Medical Imaging and Computer Graphics: What's Next?

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Developments in Computer Science and Computer Graphics have significantly impacted all fields of medicine and medical research

Whether it be in breaking down the genetic code, revolutionizing drug design, or advancing medical imaging you have impacted healthcare no different than developing a vaccine or a new drug

I would like to go from the global experience to the personal experience in my part of this session

" In theory there is no difference between theory and practice. In practice there is. "
Yogi Berra

My Collaborators or supporters over time have included

- Derek Ney
- David Heath
- Bob Drebin
- Pat Hanrahan
- Alvy Ray Smith
- Ed Catmull
- Steve Jobs
- John Flynn
- Brian Cabral
- David Ebert

3D Medical Imaging: My Experience

- 1982-2002
- Siemens Medical Systems: DEC PDP11
- Pixar: Pixar I and II Image Computers
- NeXT
- Sun Workstations 3/160 thru Sparc 2
- Silicon Graphics Onyx / Infinite Reality workstations

3D Medical Imaging: My Experience

- 1982-2002
- Silicon Graphics O2 workstation
- SGI O2 with VP500/VP1000 board
- Dell 8100 with VolumePro 1000 board and/or NVIDIA G-Force 4

Our Goals 1982
Our Goals 2002

- Improve our ability to optimize detection of disease
- Improve our ability to define the extent of disease
- Improve our ability to help with patient triage and management

Have we succeeded?

- Answer:

a. Yes
b. No
c. Maybe
d. All of the above

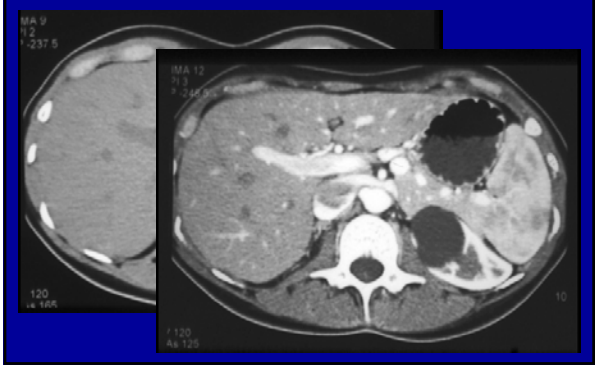
Have we succeeded?

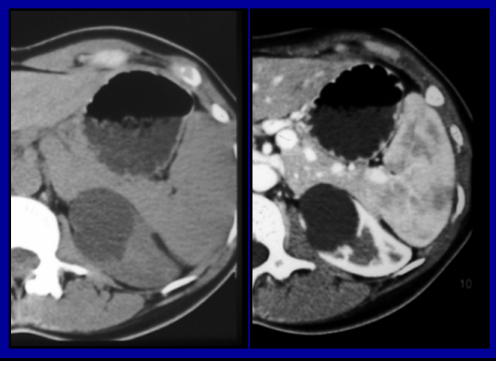
- Answer:

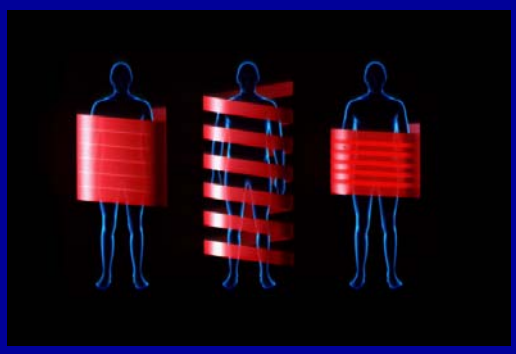
a. Yes
b. No
c. Maybe
d. All of the above

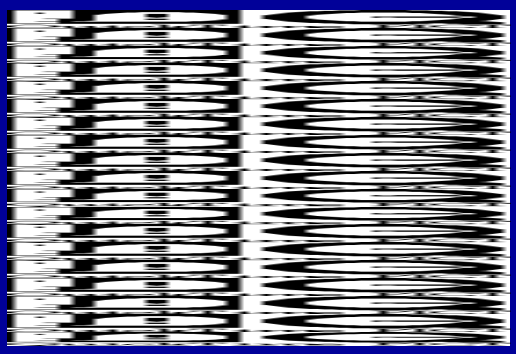
Where has technology succeeded?

