

# Volume Rendering

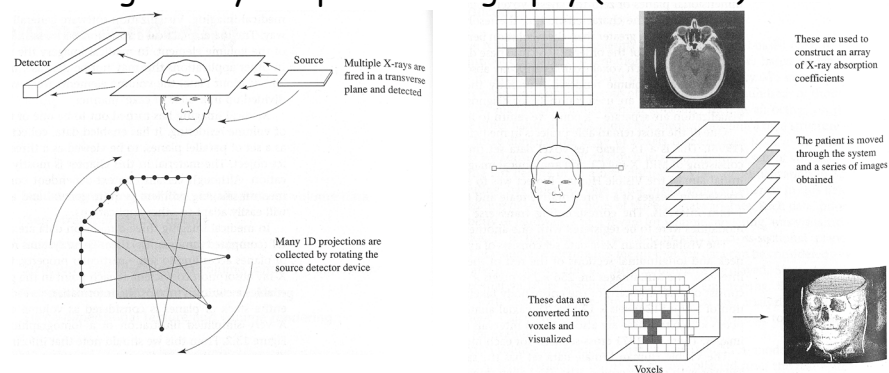


- Watt, Ch 13
- Goal: understand the basic ideas and issues

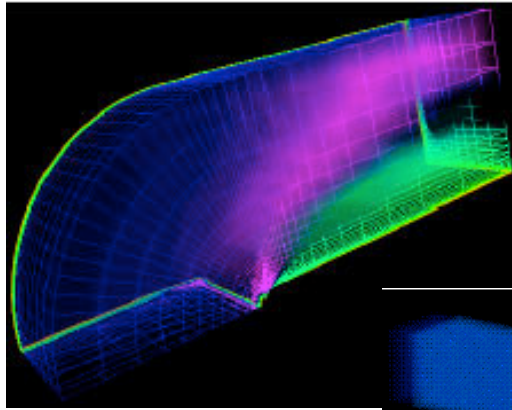
# What is Volume Rendering?



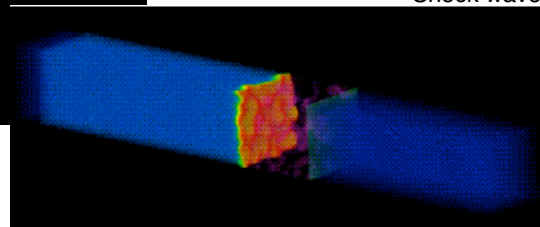
- Rendering voxel-based data
  - E.g. X-ray computer tomography (CT scans)



## Applications: Computational Fluid Dynamics



Flow around airplane wing



Shock wave

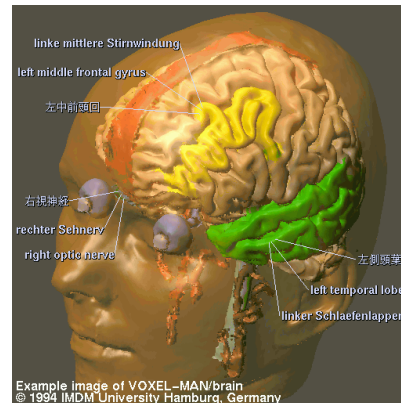
## Applications: Scientific Modeling/Visualization



Model of cloud development

## Canonical Application: Medical Imaging

- View human internals captured with MRI, CT scanner, photographs
- Color it to distinguish one type of tissue from another



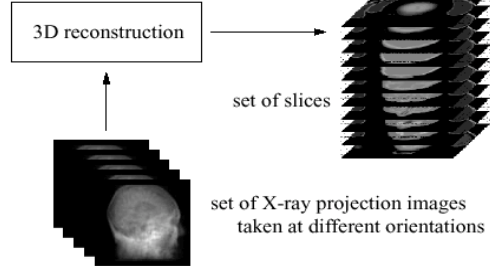
## Example Dataset: Visible Human

- [http://www.nlm.nih.gov/research/visible/visible\\_human.html](http://www.nlm.nih.gov/research/visible/visible_human.html)
- Volume Data: Man and Woman
  - Discussed in book
  - Freely available for research
- CT Scans, MRI, Color Cryosections

