Visual Medicine: 
Part Two – Advanced Applications of Medical Imaging

Virtual Endoscopy
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Outline
Advanced Applications of Medical Imaging
- Virtual Endoscopy
- Image-guided Surgery and Medical Mixed Reality
- Diffusion Tensor Imaging and Visualization
- Liver Surgery Planning
- Reconstruction and Functional Imaging
- Soft-Tissue Simulation /Deformation

Question and Answers

Virtual Endoscopy (1)
Commercial systems
Siemens Syngo
- Syngo is new system
- Uses ray casting/VolumePro
- Manual and automatic navigation
- (Virtuoso is older system: 2D texture mapping based)

Virtual Endoscopy (2)
Commercial systems, cont´:
Philips EasyVision Endo 3D
- Automatic navigation
- Colon unfolding
- Ray casting

Virtual Endoscopy (3)
Commercial systems, cont´:
GE Advantage Windows
- Semiautomatic path generation
- Ray casting

Virtual Endoscopy (4)
Commercial systems, cont´:
Viatronix V3D Viewer/Colon
- Ray Casting
- Guided/manual
- Technology partially based on SUNY SB VICON
Virtual Endoscopy (5)

Commercial systems, cont’:

Vital Images
Vitrea2/CT Colonography
- Automatic/manual
- 2D/3D Texture Mapping

© Vital Images

Virtual Endoscopy (6)

Research Systems:
- VIVENDI - U Tübingen
  - OpenGL/Visibility culling
  - Guided navigation
- VICON - SUNY Stony Brook
  - similar to VIVENDI, but bound to colonoscopy
- CRS4 Sardinia
  - 3D TEXT on SGI RE2

Advantages and Limitations (1)

Some statements:
- VE (Virtual Endoscopy) will not replace optical endoscopy
- VE is only as good as dataset/image acquisition
- Will cause a shift of revenue from GE/surgery to radiology

Advantages and Limitations (2)

Advantages of VE:
- Non-invasive
- Better patient compliance
- Control of lighting and orientation
- No physical access limitations
- All (segmented) areas are accessible
- More economical than optical endoscopy

Advantages and Limitations (3)

Limitations of VE:
1. Segmentation
   - Represented information depends totally on segmentation quality
   - Flaws of segmentation can (usually) not be fixed at rendering
   - Which is the correct classification?
Advantages and Limitations (4)

Limitations of VE:
2. Rendering
- Rendering never better than data
- Resolution of **real biopsy is unmatched**
- Transparent rendering of inner surface ("look through", "**virtual biopsy**")
  **does not replace real biopsy**

Advantages and Limitations (5)

Limitations of VE:
3. Concept
- No physical interaction with tissue: no removal of pathological tissue
- No actual intervention
- Structure of interest might have changed since acquisition ("**brain shift**")

Advantages and Limitations (6)

Requirements for VE:
- Sufficient accuracy
- Identifiable (segmentable) structures of interest
- Interactivity (> 19 fps)
- Awareness of reasons for artifacts

Introduction (1)

**Virtual Endoscopy Applications:**
- Colonoscopy
- Ventriculoscopy
- Angioscopy
- Bronchoscopy
- Endonasal Transsphenoidal Pituitary Surgery

Virtual Colonoscopy (1)

- Colorectal cancer has high incidence: **150,000 cases/yr**
- Early detection is critical for successful treatment
  - Purpose: Screening/Diagnosis
    - **rectum**

Virtual Colonoscopy (2)

Clinical screening procedures:
- optical colonoscopy
- barium enema
Alternative screening procedure
- virtual colonoscopy
Virtual Colonoscopy (3)

Optical Colonoscopy:
+ shape and texture information
+ physical tissue interaction
- low patient compliance due to uncomfortable procedure
- no access to areas behind colon collapses
- potential risk of lesions due to endoscope
- expensive (approx. 1h procedure time)

Virtual Colonoscopy (4)

Barium Enema
+ relatively simple procedure
+ relatively cheap
- low sensitivity (structures < 10mm)
- depends on experience of radiologist
- radiation exposure (although not very high)

