

Image Reconstruction 7

Image Production

Image Evaluation and Archiving

ADVANCED HEALTH EDUCATION CENTER®

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Computers – A little History

2000 years ago, the Abacus a counting machine that uses beads on a sliding wire

1822 Charles Babbage invented the difference machine to calculate mathematical tables

1890 U.S. Census use the electronic tabulator based on punch card operation

1951 the universal automatic computer became the 1st commercially available computer.



Computers in CT

Midrange Computers (formerly called Minicomputers)

- Perform complex computations while dealing with a high level of impute and output from connected computer terminals

Microcomputers (PCs)

- Small digital computers such as laptops, tablets and notebooks
- CT workstations are an example of upper end microcomputers.



Computer Hardware Components

Input Device

Central Processing Unit (CPU)
formerly called an Array Processor

Internal Memory

Output Device

External Memory or Storage



Image Reconstruction Process

The DAS “reads” each arriving ray and measures how much of the beam is attenuated

This is a ray sum

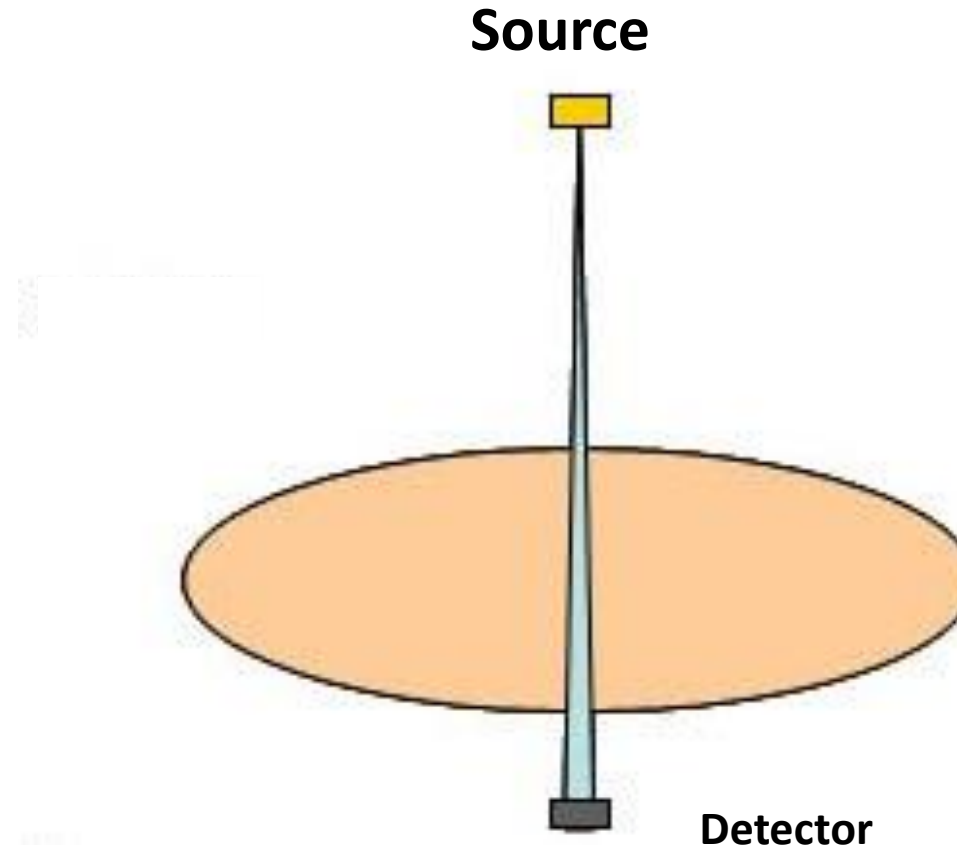
Many ray sums make up a view

Many views are needed to create an image



- **Ray**

- **Pathway of a portion of the x-ray beam from the source to a specific detector position**



View

- The projection of the fan-shaped beam from one specific x-ray tube source

Scan (image)

- Formed by rotating the x-ray tube completely around the body and projecting many views