- Scanner Design and Capabilities
  - Scanner speed
  - Scanner resolution
  - Scanner software
  - Scanner reliability









The CT Scan Journey Thru Time

year	Scan speed	Slice thickness	Interscan spacing	Total # of slices
1980	10 sec	10mm	10mm	25-30
1985	5 sec	8-10 mm	8-10 mm	30-45
1990	1 sec	3-5 mm	3-5 mm	100
1995	.75 sec	3 mm	2-3 mm	100
1999	.5 sec	1-3 mm	1-3 mm	220
2002	.4 sec	.5-.75 mm	1 mm	600-900

A typical scan today is

7/2002	.5 sec with 250 msec temporal reolution	1mm	1 mm	230 slices
9/2002	.4 sec with 105 msec temporal resolution	.5 mm	.5 mm	900 + slices

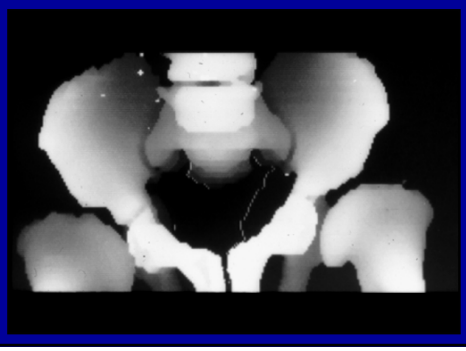
Our Goals 1980-2002

- Improve our ability to optimize detection of disease
- Improve our ability to define the extent of disease
- Improve our ability to help with patient triage and management

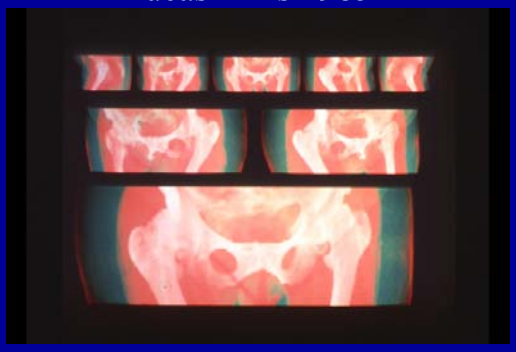
3D Imaging or Volume Visualization

- Imaging algorithms have gone from shaded surface to MIP to volume rendering
- Image displays have gone from static images to constrained rotational loops to interactive rendering
- Image interactivity has become a reality

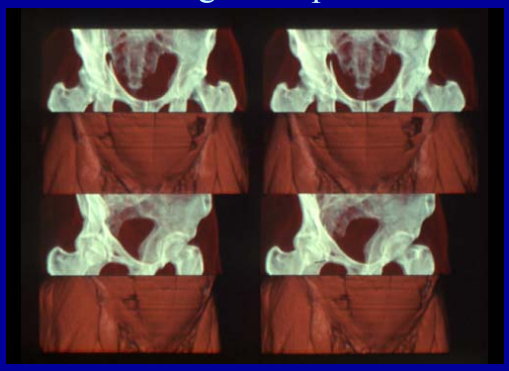
Dysplastic Hips:Circa 1982



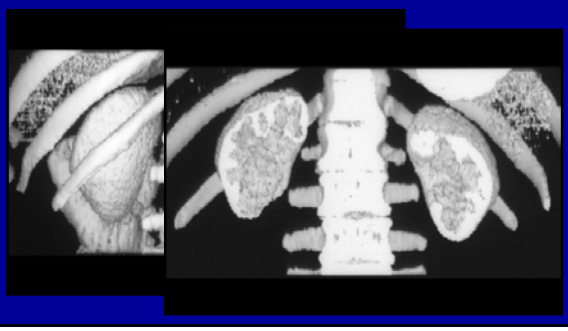
LucasFilms 1985



Pixar Image Computer 1988



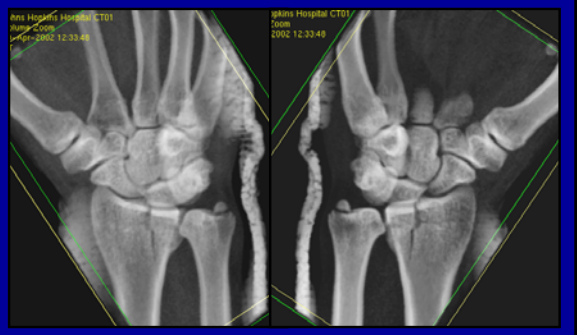
Shaded Surface Kidneys: Circa 1989



Clinical Applications 2002

- Medical and Surgical Oncology
- Vascular Surgery
- Orthopedic Surgery
- GI Surgery
- Organ transplantation
- Neurosurgery