Virtual Colonoscopy (5)

Virtual Colonoscopy:
+ same patient preparation as optical
+ cheaper than optical endoscopy
+ can inspect areas behind collapses
- no texture information
- no biopsy / removal possible
- quality depends on segmentation

Virtual Colonoscopy (6)

Protocol:
- Cleanse colon
- Pump air into colon
- CT-scan abdomen
- Reconstruct & visualize colonic surface
- If polyps are found, do optical Colonoscopy
Different modalities possible

coronal  sagittal  CT  transverse

Virtual Colonoscopy (7)

8mm polyp

virtual  optical

Virtual Colonoscopy (8)

4mm polyp

virtual  optical
Virtual Colonoscopy (9)

Virtual Ventriculoscopy (1)

- Ventricular System (VS) produces CSF (brain fluid)
- Occlusion in VS causes hydrocephalus
- Requires new drain

Purpose:
Diagnosis and planning

Virtual Ventriculoscopy (1)

Procedures:
- placement of stent
  - requires replacement after a few years
  - causes degenerations of VS
- ventriculoscopy:
  + no implantation required
  - complex procedure

Virtual Ventriculoscopy (1)

Virtual Ventriculoscopy (2)

Left Lateral Ventricle, approach from Posterior Horn:
AH - Anterior Horn, CP - Choroid Plexus, CPV - Choroid Plexus Vein

Foramen of Monro, approach from Right Ventricle:
PC - Pars Centralis, AH - Anterior Horn, F - Fornix, AI - Adhesio Interthalamica, MB - Mamillary Bodies
Virtual Ventriculoscopy (5)

Foramen of Monro, approach from Third Ventricle: AI - Adhesio Interthalamic, LLV - entrance to Left Ventricle, RLV - entrance to Right Ventricle, LT - Lamina Terminalis

Virtual Ventriculoscopy (6)

Virtual Ventriculoscopy (7)

Multi-modal visualization of ventricular system and angio-architecture

Virtual Ventriculoscopy (8)

Virtual Ventriculoscopy (9)

Intraoperative navigation

Virtual Angioscopy (1)

Among leading medical problems are vascular diseases:

- stenosis/occlusion
- aneurysms

Purpose: Diagnosis and Planning
Virtual Angioscopy (2)

Stenosis of Right Coronary Artery

Virtual Angioscopy (3)

Coronary arteries of the heart

Virtual Angioscopy (4)

Aneurysm of cerebral artery

Virtual Angioscopy (5)

Virtual Bronchoscopy (1)

- Multi-Slice CT
- Model-based Segmentation (Univ. Mainz)
- More complex segmentation
  - More complex reconstruction
- Purpose: Diagnosis and Planning

Virtual Bronchoscopy (2)

Hybrid Segmentation and Exploration of the Human Lungs

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Virtual Bronchoscopy (3)

Bronchial tree and pulmonary arteries

Virtual Bronchoscopy (4)

Bronchial tree with pulmonary arteries and tumor

Endonasal Transsphenoidal Pituitary Surgery (STEPS)

Pituitary lesions: important problem
- ~ 20% of adults
- 1/3 of treated brain tumors: pituitary lesions
- Symptoms:
  - headache, visual loss
  - fatigue, sexual disfunctions, weight gain
- Gold standard for treatment: endonasal transsphenoidal surgery

Virtual Endoscopy for
- Preoperative planning
  - 3D
  - Transparency
- Training
**STEPS: Preprocessing**

**Object preprocessing:**
- Segmentation in MRA, virtual endoscopy on CT
- Image Fusion [Capek et al., 2001]
  - Mutual Information
  - Simulated Annealing
- Segmentation
  - Manual
  - Watershed from Markers [Felkel et al., 2001]

**STEPS: Simulation**

**Simulation: surgical instruments**
- Opening of
  - Sellar floor
  - Sphenoid ostium
  - Sphenoid septa
- During simulation: reachability important

**STEPS: Navigation**

**Navigation**