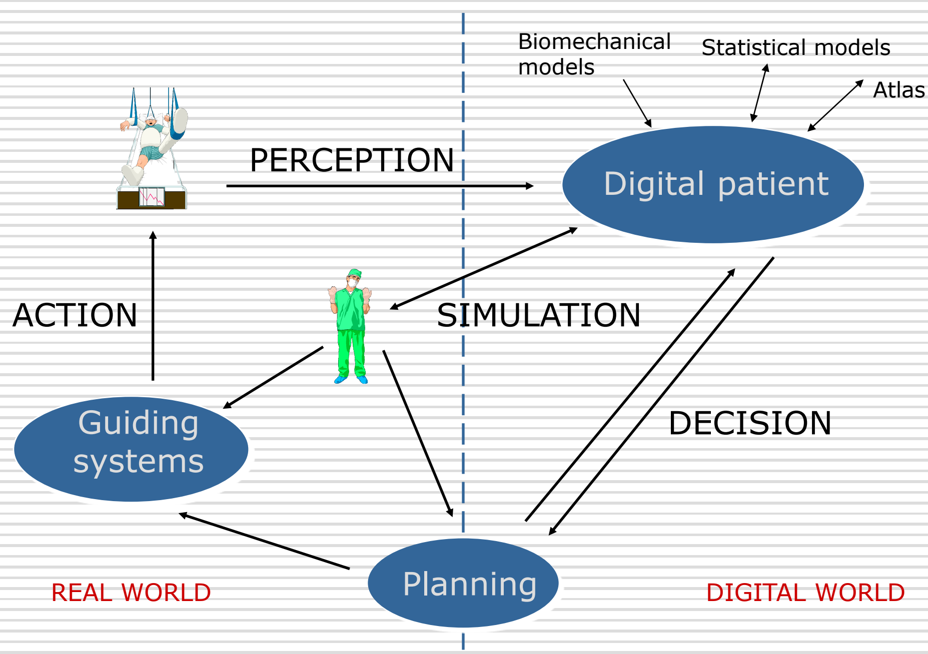
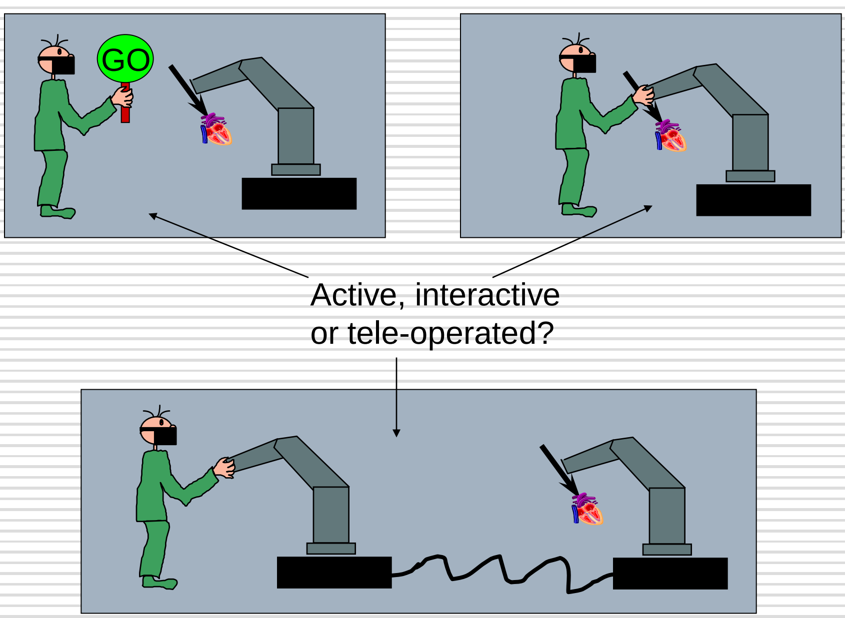


Computer-Assisted Medical Intervention

Guiding systems classification

- *Passive* systems
  - give information to the surgeon
- *Active* systems
  - realize the intervention with human supervision
- *Interactive* systems: mechanical guides
  - Semi-active devices
  - Co-manipulation devices
- *Teleoperated* devices



Passive systems: what do I do?