Radius Fracture

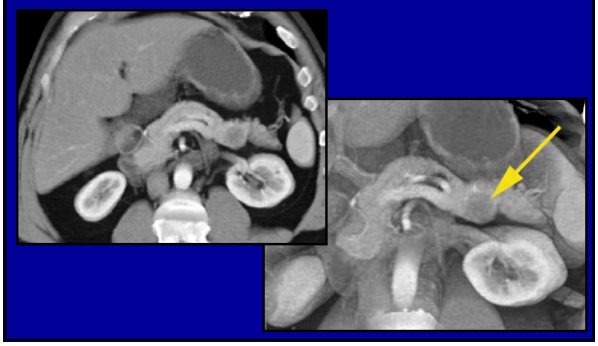


.5 mm Isotrophic Data

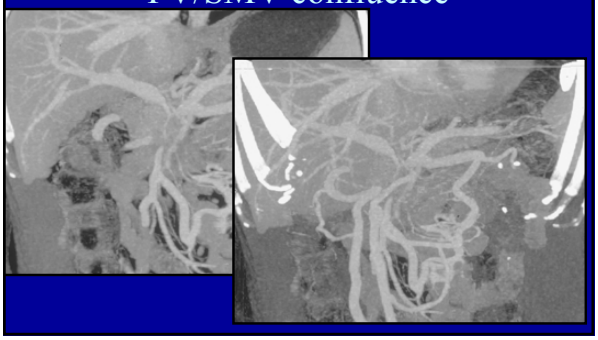
Shading With a Light Source

3D VRT of a Normal Pancreas

Carcinoma of the Pancreatic Tail



Pancreatic Cancer with Encased PV/SMV confluence



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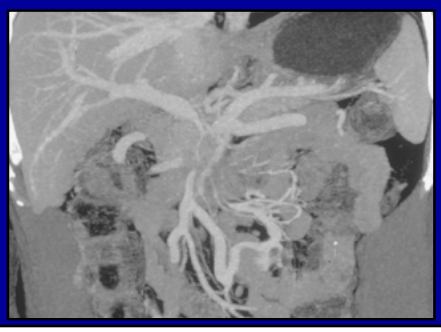

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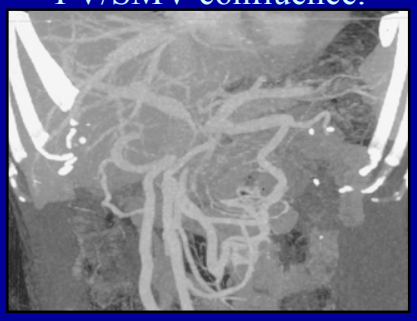
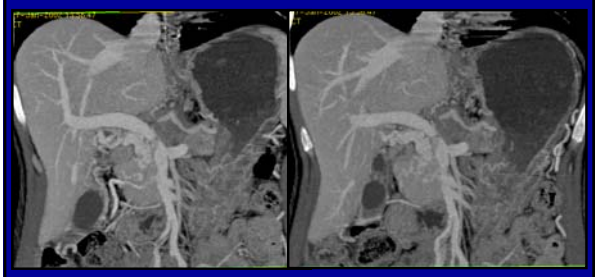
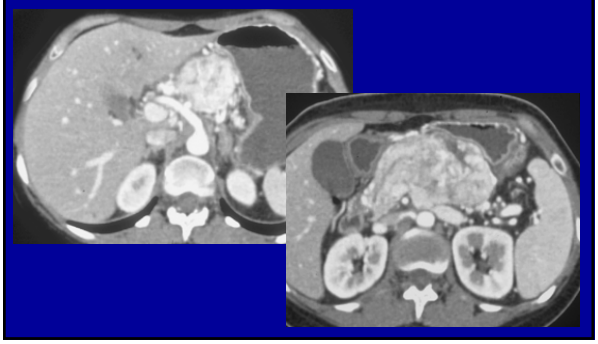


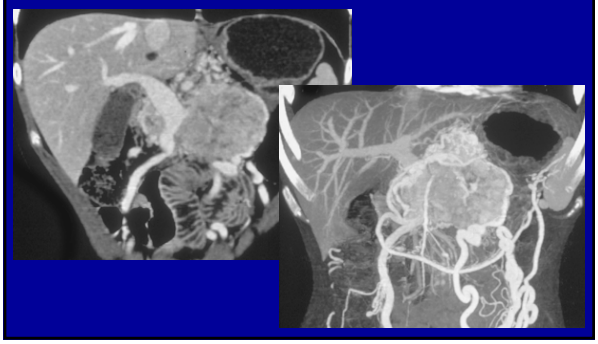
Adenocarcinoma of the Pancreas Encases the Portal Vein