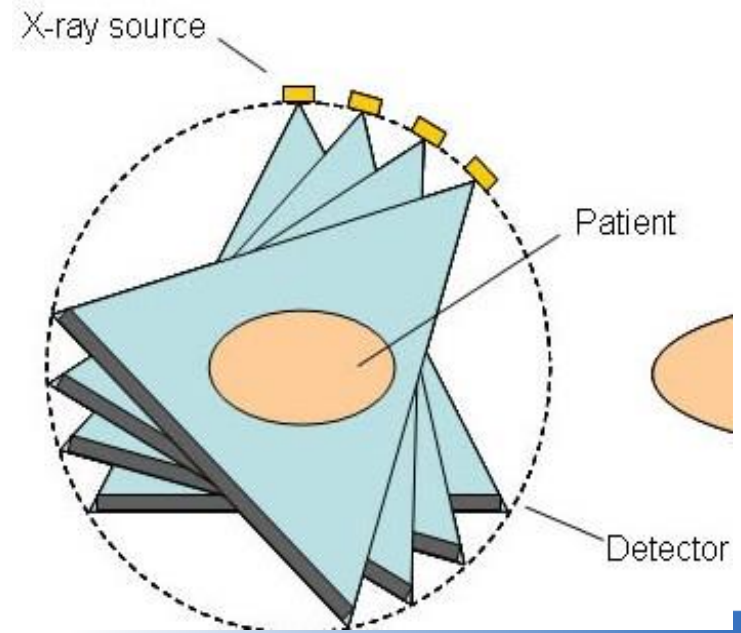
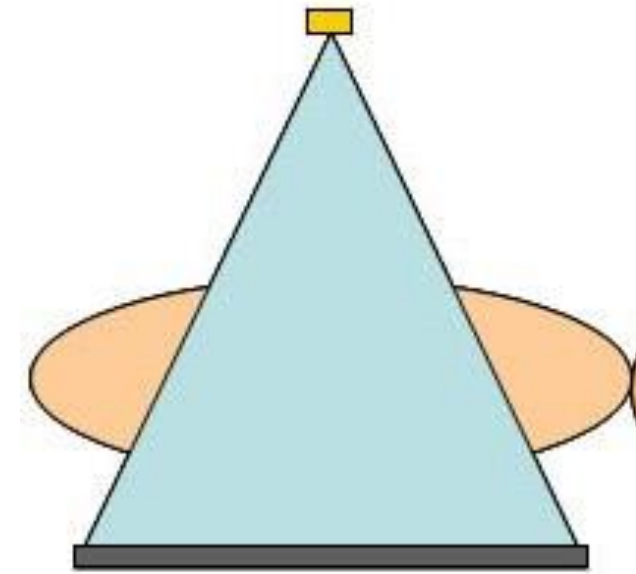


Image Reconstruction Process

An attenuation profile is created for each view

Information from all the profiles is projected onto a matrix

- The process of converting the data from the attenuation profile to a matrix is known as *back projection*



Raw Data vs Image Data

- Raw data are all the data collected
 - ◆ Also called scan data
- Image data
 - ◆ Once the raw data have been segmented and averaged so that each pixel has an associated HU we have an image with image data



Raw Data

- The process of using raw data to create an image is called **image reconstruction**
 - **Prospective Reconstruction** is that which is automatically produced during scanning
 - **Retrospective Reconstruction** refers to using the same raw data later to create a new image
- Raw data storage requires much more computer storage space than that of image data



Image Data

Image Data occurs once the computer has processed the data into pixels

Image data requires about one fifth of the computer space as does raw data

If only image data are available, data manipulation is limited (no change of algorithms)



Basic Principles

- **The reconstruction process is based on the use of an algorithm that uses the attenuated data measurements**
- **Present day scanners collect data for 360 degrees**
- **The more data collected the better quality of the images**