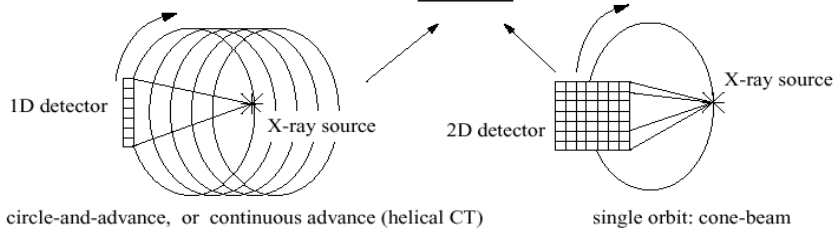
# Computed Tomography (CT)



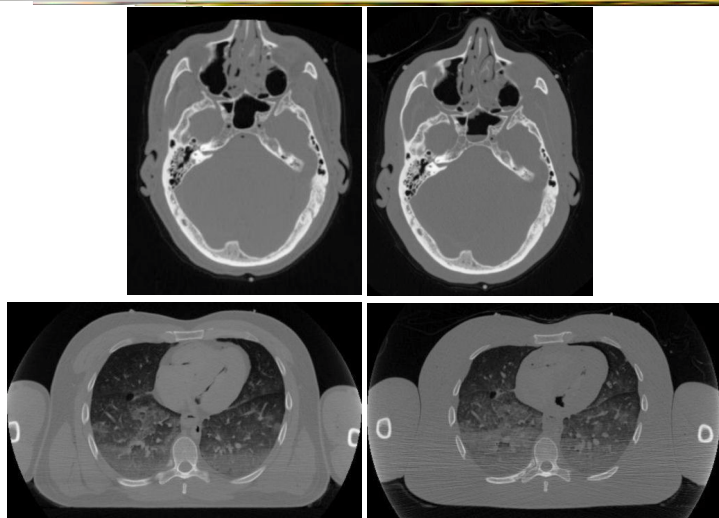
modern CT scanner



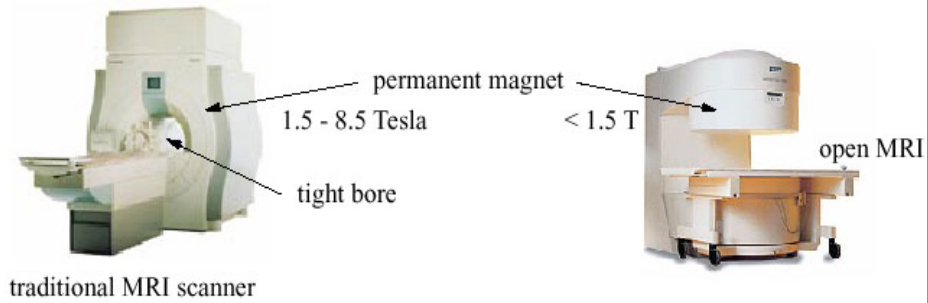
Scanning geometries:



# CT Scans of the Visible Man

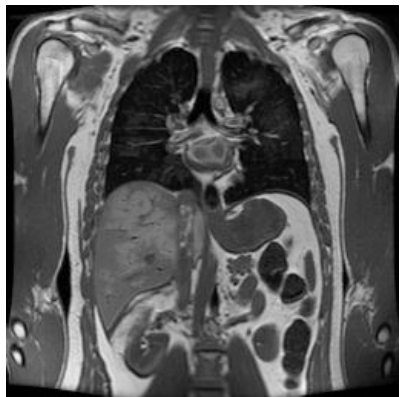


## Magnetic Resonance Imaging (MRI)

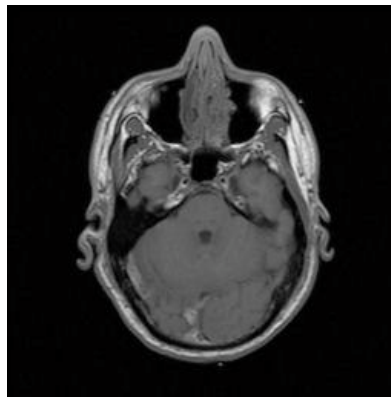


## MRI Scans of the Visible Man

Grey matter vs white matter

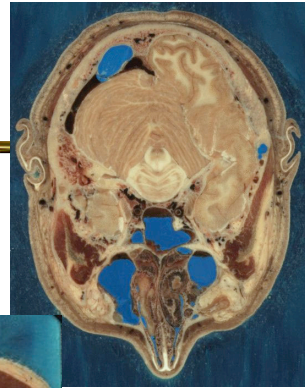


No bone



## Color Cryosections

- Freeze, slice, photograph



Cryosections of the Visible Man

## Ultrasound



ultrasound in action



sound field of the probe



probe location



3-D face



scans obtained with 2D ultrasound

result from 3D ultrasound

## Volume Rendering Overview

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- Three basic approaches
  - Display 2D slices from dataset
  - Extract/display geometry of known object
  - Composite transparent, colored voxels

## 2D Slice Animation

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- Hard to understand internal structures
  - Especially for novices



- Trained experts prefer them

## The Visible Man

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## More of the Visible Man

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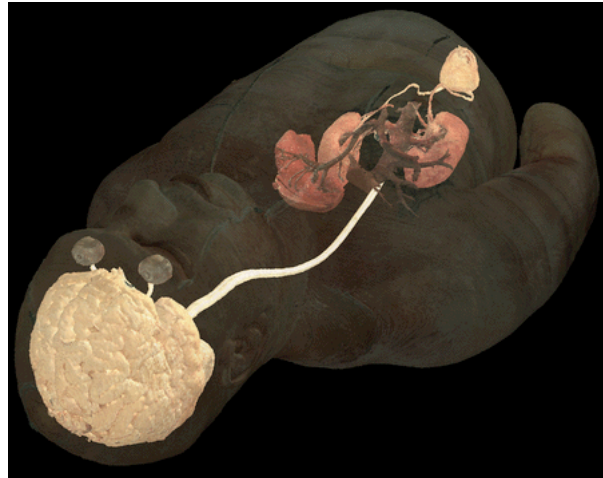