- Three components
  - a localization device
    - 3D localizer, surface sensor,
    - intra-operative imaging sensors (microscopy, endoscopy, interventional MR, etc.)
  - a registration component (optional)
  - a display (2D, 3D screen, 3D HMD, etc.)
- Well-suited to « simple » tasks
- Commercially available (neurosurgery, ortho [spine, knee, hip], ENT, etc.)





Medtronics, Aesculap,
Praxim, Traxtal,
Stryker,
Orthosoft, etc.

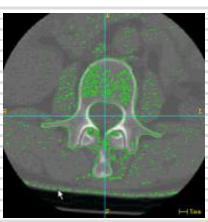


Navigation in the CT data

- Pre-operatively: CT data acquisition and surgical planning
- Intra-operatively: intra-operative data acquisition and registration, guidance
- Post-operatively: evaluation

- Most used type of system

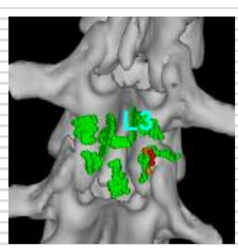
CT segmentation and planning

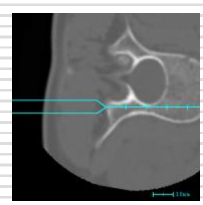


Data digitization

Reference rigid body

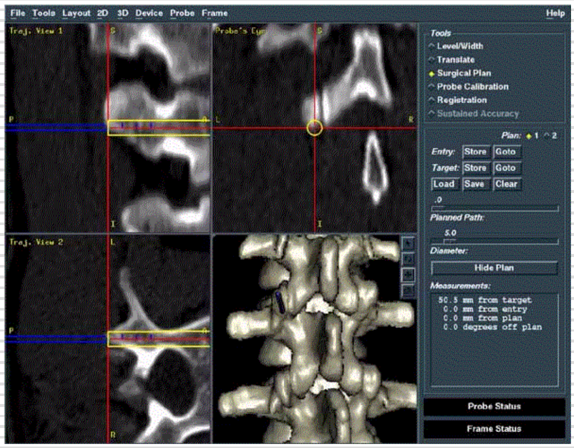
Registration





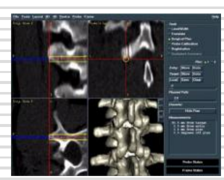
Guidance

Navigation system



Visualization in guiding systems

- Passive systems
  - Classically: a screen with localization information (GPS type)
  - Augmented reality systems: information merged to the reality
- Expected advantage of AR
  - Information easier to interpret
  - Located where the surgeon has to focus his/her attention



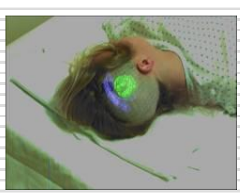
Technical possibilities

- Merging mode: optical / video (digital)
- Display: head-mounted display (HMD) / external screen / specific display (i.e. surgical microscope)
- Visualization: mono / stereo

Overlay
Video/Optical

Display
Screen/HMD

Univ. of Rochester



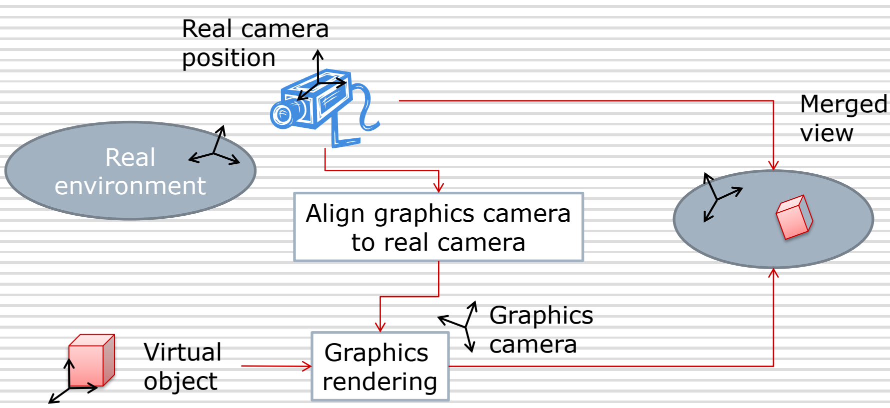
MIT – Harvard Med School

CMU – Shadyside Hospital

Image superimposition

- Requires to register the patient (reality) to the data (augmentation)
- Video overlay:
  - Capture the real environment
  - Compute the data in the right location
  - Merge reality and data images
  - Display
- Optical overlay:
  - Compute the data in the right location
  - Display
- Involves calibration