ALGORITHMS

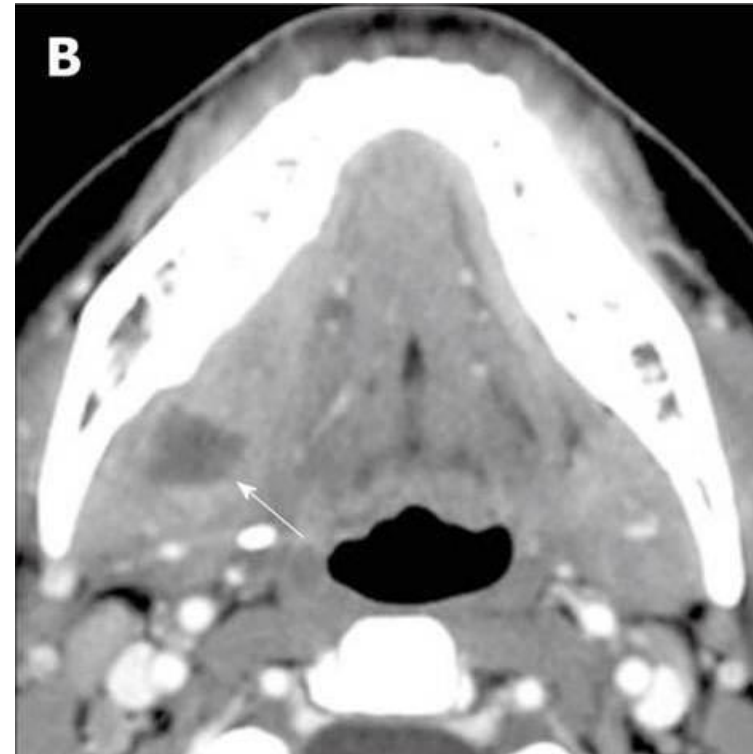
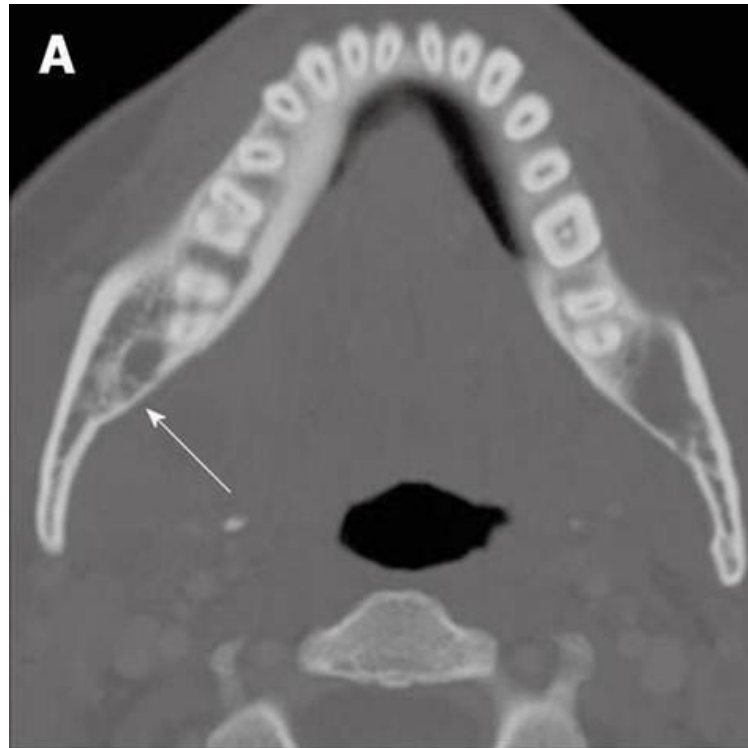
- **A set of rules or directions for getting a specific output from a specific input**
- **Reconstruction algorithms are a set of well-defined software steps designed to produce an image from a given input**
- **Each algorithm uses a different mathematical formula for processing data, which will enhance certain features of the CT image.**



Example:

Bone algorithm-enhances the edges of anatomic structures and higher contrast image is produced

Soft tissues algorithms –reduced contrast and smooths the image



Reconstruction Algorithms

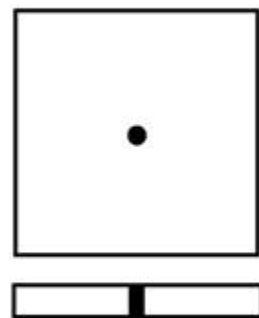
- **Back Projection**
 - Called the summation method
 - Simple but produced “star” or blurring artifacts
- **Iterative**
 - Hounsfield used this in the EMI brain scanner
 - Not used today
 - Difficult to obtain accurate measurements
 - Too long to produce images
- **Adaptive Statistical Iterative reconstruction**
 - Similar to Filtered Back Projection
 - Algorithms to overcome problems of Back Projection



