

# Medical Image Analysis

CS 593 / 791

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# Outline

- 1 CT Imaging
- 2 CT Reconstruction
- 3 CT Systems
- 4 CT Images

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# CT imaging



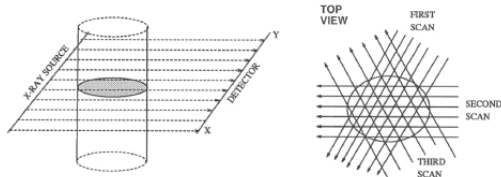
- CT : Computed tomography
- CAT: Computed Axial Tomography

Noninvasive technique combining X-rays and a digital reconstruction technique to give 3D images of the body.

## CT

**Computed tomography**

- Physical basis: X-rays are attenuated (absorbed or scattered) by hard tissue and may pass through soft tissue. Injected or swallowed contrast agents can change attenuation in soft tissue.
- Hardware: Rotating ring of x-ray tubes and detectors.
- Image formation: Multiple projections are used to reconstruct a 2D slice. Multiple slices are combined to form a 3D volume.



- Applications: Skeletal and organ structure.
- Problem: Risk associated with radiation exposure.

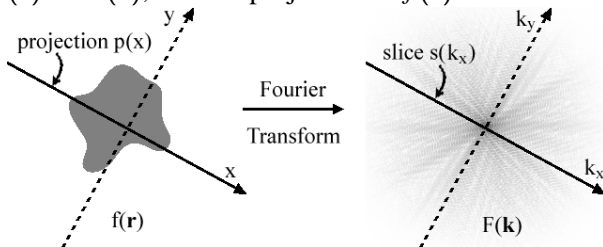
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# Tomographic reconstruction

Projection slice theorem :

If  $f(r) \leftrightarrow F(k)$ , FT of a projection of  $f(r) =$  slice of  $F(k)$ .



- More projections give a more complete  $F(k)$
- Resample  $F(k)$  onto a rectangular grid
- Apply inverse FT to obtain  $f(r)$
- Not practical to use this for reconstruction.

# Back projection

Form a 2D image from a 1D projection by replicating the projection along all lines perpendicular to the projection direction.

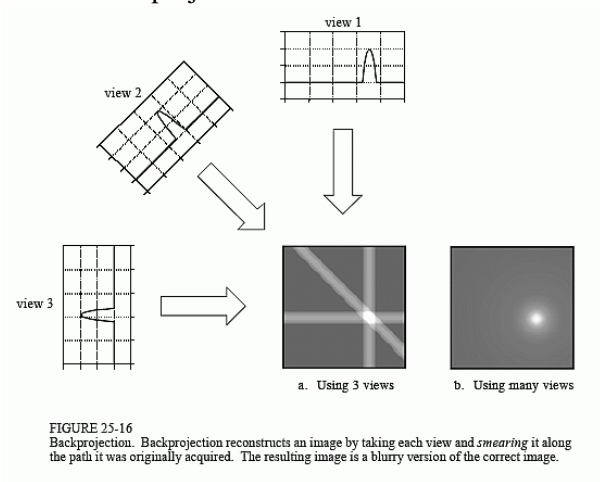


FIGURE 25-16

Backprojection. Backprojection reconstructs an image by taking each view and *smearing* it along the path it was originally acquired. The resulting image is a blurry version of the correct image.

# Filtered back projection

Two approaches:

①

- ▶ Back project  $1D \rightarrow 2D$
- ▶ 2D Filter
- ▶ Sum over all angles

②

- ▶ 1D Filter
- ▶ Back project  $1D \rightarrow 2D$
- ▶ Sum over all angles

Second technique is more efficient (1D filtering).

## Back projection

Filtering corrects for the point spread function of the system. Resulting images are less blurry.

