# Theoretical lecture: Computed Tomography

## Introduction

**Computed Tomography (CT)** is a medical imaging technique that uses X-rays to obtain structural and functional information about the human body. The digital geometry processing can be used to generate a three-dimensional image of the internal structures of the human body from a large series of two-dimensional X-ray images taken around a single axis of rotation. (figure1).

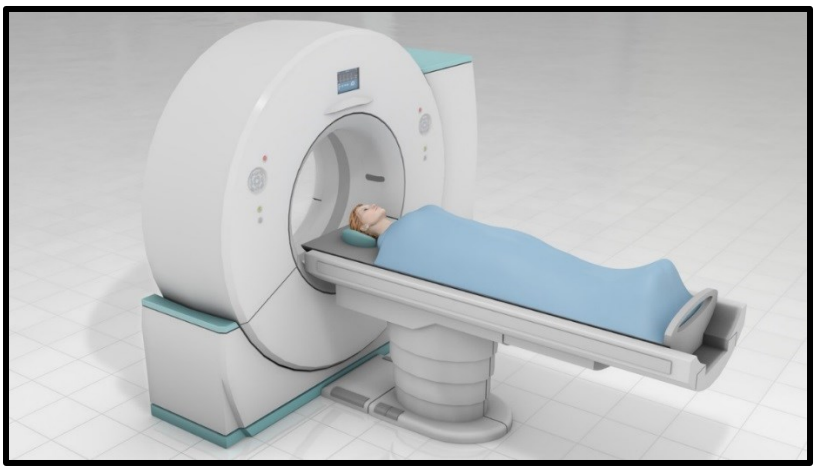

Figure1: CT machine.

Computed tomography known as cross-sectional imaging are used for diagnostic procedures and visualization to guide therapeutic procedures in various medical disciplines.

The radiation dose imparted to the patient's body during a procedure is a relatively high dose compared to radiography. But in spite of that, the computed tomography (CT) is now one of the most effective imaging methods and value to medical diagnosis and guidance of therapeutic procedures.

In conventional radiography, all structures of the patient are exposed to X-rays. Therefore, the image of a particular structure with in a patient is obscured by overlying and underlying objects. To overcome this, the image of the overlying and underlying objects may be blurred by moving the X-ray tube and film during exposure, about an axis through the structure of interest. The blurring of undesired images by movement of the X-ray tube and film is referred

to as ***tomography*** (cross sectional imaging) that produces sectional view of the patient in a plane, parallel to the table top (figure 2).

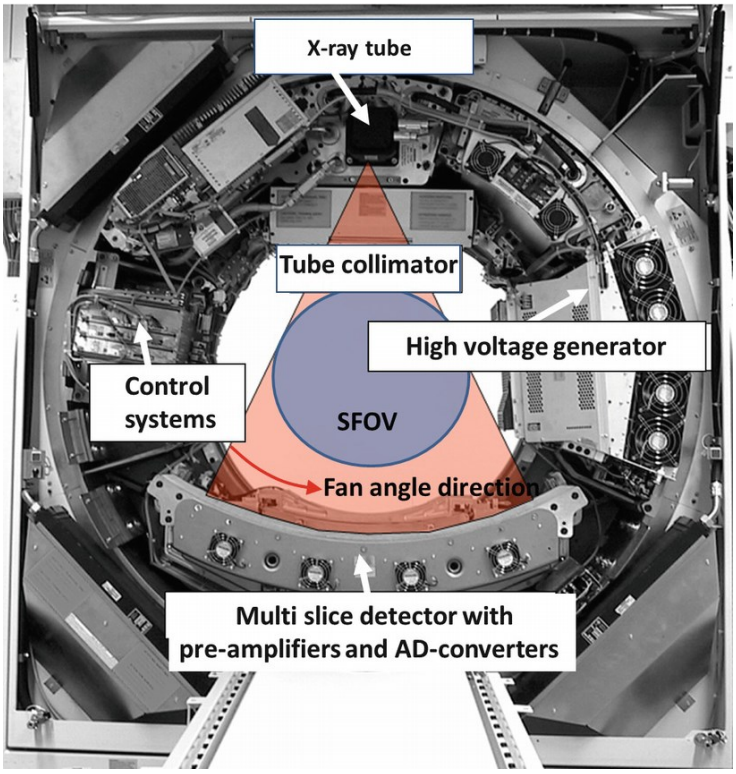


Figure2: parts of CT gantry.