Example: video overlay

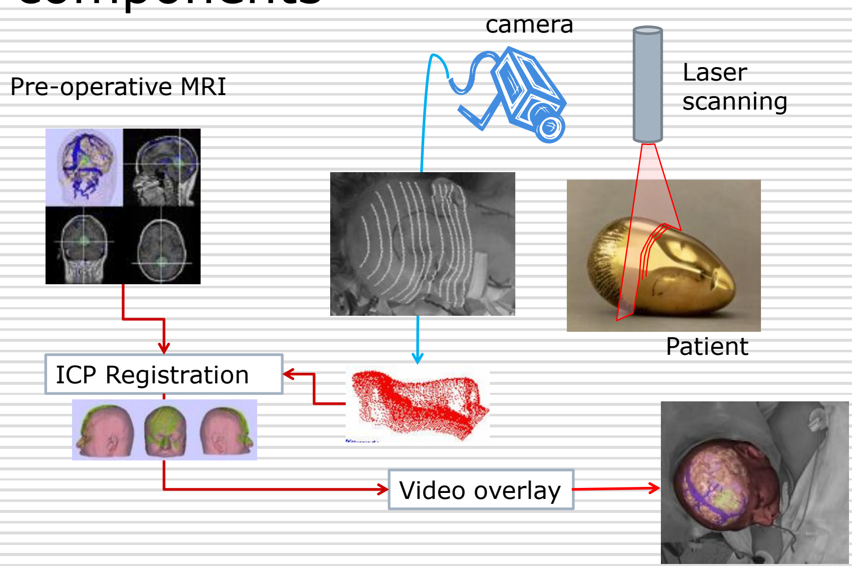


Example I (video/screen)

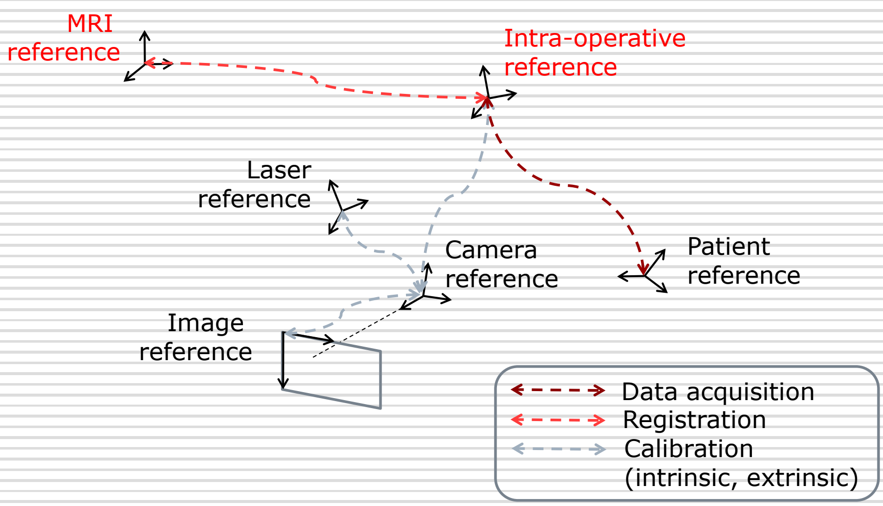
Harvard-MIT system [Grimson, Kikinis]

- Pre-operative MR imaging and 3D modeling
- Intra-operative surface acquisition and registration
- Video overlay on a screen

Example 2: Technical components



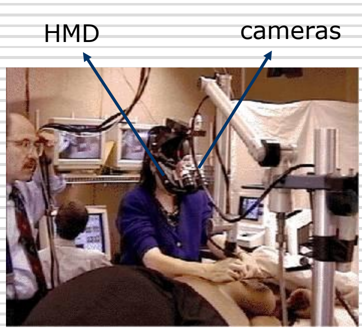
Reference frames to be linked

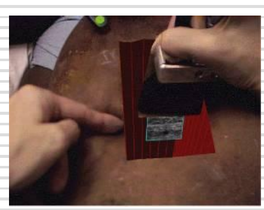


Example 2 (video/HMD)