## More Visible Man

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- Choose viewpoint



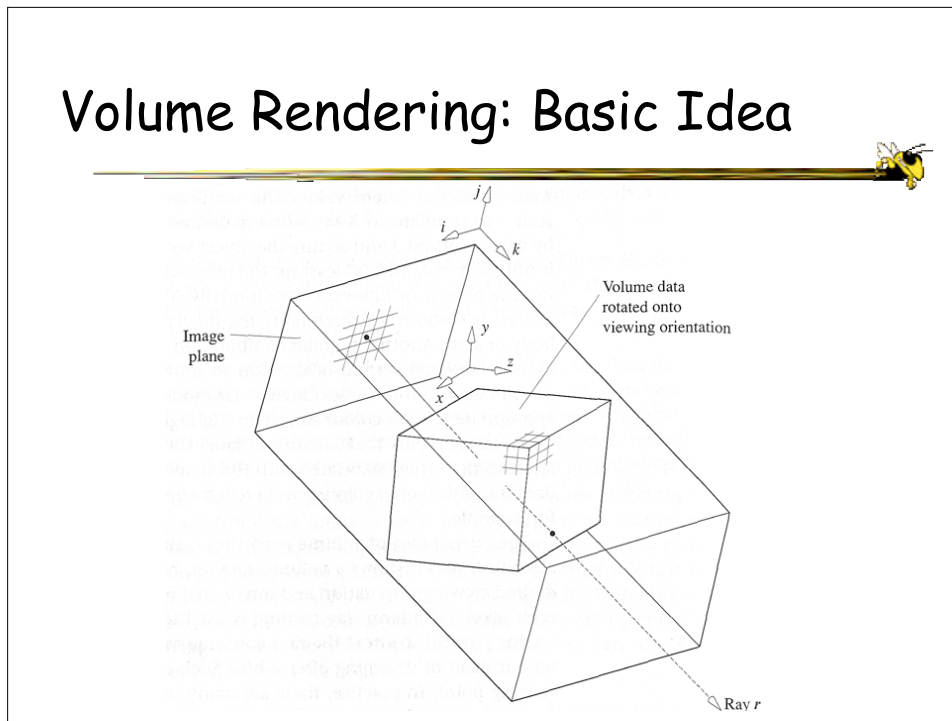
## Volume Rendering: Basic Idea

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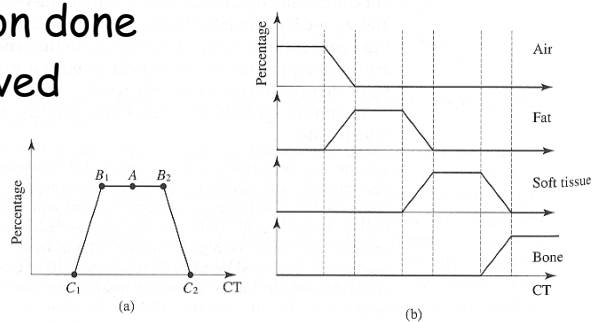
- Each voxel: color  $C$  and transparency  $\alpha$ 
  - Involves classifying each voxel
  - Color is arbitrary, chosen for aesthetics
- Set view position
  - Cast rays through screen pixels into volume
  - Alpha-blend voxels from back to front

## Volume Rendering: Basic Idea



## Volume Rendering: Classification

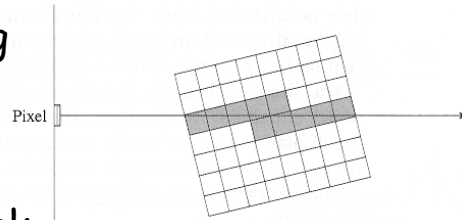
- Voxels are relatively large
  - Could contain multiple "types"
- Classification done once and saved



## Casting Rays Through Volume



- Resampling, Aliasing issues
- Composite from back to front using alpha-blending
- No "lighting": using assigned colors



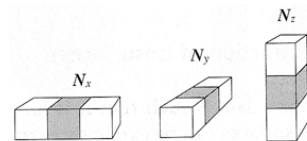
## Adding Opaque Surfaces



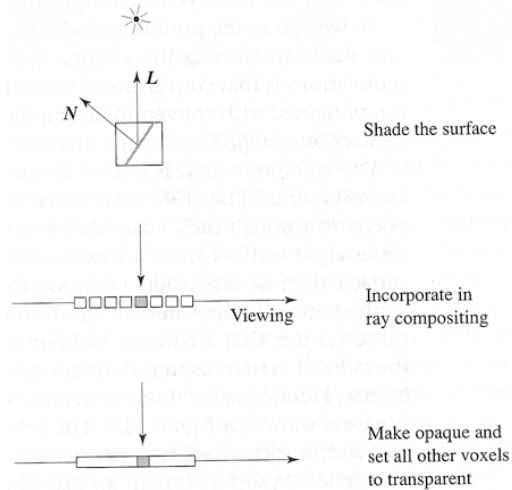
- Two approaches
  - Compute volume gradients locally from volume data, detect surfaces
  - Extract isosurfaces from data and render using conventional graphics techniques

## Volume Gradients

### Local operation



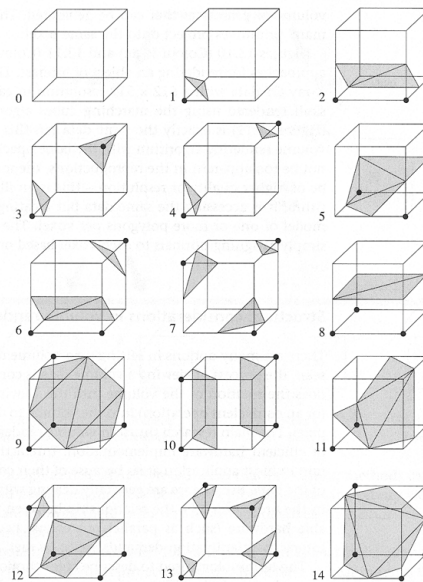
Is a surface present?  
Evaluate the gradient  $N$



## Surface Extraction:

### Marching Cubes

- Create triangles based on data at voxel corners
- Many triangles!
- Appears more detailed (good & bad feature)



# Volume Rendering Algorithms

