The Origin and Review of Historical Development of Computed Tomography (CT) Scan towards improving human Health diagnosis

[1]Nwabueze Charles N, [2]Oluka S.I., [3]Nnenna Harmony Nwobodo-Nzeribe, [4]Agbokwor Blessing,

[1,3,4] Department of Biomedical Engineering, Enugu State University of Science and Technology, ESUT, Enugu State, Nigeria

[2]Department of Agricultural and Bio-Resources Engineering, Enugu State University of Science and Technology, ESUT, Enugu State, Nigeria

[1]Corresponding Author: Email: ultimatecharles45@yahoo.com. Tel: +2347063650939

Received : 5/7/2023
Accepted : 29/7/2023
Publication : 1/8/2023

Abstract

Computed tomography, are often formerly referred to as computerized axial tomography (CAT) scan, which is an X-ray procedure that combines many X-ray images with the aid of a computer to generate cross-sectional views and, if needed, three-dimensional images of the internal organs and structures of the body. It is commonly known by its abbreviated names, CT scan or CAT scan.CT scanners were first introduced in 1971 with a single detector for brain study under the leadership of Sir Godfrey Hounsfield, an electrical engineer at EMI (Electric and Musical Industries Ltd). Thereafter, it has undergone multiple improvements, with an increase in the number of detectors and a decrease in the scan time. The basic principle behind CT is "the internal structure of an object can be reconstructed from multiple projections of the object". Because of the importance of CT and its development, there have been many articles written about its history, including work in other fields. Over the past 30 years, technological developments of CT have contributed to the success of CT in many clinical applications such as trauma, oncology, cardiac imaging, and stroke. Advanced clinical applications have and will continue to demand more advanced technology development. The research findings affirm that CT scanning has evolved through seven generations due to technology advancements, leading to enhanced CT performance and significant clinical impact, especially in the diagnosis of cardiac diseases. These advancements have revolutionized the field, empowering clinicians to accurately diagnose and manage heart conditions with unprecedented precision and efficiency.

Keyword: Computed tomography, early history, detector, technical development, generation

1. Introduction

Computed tomography (CT) is an imaging procedure that uses special x-ray equipment to create detailed pictures, or scans, of areas inside the body. It is sometimes called computerized tomography or computerized axial tomography (CAT). Computerized tomography is more commonly known by its abbreviated names, CT scan or CAT scan. A CT scan is used to define normal and abnormal structures in the body and/or assist in procedures by helping to accurately guide the placement of instruments or treatments. CT scans are performed to analyse the internal structures of various parts of the body. This includes the head, where traumatic injuries, (such as blood clots or skull fractures), tumors, and infections can be identified. In the spine, the bony structure of the vertebrae can be accurately defined, as can the anatomy of the intervertebral discs and spinal cord. In fact, CT scan methods can be used to accurately measure the density of bone in evaluating osteoporosis (Melissa et al, 2020).

The first detailed picture of a living brain was taken by a CT scanner in 1971 and it was designed to only take pictures of the brain, and revealed a brain tumour. CT scanners, a type of X-ray machine, became important for diagnosis within hospitals during the late 20th century, (Young, 2009). Unlike X-ray machines, CT scanners send multiple X-ray beams through the body at different angles. This is called tomography. Detectors inside the machine record how the beams pass through sections of the body. A computer uses complex mathematics to process these measurements and construct an internal image of the body, displayed on a monitor, (Well, 2005).

The term tomography comes from the Greek words tomos (a cut, a slice, or a section) and graphein (to write or record). Each picture created during a CT procedure shows the organs, bones, and other tissues in a thin “slice” of the body. The entire series of pictures produced in CT is like a loaf of sliced bread you can look at each slice individually (2-dimensional pictures), or you can look at the whole loaf (a 3-dimensional picture). Computer programs are used to create both types of pictures. The pictures are taken from different angles and are used to create 3-dimensional (3-D) views of tissues and organs. A dye may be injected into a vein or swallowed to help the tissues and organs show up more clearly. According to amber diagnosticswebsite, the CT machine has been called one of the most important advances in radiology since the X-ray. The introduction of CT scanners has helped cut down the need for invasive procedures, allowing detailed glimpses into the body without having to touch a scalpel. Major benefits of the spiral CT include its ability to create 3-D images of areas inside the body; detection of small abnormalities; and its rapid scan time, which means less time for patients to lie still.

