Physics of Computed Tomography

Second Semester

Week 9: Image Reconstruction

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- Image Reconstruction
- Image reconstruction is a mathematical process that generates tomographic images from x-ray projection data acquired at many different angles around the patient.

- The scanning process produces the image by the attenuation of the x-ray beam; the patient absorbs the radiation in varying amounts depending upon its interactions with the various tissue types. The exit radiation is collected by the detector array and transmitted to the computer for processing. This process is termed image reconstruction.

- The information (measurements) acquired from the scan is recorded in digital form by the computer. From this information, the computer reconstructs the image. The computer software that runs the image reconstruction procedure processes the data. The computer programs are generally referred to as algorithms, or more specifically, reconstruction algorithms. The processing procedure can affect both the quality and the appearance of the image—selection of the matrix size can affect the resolution. In general, the larger the matrix, the greater will be the resolution (and quality) of the image.

- The reconstruction process is based on the use of an algorithm that uses the attenuation data measured by detectors to systematically build up the image for viewing and interpretation.

- The algorithm is a part of the computer program and cannot be altered. Many different algorithms are used for processing the data; however, the algorithms are specific for the type of equipment and software options used.

- Image reconstruction involves several algorithms to calculate all the μ from a set of projection data. The algorithms applicable to CT include back-projection, iterative methods, and analytic methods.

- Currently, there are currently two forms of image reconstruction:

Filtered back-projection (FBP) and

Iterative reconstruction (IR).

Back-Projection

Back-projection is a simple procedure that does not require much understanding of mathematics. Back-projection, also called the "summation method" or "linear superposition method. Back- projection can be best explained with a graphical or numerical approach.

The filtered backprojection (FBP)

1- algorithm is simple and fast, and can be used to reconstruct images in nuclear medicine and x-ray CT.

2-Filtered back-projection (FBP) was the dominant algorithm used in image reconstruction for the first 30 years of CT because of its computational efficiency and accuracy.

3- The algorithm lends itself nicely to parallel processing and allows images to be reconstructed in nearly real time as the patient is being scanned

4- From an accuracy point of view, the algorithm can reconstruct the "exact" replica of the scanned object when the input sinogram is "ideal." These highly desired properties, however, come with significant limitations.

FBP generally fails to model the non-ideal behaviors of the CT system.

1-Departures from ideal behavior can come from the fundamental properties of X-ray physics

(e.g., beam hardening and scatter), the statistical nature of the data acquisition

(e.g., limited X-ray photon flux and electronic noise),

2-geometric factors of the system (e.g., partial volume or finite X-ray focal spot size and detector cell size),

3-and patient related factors (e.g., patient positioning and motion). These limitations often lead to higher radiation doses for patients in order to get acceptable image quality or result in reconstructed images of limited quality

- **To overcome the shortcomings of FBP, iterative reconstruction (IR)**
- Filtered Back-Projection (FBP) is accurate when radiation dose is **high** and the input is ideal, but in **low dose settings**, it is challenged with higher image noise and artifacts. Iterative Reconstruction (IR) is successful in **reducing radiation dose,** but has image texture challenges with full strength due to limited complexity of the model.

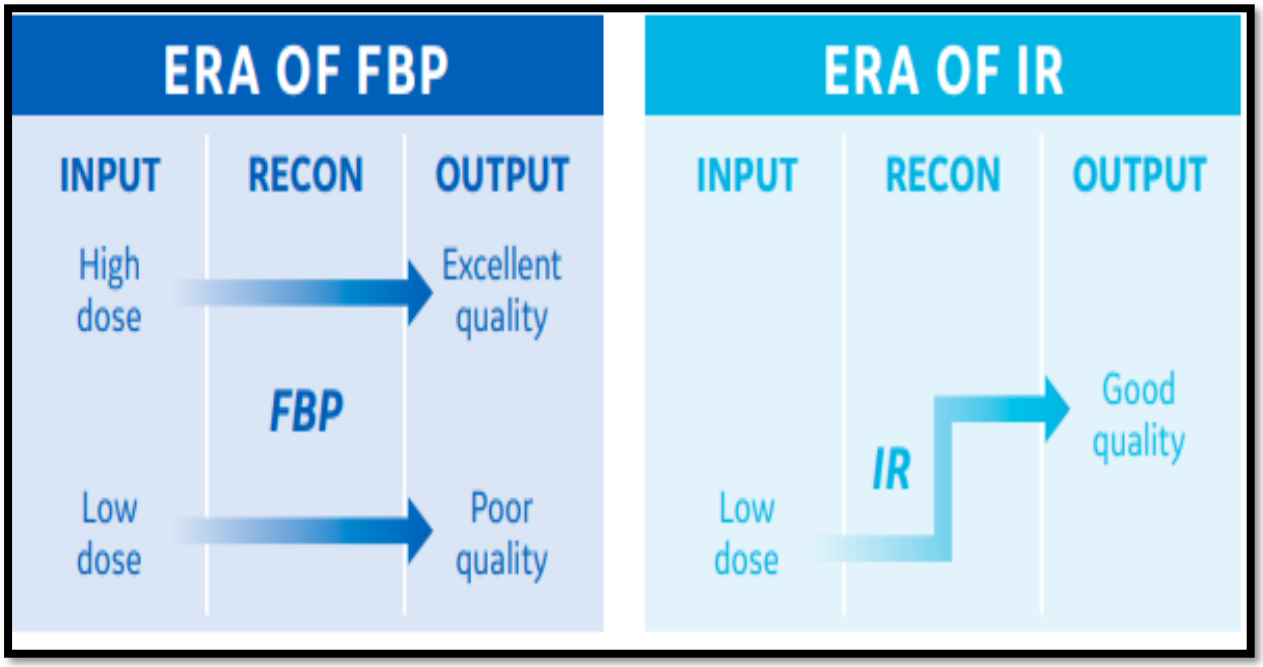

Image Display and Storage

1-CT images are digitally captured and manipulated. The reconstructed image can be displayed on a cathode ray tube (CRT) monitor for viewing.

2-The image can also be recorded and stored for future viewing.

3- One common method for viewing and storage of the study is by producing hard copy images on medical x-ray film using laser cameras. The images can also be stored on discs, or optical storage media. The images can usually be manipulated through the use of various software packages.