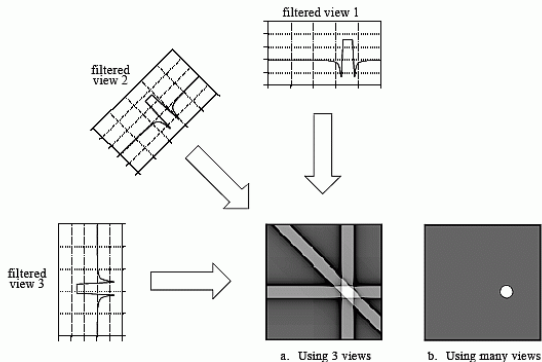
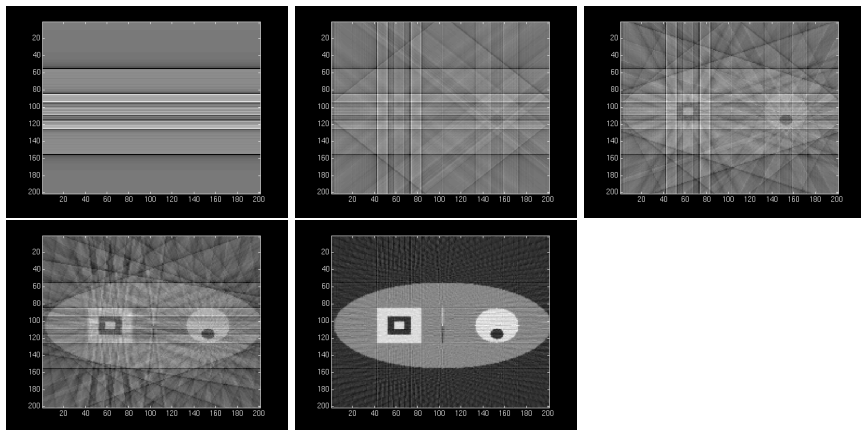


FIGURE 25-17

Filtered backprojection. Filtered backprojection reconstructs an image by filtering each view before backprojection. This removes the blurring seen in simple backprojection, and results in a mathematically exact reconstruction of the image. Filtered backprojection is the most commonly used algorithm for computed tomography systems.

# Filtered back projection results



1, 4, 8, 15, 60 back projections.

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## Evolution of CT hardware



- Parallel beam
- Fan beam
- Spiral CT
- Multislice
- Cone beam

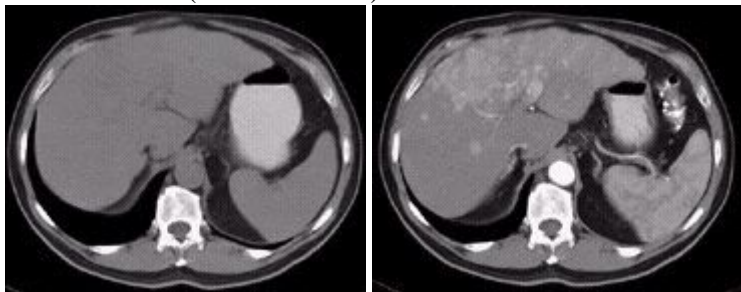
Cannot always use filtered backprojection for reconstruction.

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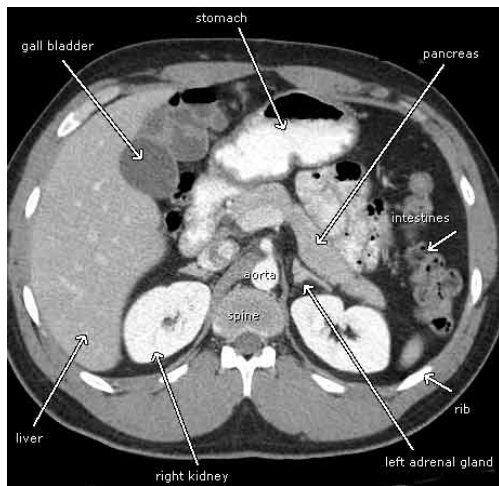
## CT

Contrast enhancement (iodine solution) in CT.



Abdominal CT without contrast (left), with contrast (right).

## CT



Abdominal CT.

## CT



CT Angiogram (Chest).

## CT



Abdominal CT.

## CT



Brain CT.

## CT



Surface reconstruction showing hip fracture.