## History of Computed Tomography

- In 1963, David E. Kuhl and Roy Q. Edwards introduced transverse tomography using radioisotopes, which was further developed and evolved into today's emission computed tomography.
- In 1963, the physicist Allan M. Cormack reported the findings from investigations of perhaps the first CT scanner actually built.
- The development of the first clinical CT scanner began in 1967 with English engineer Godfrey N. Hounsfield at the Central Research Laboratories of EMI, Ltd. in England.
- The first successful practical implementation of the theory was achieved in 1972 by Hounsfield, who is now generally recognized as the inventor of CT.

## The special features of CT image

[1] Images are cross sectional.
[2] Eliminates the superimposition of structures.
[3] Not influenced by the properties of the neighboring region.
[4] Subtle differences in X-ray attenuation is 10 times higher than radiographic image, due to scatter elimination.

## Uses of CT in Medicine

A CT scan can be used to visualize nearly all parts of the body and is used to diagnose disease or injury as well as to plan medical, surgical or radiation treatment.

[1] CT scans can detect bone and joint problems, like complex bone fractures, tumors and Osteoporosis.
[2] CT scans can spot cancer, heart disease, emphysema, or liver masses.
[3] Can help locate a tumor, blood clot, excess fluid, or infection.
[4] Show internal injuries and bleeding, such as those caused by a car accident.

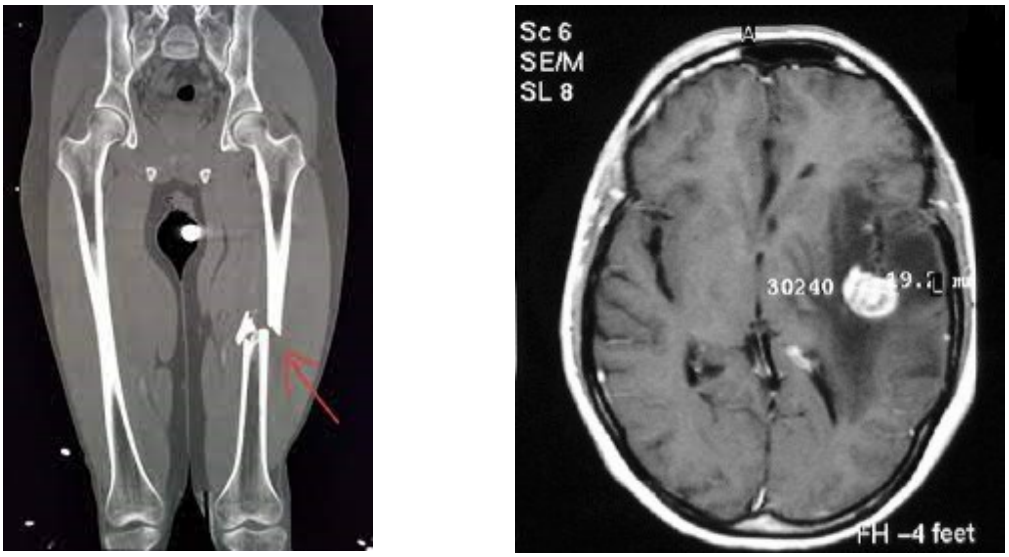


Figure 3: CT scan for left; bone fracture. Right; tumor.

