MPRs, MIPs and VR in Abdominal applications

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Objectives

• Define the different 2D and 3D image formats
  • advantages and disadvantages

• Common (and some less common but practical) uses of MPRs, MIPs and 3D techniques
Images are stacked to form a volume data set
Volume Data then Manipulated by Computer

- Cut volume in different planes
- View data from different angles
- Emphasize or de-emphasize data
  - Location within the volume
  - CT HU density / MR signal intensity
  - Assigning relative values to density / intensity
  - Apply ‘lighting’ or shading
Why do 2D & 3D post processing?

- View information not easily shown by planar images
  - Data not always projects in the acquisition plane
- Convey information in a format easily understood
  - Simulates angio, colonoscopy, IVU - better communication
- Replace costly or riskier studies
  - Diagnostic angiography
- Open new markets
  - New types of scans: CT Colon / Coronary CTA
  - Added value - increase referrals
Basic types of 2D & 3D image Formats

• Two-dimensional (2D) formats
  • Multiplanar reformations (MPR)
  • Curved planar reformations
  • Maximum intensity projection (MIP)
  • Minimum intensity projection (MinIP)

• Three-dimensional (3D) formats
  • Surface shaded displays (SSD)
  • Volume rendering (VR)
  • Perspective surface or volume rendering

• Map projections
Common Uses for MPRs, MIPs and 3D

• Most common MPR: coronal or sagittal MPR in routine scanning

• Most common MIP: CTA / MRA

• Most well-known 3D: perspective VR/SSD in CT colonography / virtual colonoscopy
Abdominal uses of 2D and 3D imaging

- CT / MR Angiography - minimally invasive replacement for diagnostic angiography
  - Aortic and iliac artery aneurysms / stenosis
  - Living renal transplant donors
  - Mesenteric angiography
  - Renal artery stenosis
  - Nephron-sparing renal surgery
  - Liver transplant pre-op/post-op assessment
Non-vascular Abdominal 2D and 3D

- Diagnostic evaluation
  - CT enterography, SBO
  - CTU, renal stones
  - Adrenal (nodules vol avg, adrenal v renal lesion)
  - Diaphragmatic hernia / trauma
- “Virtual endoscopy”
  - CT colonography
  - Uncommon / investigational
    - Virtual cystoscopy
    - Virtual angioscopy
Overlap & thinner slices – less artifact

- 3 mm slice thickness
- 3 mm interval
- 1 mm slice thickness
- 0.8 mm interval
Use High Contrast Differentials

- Greater differences between the structures of interest and the background allows easier separation of data
- Main “contrast agents” for 3D provide a difference from soft tissues
  - Contrast – CT Angiography (350 or 370 mgI/ml agents)
  - Air / CO₂ - colon, bronchi, bladder
  - Calcium in bones – skeletal applications
Multiplanar and Curved Planar reformations

- Simplest 2D format
- Planes placed in any orientation through the volume
- Advantages
  - maintains all gray scale information (calcium and fat)
  - Allows viewing along non-acquisition planes without additional imaging (radiation)
- Disadvantages
  - 2-Dimensional – need a series of images to retain all data
  - No depth information
  - Resolution traditionally less than non-axial planes
MPR cuts volume along any plane . . .
CT Enterography

- CTE protocol axial and coronal MPRs
- Mesenteric vessels and LNs are nicely shown coronal
Small Bowel Obstruction

Closed-loop SBO
Sclerosing mesenteritis

Coronal MPR
Back / flank pain - “r/o kidney stone”

... after recently placed IVC filter!
Coronal MPRs for diaphragmatic hernias
Curved planar reformations (CPR)

- Draw bendable plane from reference images
- Trace along vessels, spinal column, ureter
- Limitations
  - Curved planar reformations have no restrictions
  - Only include data “requested”
  - Can be misleading
Renal artery stent patency

- Coronal MPR
- Curved MPR
Maximum Intensity Projection (MIP)

- Projects through the volume
- Displays only the highest HU value along line of ‘sight’
- Uses data from the entire volume or a “slab” volume but selects only desired data (max on min HU)
- Common uses: CT/MR angiography, MRCP
- Typically combined with a series of rotating images to give ‘3d’ location, but opposite views are similar not complimentary
Maximum Intensity Projection (MIP)

- **Advantages**
  - Angiographic- or ERCP-like image
  - Maintains gray scale info - calcium is visible
- **Disadvantages**
  - 2-dimensional
  - Often need multiple projections
  - Can require extensive image editing
    - remove unwanted data
    - “Slab” mips - MIP from only a few images
Thin MIP CTA renal donor - FMD
Thin MIP CTU - TCC
Shaded Surface Display

- Select threshold value
- Eliminate all voxels below the threshold
- Project first voxel above chosen threshold along line of site into the volume
- All voxels given same intensity, grayscale or color
- Grayscale values used for shading from artificial light source to provide depth
Celiac Aneurysm – axial images
Celiac aneurysm – SSD / MIP
Shaded Surface Display

• Advantages
  • 3-Dimensional
  • Surface renderings such as used in CT colonography

• Disadvantages
  • Resultant image extremely sensitive to chosen threshold
  • Loses all gray scale information
    • Cannot differentiate between vessel lumen and calcifications, e.g.
Volume rendering

- Each voxel assigned grayscale or RGB, brightness, and opacity
- Opacity “probability” CT density or MR signal intensity
  - 0% - invisible
  - 100% - opaque
- Brighter objects behind will shine through lucent ones
- Advantages: uses entire data set, real time display, 3D
- Disadvantages: more memory intensive, slower
Clinical images – angiodysplasia SMA
VR and conventional Angio
VR renal transplant donor vessels
Clinical images - CT Urography

• Low opacity (26%) Volume renderings mimic plain radiology
Volume Rendering – CT urography

Low and high opacity settings
Perspective Volume or Surface Rendering

- Objects mapped to artificial point in the distance
  - near objects larger
  - far objects smaller
- Advantages
  - depth cues
  - endoluminal viewing similar to endoscopy
- Disadvantages: limited FOV, slower, more complex
Colon Polyp / FOV
Billing – two main CPT codes

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Not billable with CTA
So, … what do we really do?

- MPRs – routine coronals on vast majority of cases
  - Sag and coronals on renal mass (surgical planning)
  - Sagittal through celiac / SMA on pre & post OLT patients
- Thin MIPs
  - Routine on renal donors (arterial phase)
  - Routine coronal thin MIPs on CTU
- Volume rendering
  - Low-opacity VR on CTU for Urogram-like image
  - Partial Nx and renal donor planning on request
- CT Colonography – primary 3D reading (perspective)