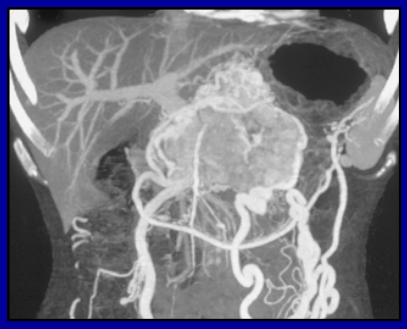
Islet Cell Tumor of the Pancreas



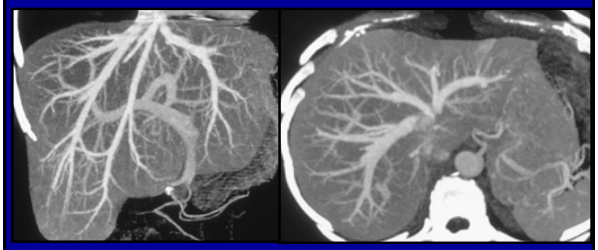
CT Angiogram of Islet Cell Tumor



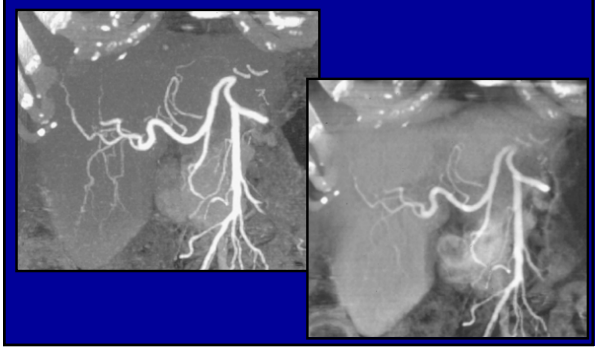
CT Angiogram of Islet Cell Tumor



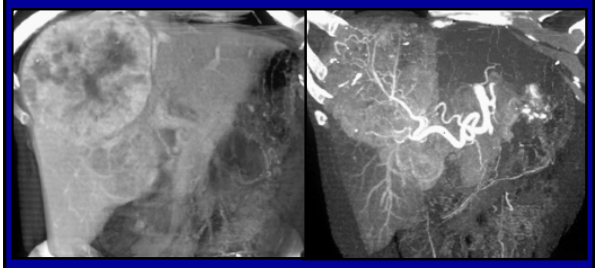
MIP-Normal venous Anatomy



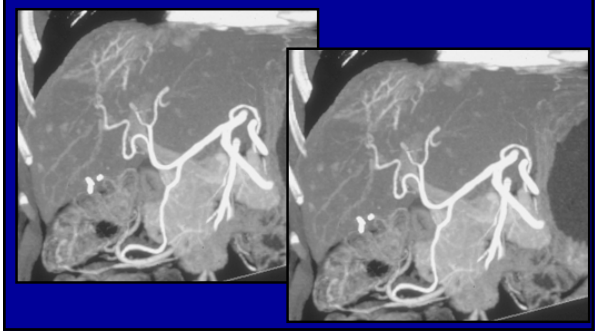
MIP/VRT of Hepatic Artery



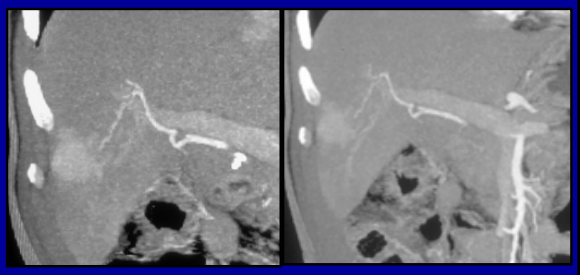
VRT/MIP of Hepatoma



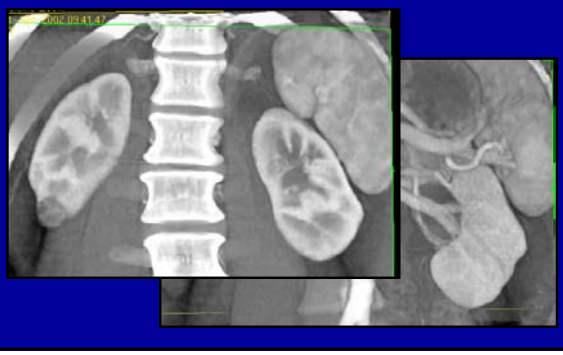
Hepatoma on CT Angiogram Without Mass