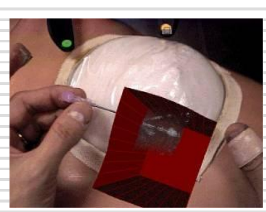
UNC – Fuchs and colleagues

- For ultrasound guided procedures





US acquisition and planning



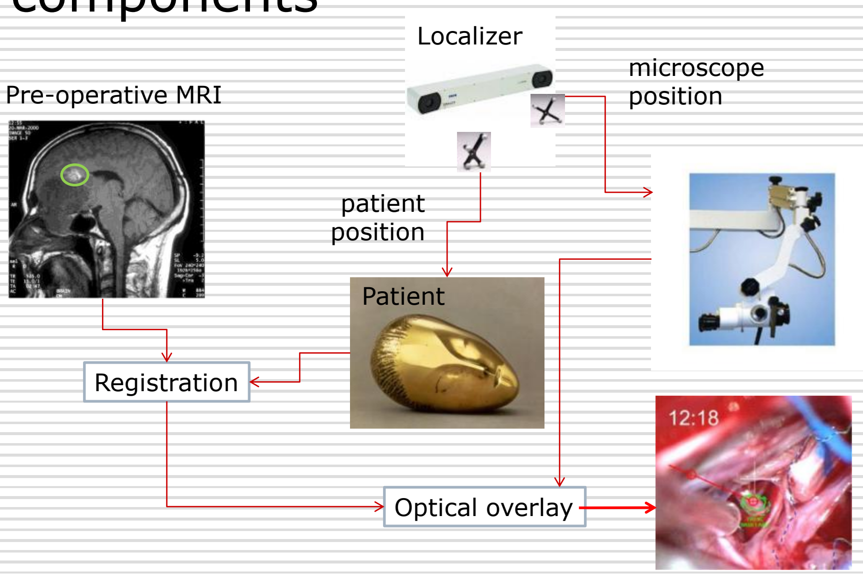
Video overlay in the HMD

Example 3 (optical/surgical microscope)

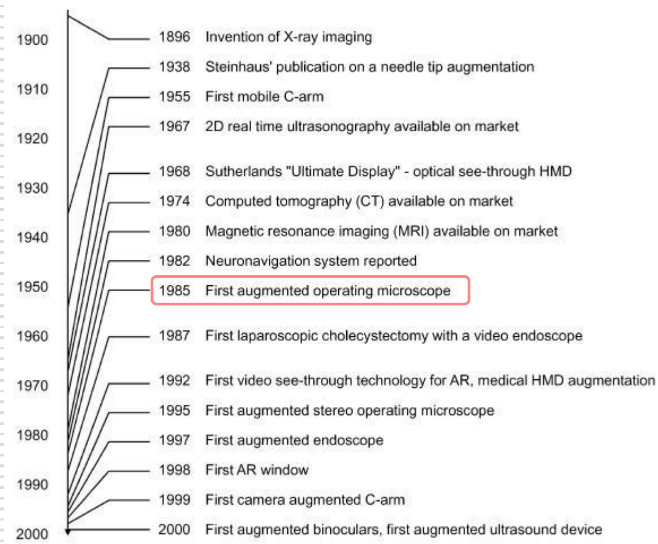
- Application in neurosurgery/ENT
- Add planning information in the images coming from the binocular
- Integrated into products
- Easy to use in clinical practice (natural evolution of existing device)
- Simple visualization

HMD version
[Birkelfelner et al.]

Example 3: Technical components

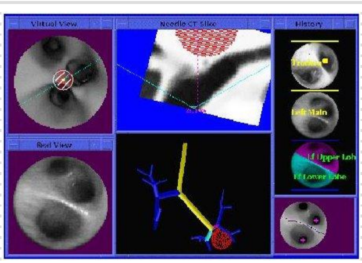


From Sielhorst et al. JOURNAL OF DISPLAY TECHNOLOGY, VOL. 4, NO. 4, DECEMBER 2008

