Theoretical Lecture: Generations of CT scanners

Introduction

A variety of CT geometries have been developed to acquire the X-ray transmission data for image reconstruction. These geometries are commonly called generations.

The main objective of different generation is:

(i) Scanning time reduction.
(ii) Simplification of mechanical motion.

FIRST GENERATION:

The first generation CT scanner is a rotate/translate, pencil beam system. It had two X-ray detectors and used parallel ray geometry (Figure 1). It took about 4.5 minutes per scan and it is rotated between translations to acquire 180 projections at 1° interval. The patient surrounded by a water bath due to the increase in the x-ray flux.

The advantages of the system is the efficient scatter reduction.

The disadvantage includes; the amount of time it took to acquire the images and to reconstruct the images using the computer.

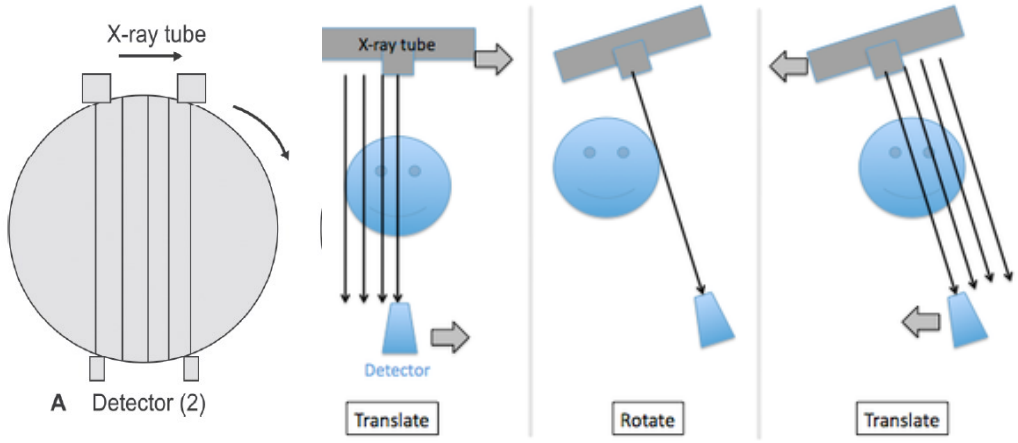

Figure1: first generation of CT scan

SECOND GENERATION:

The second generation CT scanner is also rotate/translate system (figure 2), with narrow beam geometry (10°). Linear array of 30 detectors were used to acquire more data, to improve image quality. These scanners provided larger rotational increments and faster scans. The shortest scan time was 18 seconds per slice. Narrow fan beam allows more scattered radiation to be detected.

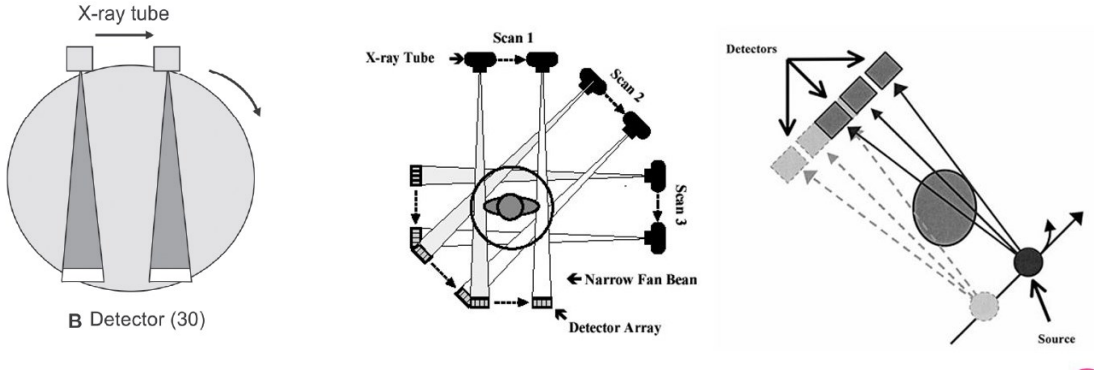

Figure2: Second generation of CT scan.

THIRD GENERATION:

The third generation scanner is a rotate/rotate system with wide beam geometry (Figure 3). The number of detectors has increased substantially (> 800 detectors) and the angle of fan beam is increased to cover entire patient. It eliminated the need for translational motion. The X-ray tube and detector array are mechanically joined and rotate together. Newer systems have scan times of the order of < 0.5 second.

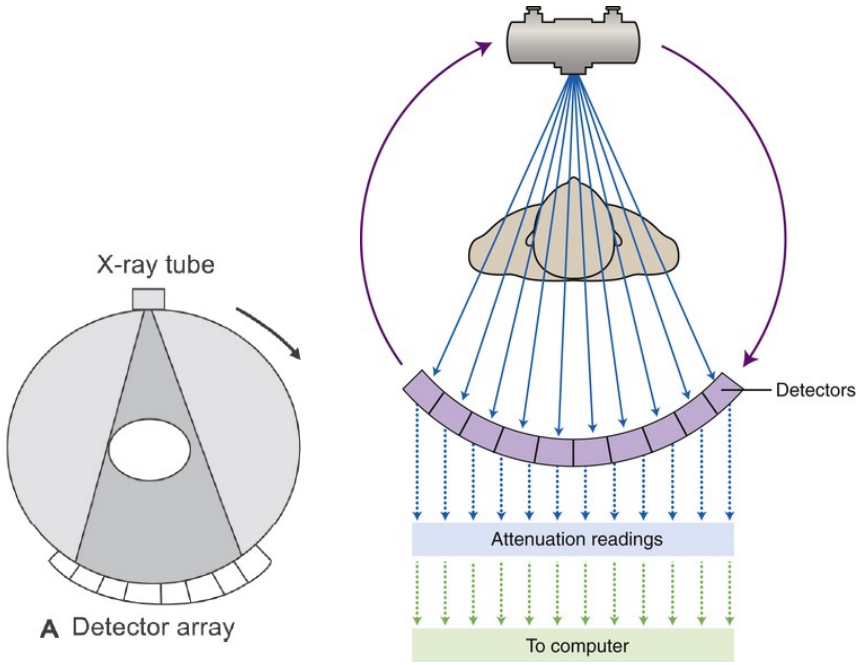

Figure 3: third generation of CT scan.