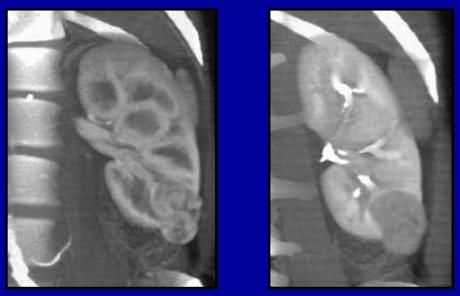
Feeding Vessel to Hepatoma



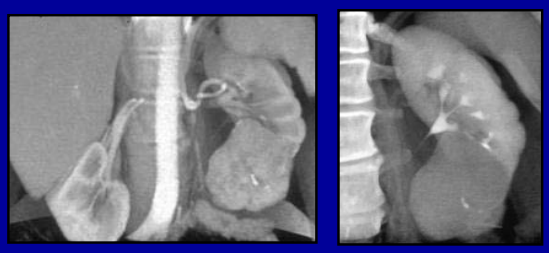
1 cm Renal Cell Carcinoma



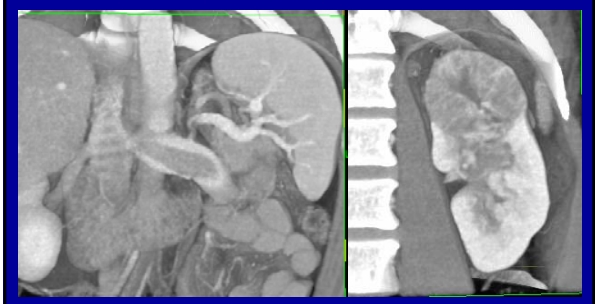
Incidental renal cell carcinoma in a potential renal donor



Renal cell carcinoma ineligible for partial nephrectomy



Renal Cell Carcinoma with Renal Vein Extension



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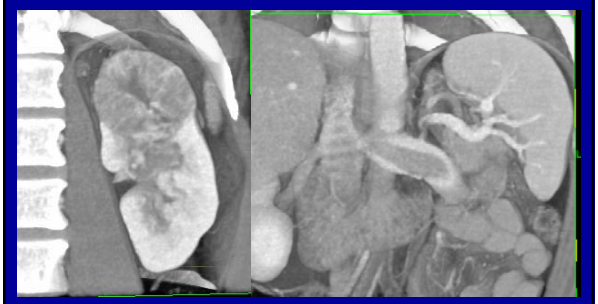
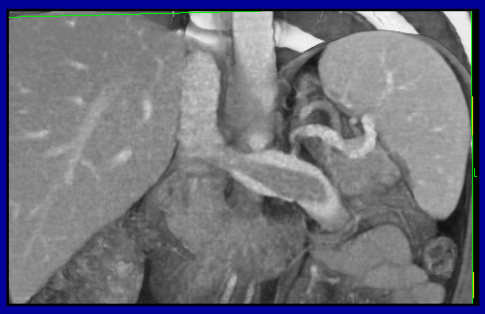
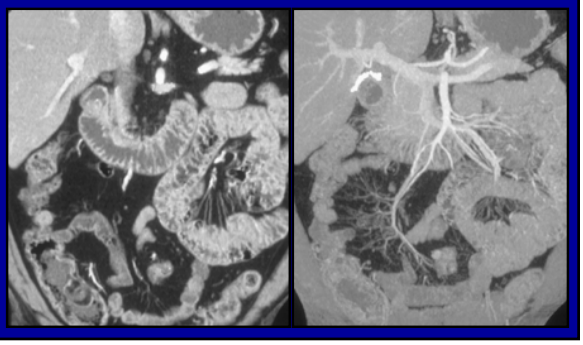