## Principle work of CT

The tissues and materials generally differ in their ability to absorb X-rays, therefore the different tissues seem different when the X-ray film is developed. For example, the dense tissues such as the bones appear white on a CT film while the soft tissues such as the brain or kidney appear gray while the cavities filled with air such as the lungs appear black.

CT uses ionizing radiation, or x-rays, coupled with an electronic detector array. The x-ray beam rotates around the object within the scanner such that multiple x-ray projections pass through the object.

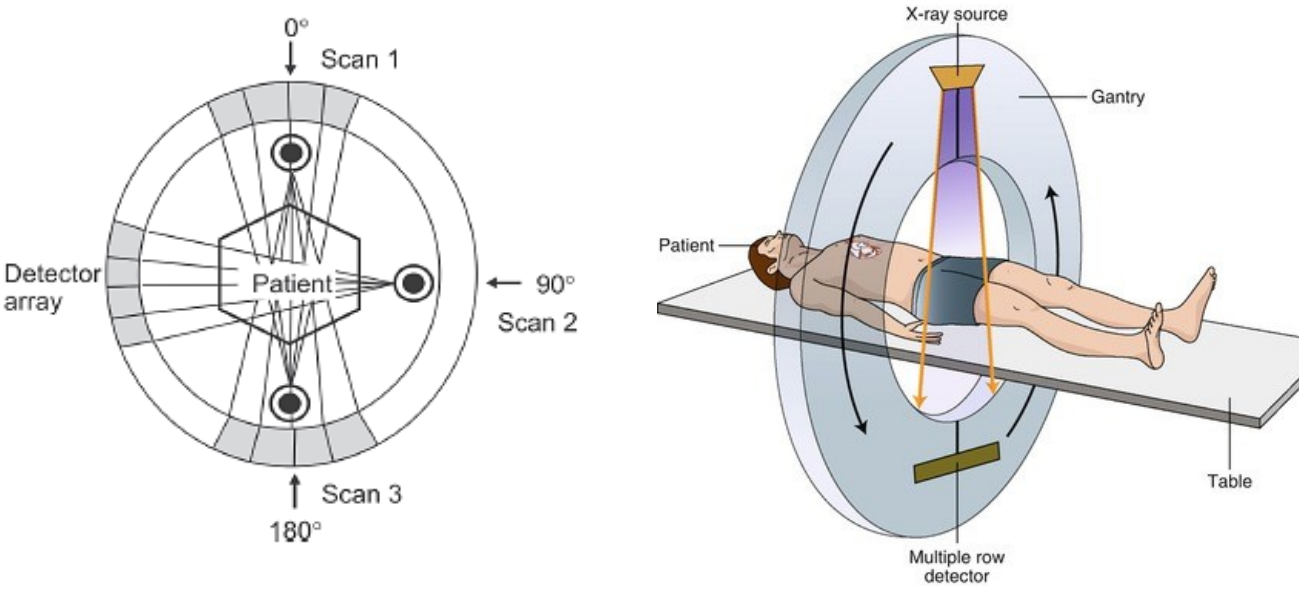


Figure4: computed tomography scanning principle.

Unlike a conventional x-ray which uses a fixed x-ray tube, a **CT scanner** uses a motorized x-ray source that rotates around the circular opening of a donut-shaped structure called a gantry. During a CT scan, the patient lies on a bed that slowly moves through the gantry while the x-ray tube rotates around the patient, shooting narrow beams of x-rays through the body. Instead of film, CT scanners use special digital x-ray detectors (solid state crystal or with xenon gas ionization chambers), which are located directly opposite the x-ray source. As the x-rays leave the patient, they are picked up by the detectors and transmitted to a computer (figure 4).

Each time the x-ray source completes one full rotation, the CT computer uses sophisticated mathematical techniques to construct a 2D image slice of the patient.

The thickness of the tissue represented in each image slice can vary depending on the CT machine used, but usually ranges from 1-10 millimeters. When a full slice is completed, the image is stored and the motorized bed is moved forward incrementally into the gantry. This process continues until the desired number of slices is collected.