FOURTH GENERATION:

The fourth generation scanners (figure 4) are designed to overcome the problem of ring artifacts. It has a stationary ring of about 4,800 detectors, and the X-ray tube has to move inside this detector. Since it is rotated continuously, very fast scan time is possible. It has inter scan delay times, since the X-ray tube had to return to its starting position (home).

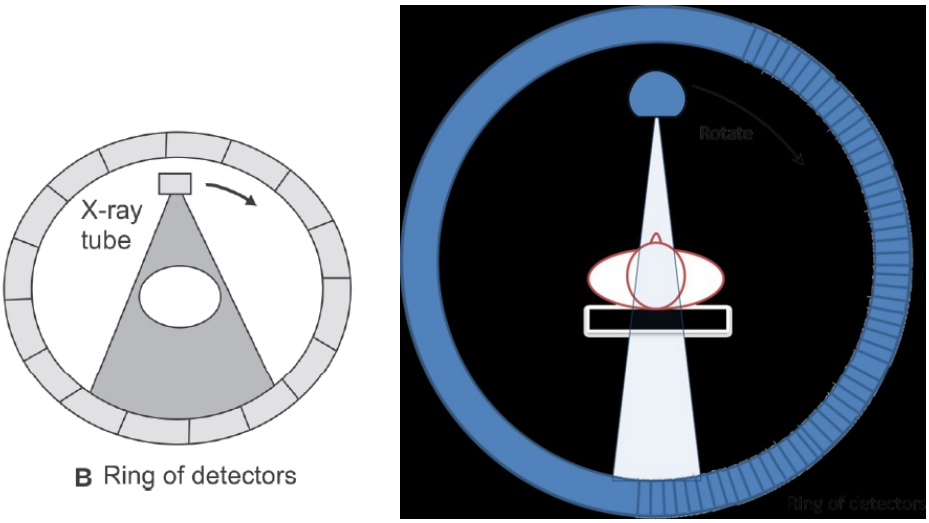

Figure 4: fourth generation of CT scan.

FIFTH GENERATION

The fifth generation scanner (figure5) is a stationary/stationary system, developed specifically for cardiac tomography imaging. No conventional X-ray tube is used, instead large arc of tungsten (210°) encircles patient and lies directly opposite to the detector ring. It uses an electron gun that deflects and focuses a fast moving electron beam along tungsten target ring in the gantry. Since the detector is also in the form of ring, it permits simultaneous acquisition of multiple image sections.

The images are obtained in 50 ms times and can produce fast frame rate CT movies of the beating heart with minimum motion artifacts.

The advantages is the speed of data acquisition. The whole heart can be acquired in 0.2 s. These scanners are useful in cardiac imaging, pediatric and trauma patients.

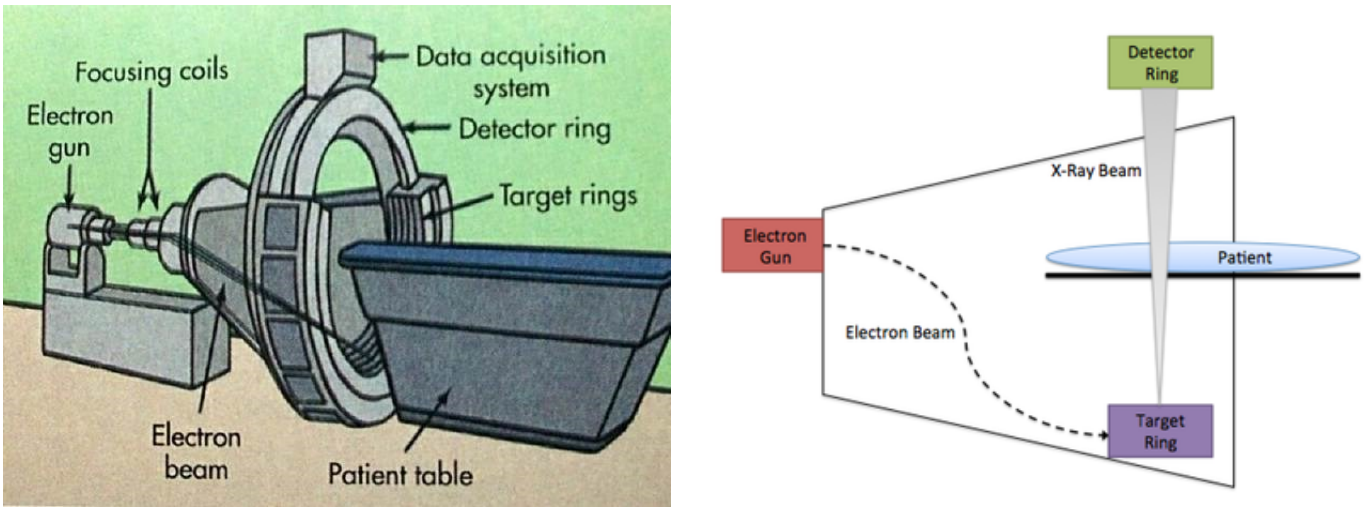

Figure 5: fifth generation of CT scan.