2. Literature Review: Invention

CT was invented in 1972 in England at the Central Research Laboratory of EMI, Ltd by British engineer Godfrey Hounsfield of EMI Laboratories, England and by South Africa-born nuclear physicist from Johannesburg Allan Cormack of Tufts University, Massachusetts. Hounsfield and Cormack were later awarded the Nobel Peace Prize for their contributions to medicine and science in 1979.

Figure 1: Godfrey Hounsfield at EMI Laboratories after installing the CT Scan(Courtesy: Wright and Michael, 2020)

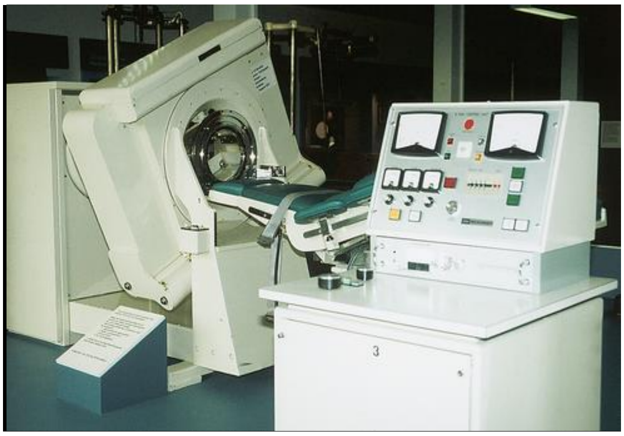


Figure 2: First-generation EMI CT unit: dedicated head scanner. (Courtesy: Wright and Michael, 2020)

Godfrey Hounsfield's early life did not suggest that he would accomplish much at all. He was not a particularly good student. As a young boy his teachers described him as "thick." He joined Electric and Musical Industries (EMI) in 1949 when he was 30. His only formal training was an Associates Certificate from the Faraday House. He had a passion for understanding basic principles of technologies and worked on radar during the wartime effort prior to joining EMI. After the war, as a British Royal Air Force staff, he followed his commander's advice and got a degree in engineering. Hounsfield was transferred to EMI's Central Research Lab (CRL), which was famous for pioneering stereo recording, television broadcasting, and radar and communications work. Working within CRL on pattern recognition techniques, he was asked to think about projects that might be fruitful. He focused on that idea and asked himself the general question: could the unknown contents of a box be calculated by taking "readings" through the box? While on a forced holiday to ponder his future and what he might do for the company, Hounsfield met a physician who complained about the poor quality of X-rays of the brain. Plain X-rays show marvelous details of bones, but the brain is an amorphous blob of tissue – on an X-ray it all looks like fog. This got Hounsfield thinking about his old idea of finding hidden structures without opening the box. He held onto this idea over the years, which can be paraphrased as "looking inside a box without opening it." Ultimately he did figure how to use high-energy rays to reveal what's invisible to the naked eye. He invented a way to see inside the hard skull and get a picture of the soft brain inside, (Edmund S, 2021).

He pondered whether a system could theoretically recognize text in a closed book, page by page, "by shining a bright light across each page from various angles and measure what came out the other end." He had simplified the volumetric "book-box" problem to a two-dimensional problem by breaking it down into a series of parallel slices. He believed that "given enough information you could calculate what was written on the page."

After CT was shown to be a useful clinical imaging modality, the first full-scale commercial unit, referred to as a brain tissue scanner, was installed in Atkinson Morley's Hospital in 1971. Physicians recognized its value for providing diagnostic neurologic information, and its use was accepted rapidly. After CT was accepted by physicians as a diagnostic modality, numerous companies in addition to EMI began manufacturing scanners. Although the units differed in design, the basic principles of operation were the same, (Gaylek et al 2020)

According to Alissa Czyzof imagines website, the first clinical CT scanners were installed between 1974 and 1976. The original systems were dedicated to head imaging only, but "whole body" systems with larger patient openings became available in 1976. CT became widely available by about 1980. There are now about 6,000 CT scanners installed in the U.S. and about 30,000 installed worldwide.The first CT scanner developed by Hounsfield in his lab at EMI took several hours to acquire the raw data for a single scan or "slice" and took days to reconstruct a single image from this raw data. The latest multi-slice CT systems can collect up to 4 slices of data in about 350 ms and reconstruct a 512 x 512-matrix image from millions of data points in less than a second. An entire chest (forty 8 mm slices) can be scanned in five to ten seconds using the most advanced multi-slice CT system.