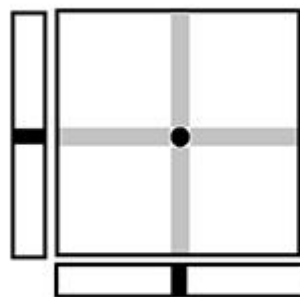
Back-Projection

- Also called Summation Method or Linear Superposition Method
- Back-Projection does not produce a sharp image of the object, therefore it is not used in Clinical CT

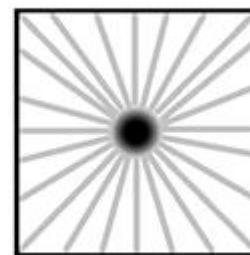
High contrast object back projected onto image matrix



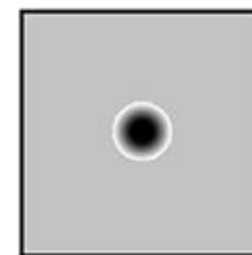
Attenuation profile



Multiple profiles collected



Profiles projected back onto image matrix

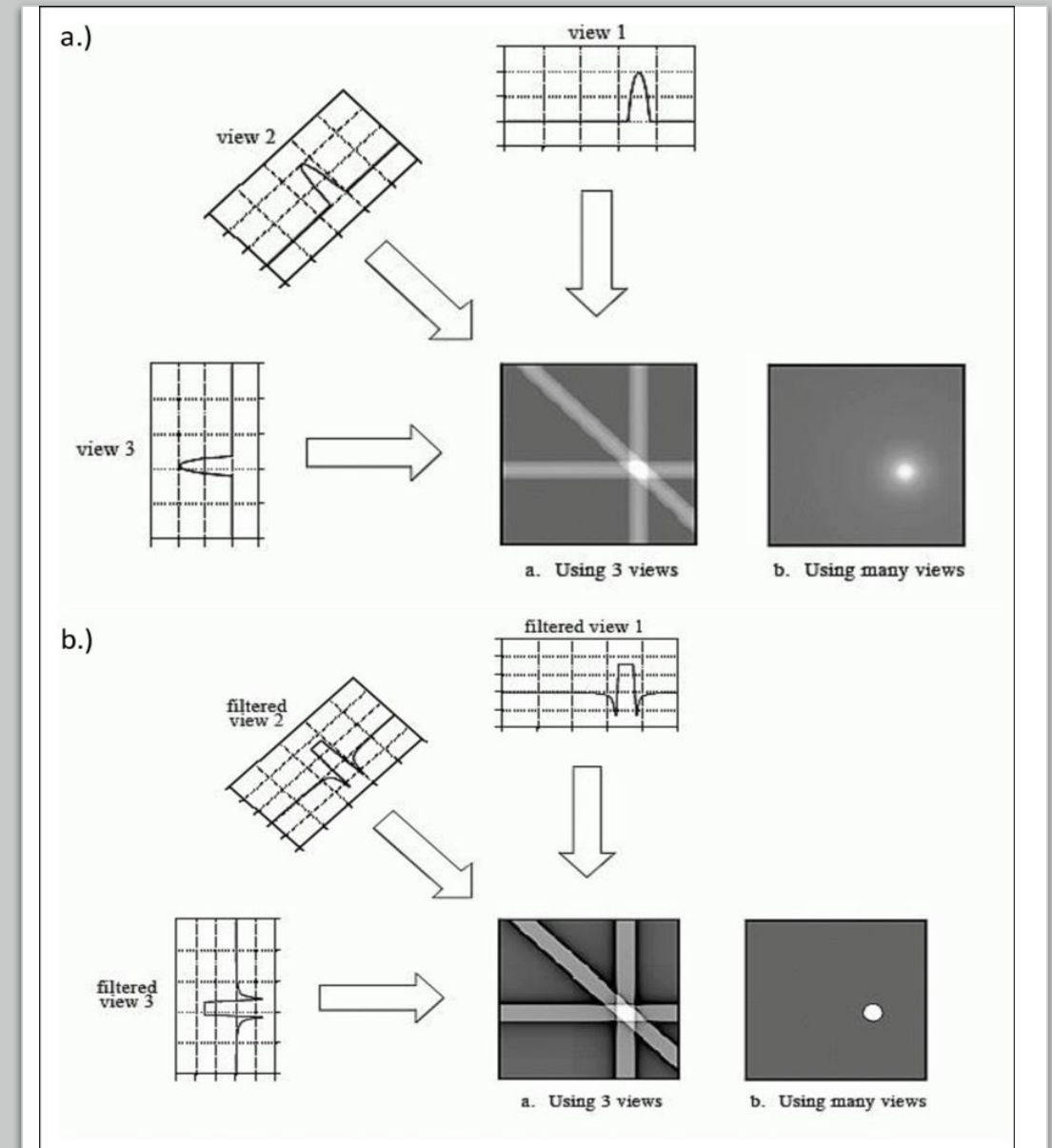


Back projected object blurred by reconstruction



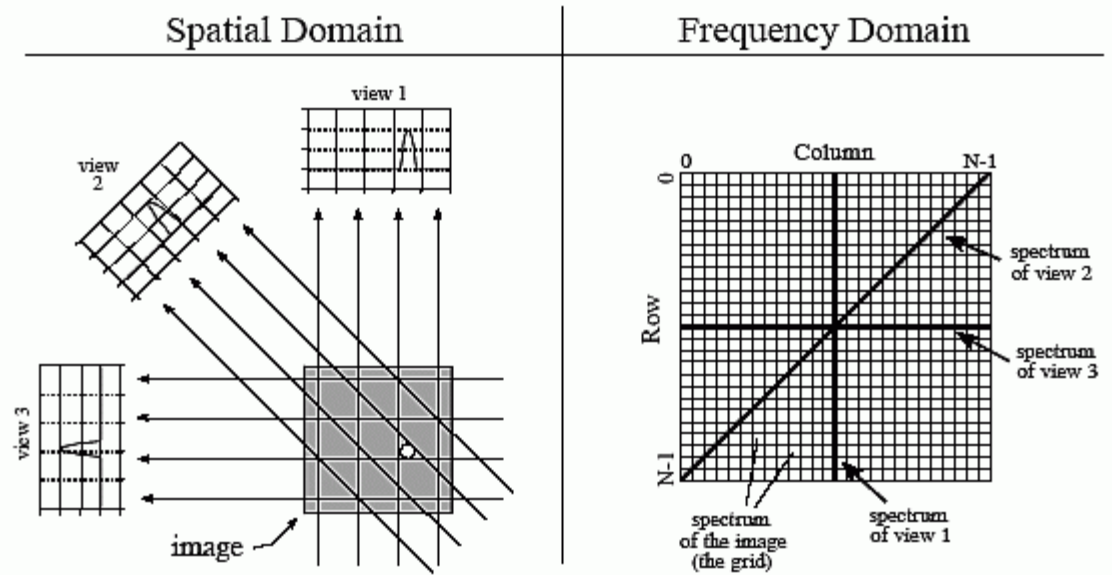
Filtered Back Projection

- Also referred to as the Convolution Method
- Projections profiles are Filtered or Convolved to remove the blurring that was associated with the Simple Back-Projection



Fourier Transform & Reconstruction

- **Fourier Transform** is a mathematical operation which converts a spatial domain signal into a frequency domain signal.
- A rough analogy would be incoming sound waves to the ear are separated into different signals and intensities. These signals arrive at the brain and are rearranged to produce a perception of the original sound.