Renal Cell Carcinoma with Renal Vein Extension

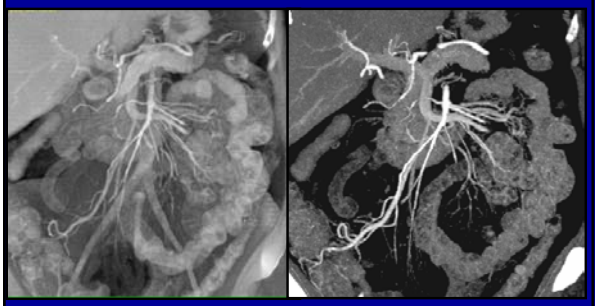


Renal Cell Carcinoma Invades the Renal Vein and IVC

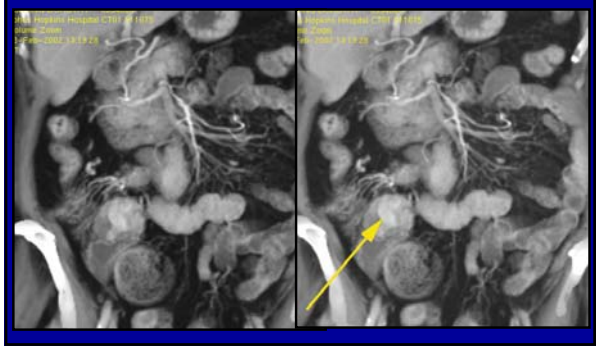
Normal 3D of Small Bowel



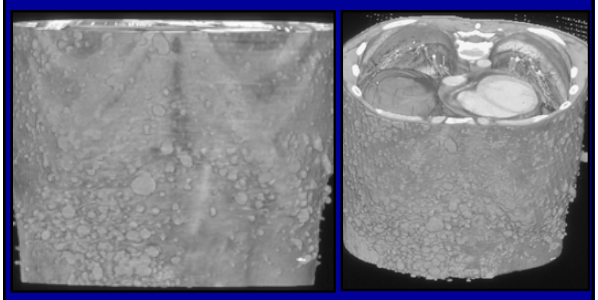
Normal Mesenteric Vessels



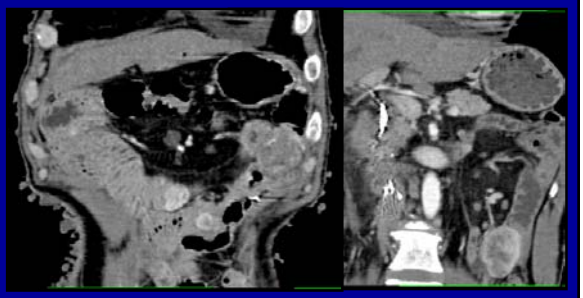
Carcinoid Tumor



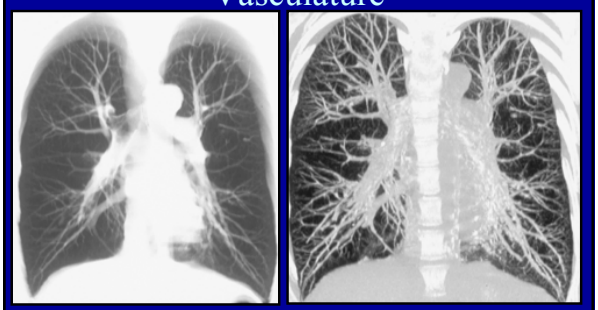
Neurofibromatosis



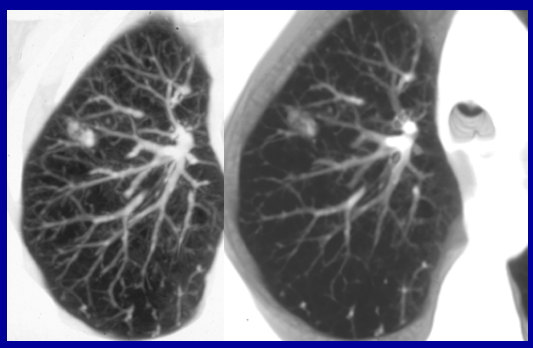
Multiple GIST Tumors in the Small Bowel



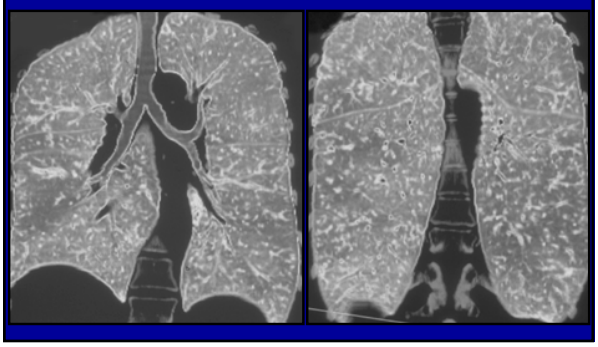
3D-VRT of the Pulmonary Vasculature

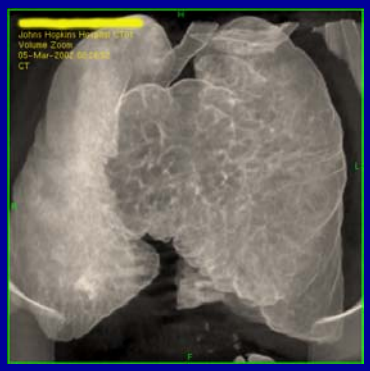


Small Lung Nodule

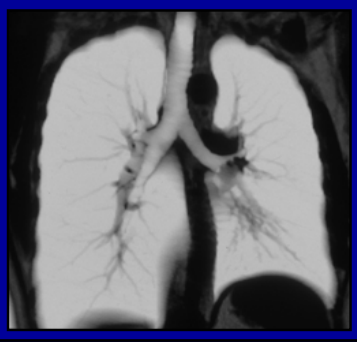