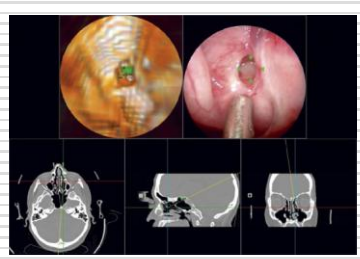


Other "natural" displays

- Endoscopic images



Bricault et al. IEEE TMI1998

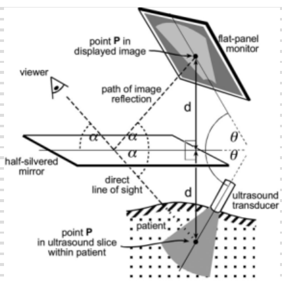


Shahidi et al. IEEE TMI2002

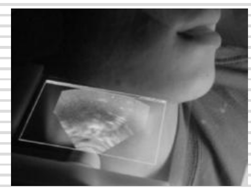
- Fluoroscopic images

Other devices (1)

- Sonic flashlight (Stetten et al. CMU)
  - To visualize US data where they are acquired



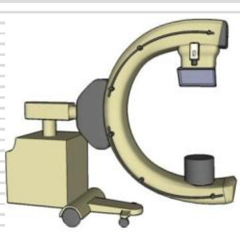
Principle

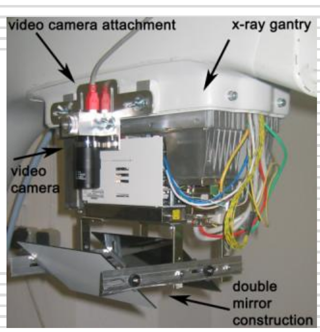


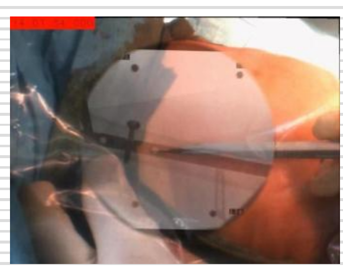
Applications

Other devices (2)

- CamC (Navab et al. & Siemens)
  - Combine X-ray views to video views of the patient
  - Modified X-ray system (camera+mirrors)







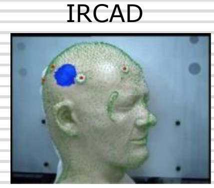
Technical issues

- Right place: calibration
  - Optical overlay less accurate (user-based subjective calibration)
- Right time: synchronization
  - Video overlay: ability to synchronize but possible delay
  - Optical overlay: time lag
  - May be an issue for instrument guidance

Technical issues (2)

- Right way: visualization and perception
  - Brightness (low for see-through systems)
  - Virtual object always appears sharp whatever the distance
  - Spatial relationships of the objects
- Other constraints: sterility, clinical usability

IRCAD



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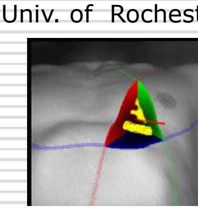


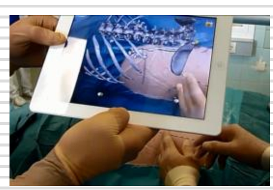
Grenoble Univ. (TIMC)

Some conclusions

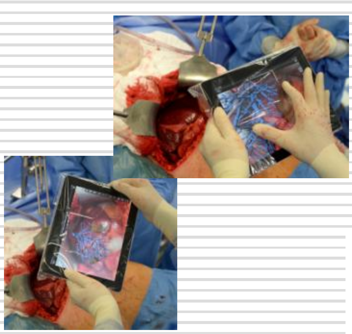
- Advantages of video overlay
  - Good quality
  - More precise
  - Data synchronized
  - Possible storage
- Advantage of “natural” live images (surgical microscopy, endoscopy, fluoroscopy, etc.)
  - Already in the OR
- Very few clinical evaluations

New hardware opportunities

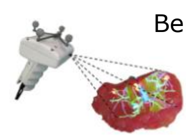
- Tablets, smart phones, xxx glasses, RGB-D cameras



Dr Meinzer, Heidelberg



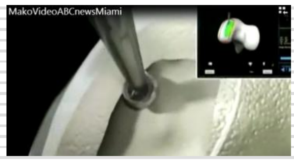
Pr Oldhafer, Hamburg



Bern, Liver surgery project

« Haptic » augmented reality

- Co-manipulation systems
  - Example: RIO



- Augmented tools
  - Example: NavioPFS