- Fourier Reconstruction is used in MRI but NOT in Modern CT because it required more complicated mathematics than Filtered Back Projection



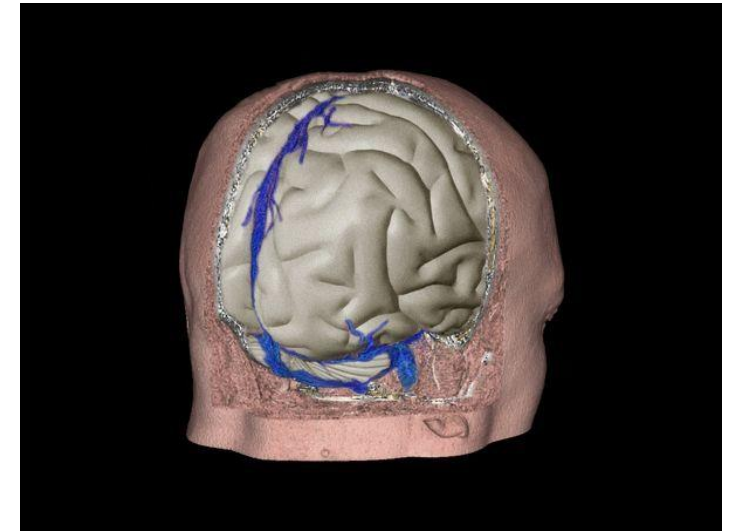
Adaptive Statistical Iterative Reconstruction

- Newer method of image reconstruction
- Complex method that computes projections from the image, compares it with the original projection data, and updates the image based on the difference
- Can reduce image noise
- Shown to reduce the radiation dose to the patient by as much as 50%



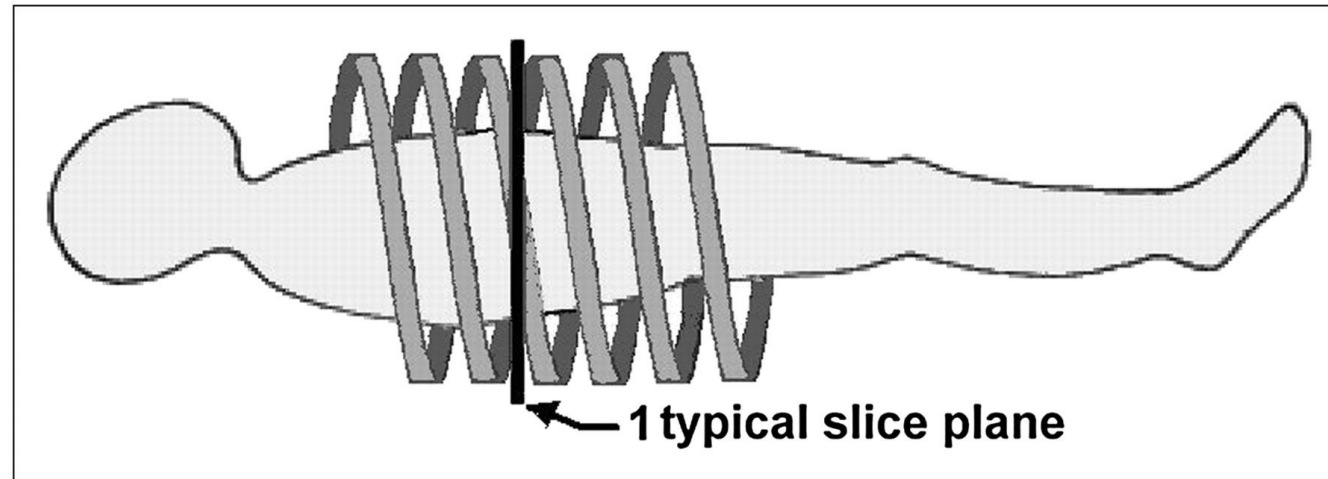
3-Dimensional Reconstruction

- **3D reconstruction** is the process of capturing the shape and appearance of real objects.
- 3D imaging is the process of manipulating 2D data into three-dimensional format, creating the illusion of depth.



INTERPOLATION

- Is a mathematical method of estimating the value of an unknown function using the known value on either side of the function
- Used in the CT image reconstruction process and determination of slices in spiral/helical imaging



Reconstruction Algorithm vs Window Setting

- **Changing the algorithm changes the way the raw data are manipulated to reconstruct the image**
- **This contrasts with changing the window setting, which merely changes the way the image is viewed**