Volume Rendered Lung Parenchyma

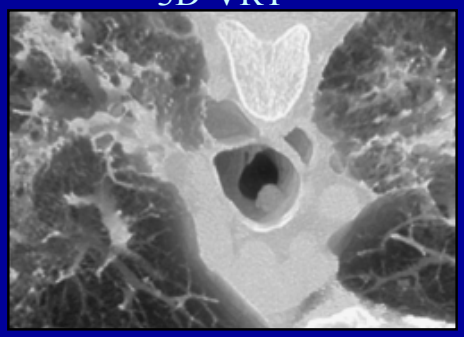




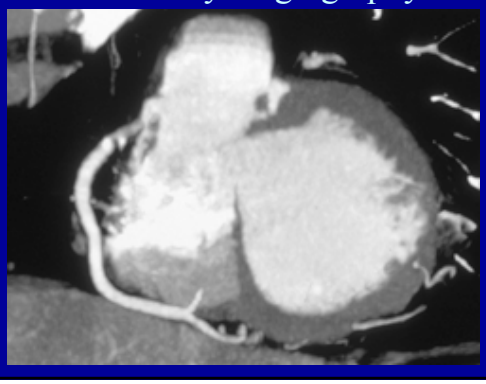
Carcinoid Tumor Invades Left Mainstem Bronchus



Polyp in Tracheal Lumen with 3D-VRT



Coronary Angiography



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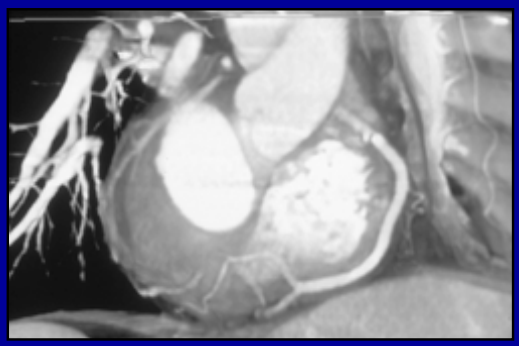
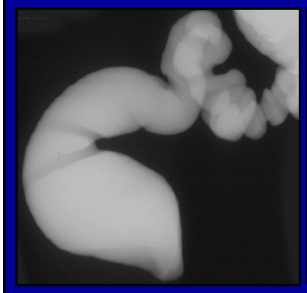
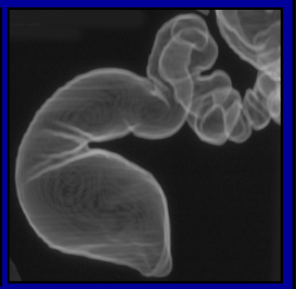
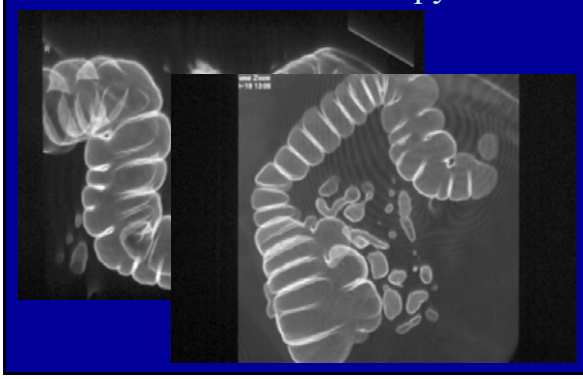


Virtual Colonoscopy of the Rectum

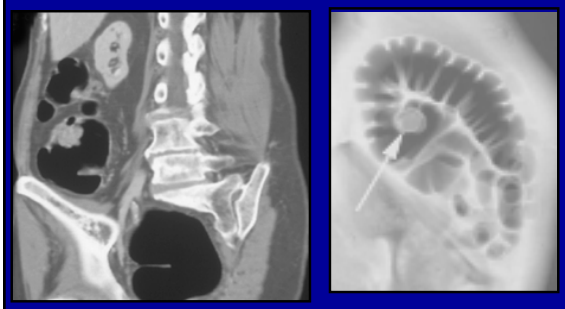




Virtual Colonoscopy



Cecal Cancer on Virtual Colonoscopy



Do radiologists use 3D workstations in 2002?

- Probably less than 25% of radiologists use 3D workstations even if they own them
- Why?

Why is this true?

- lack of adequate training
- lack of time for adequate training
- changing the patterns of workflow is always slower than what one would expect

Radiology Workstations are typically

- Underpowered
- Poorly designed
- Overpriced
- Unloved

Who are the manufacturers of workstations?

- Full product companies: GE, Siemens
- Workstation only companies: Vital Images, TeraRecon Inc.
- Software only companies: HipGraphics

What do I(we) need?

- Better rendering algorithms in hardware and/or software
- Better design of current workstations for efficient workflow
- Increased tools/functionality that are easy to learn and use

What do I(we) need?

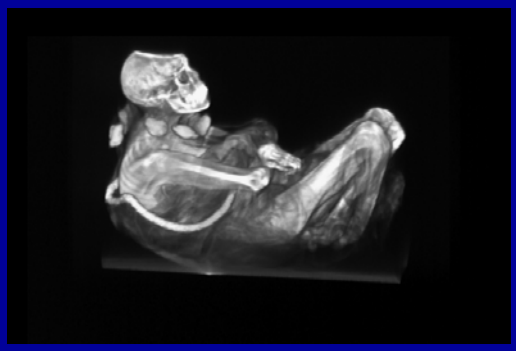
- Lower priced workstations
- Distributed computing (server thin client model)
- Collaboration beyond medicine (i.e. to this audience)

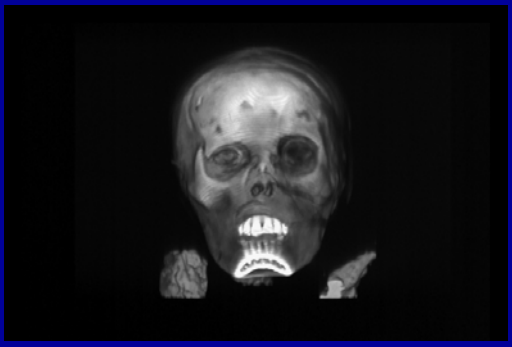
Clinical Applications

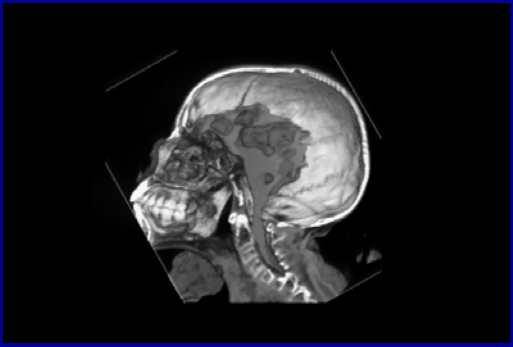
- Faster scan times and narrower collimation are driving potential clinical applications
  - CT Angiography
  - Virtual Imaging
  - Cardiac Imaging

The Future 2002-2005

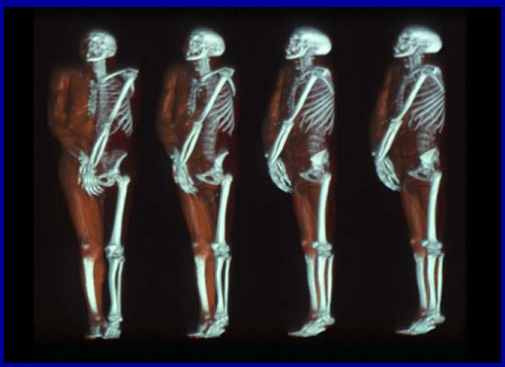
- Real time 3D display of data as the primary reconstruction method
- Integration of graphic tools into the clinical environment for improved patient care
- Continued developments to Star Wars and Star Trek imaging







" Change is the law of life. Those who look only to the past or the present are certain to miss the future. "

President John F. Kennedy

May the force be with you…