3. Development (Generation) of CT scan

The development and adoption of CT arguably marked the beginning of a major transformation of diagnostic imaging and of radiology as a field, from analog imaging largely involving film, to digital imaging in which pixel values are calculated by algorithms, and the beginning of imaging in which computers play a major role. Because of the importance of CT and its development, there have been many articles written about its history, including work in other fields,(Schulz et al, 2021).

According to Brian Nett, CT scanning prototypes were developed in the late 1960s and this paper describes the stages of technological development for CT scanners (Generations 1-7).The differences in CT generations can also be clearly highlighted in table form for a quick means to understand the geometric differences.

Table 1.1: the overview of the 7 generation of the CT scan

Generation	Year	Why Developed	Anatomy	Source-Detector Movement	Time to acquire 1 image	Why it died?
1st Gen	1971	To show CT works	Head Only	Translate-Rotate	~5 min	Slow
2nd Gen	1974	Image Faster	Head Only	Translate-Rotate	20sec-2min	Slow
3rd Gen	1975	Image Faster	All Anatomy	Rotate-Rotate	1 sec	This Geometry won.
4th Gen	1976	Make images without rings	All Anatomy	Rotate-Stationary	1 sec	Expensive, not good for scatter.
5th Gen	1980s	Fast Cardiac CT	Cardiac Only	Stationary-Stationary	50 ms	Cardiac specific, low x-ray flux.
6th Gen	1990s	To use slip-ring technology to replace the cables.	Cardiac Only	Stationary-Stationary	120 sec	Expensive
7th Gen	1992	introduced with the potential to achieve significantly higher temporal resolution than is currently possible in medical imaging CT.	Cardiac Only	Flying Detector	15 to 20 seconds	Active

3.1 First Generation

The very first CT scans were performed on first generation geometry on a CT benchtop. In the benchtop systems patients were not imaged but rather an object to be imaged is placed on a stage that can rotate (i.e. like a slow and well calibrated record player).

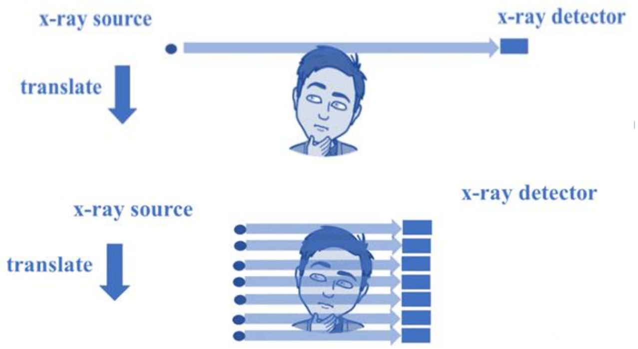


Figure 3: First generation geometry on a CT bench-top.

Then in order to image patients (rather than biological samples) a rotating gantry is needed so that the patient can lie on an imaging table and the x-ray source and detector will rotate around the patient. Both of the benchtop and first generation rotating CT systems share a common configuration that is referred to as a translate/rotate acquisition. In first generation CT scanners, there was one X-ray source and one X-ray detector.

So, in order to acquire an axial image of the patient, one ray would go through body of patient and be measured using a single detector. The x-ray source and the detector moved together to collect the data. In order to reconstruct one slice, the x-ray source would have to translate many times for each view. Then the source and tube were rotated with respect to the patient (or another object being imaged).This process was very time-consuming and scanners were slow. Such scanners with only one source and one detector proved that there was tremendous value in CT but they could be very slow taking ½ hr for an average acquisition of several slices.

3.2 Second Generation

Second generation CT was a refinement on first generation CT but still using the same general concepts.

Figure 4: 2nd generation of CT;The translate and rotate acquisition

The translate and rotate acquisition was still used but while 1st generation CT had only one x-ray source and detector, in 2nd generation CT there was a small fan beam appeared that enabled more coverage than just one detector (5-53 detectors at a time).

Second generation CT was significantly faster taking an average exam from a significant fraction of an hour to the order of minutes. An average scan during on this system was ~1.5 minutes. Each slice went from taking 5 minutes on 1st generation to as low as 20 seconds on 2nd generation.Second generation CT is still a translate rotate acquisition but was significantly faster than 1st generation CT. Multiple versions of second generation CT were built where more detectors used at once lead to more speedup.

3.3 Third Generation

Then a significant improvement was again made going from 2nd generation CT to 3rd generation CT where the translation of source within each view was eliminated by having a fan-beam shaped x-ray beam acquiring all the data (for a slice) within each view.

This acquisition mode can be termed rotate-rotate as both the x-ray source and x-ray detector are rotating together. Using a rigid ring the x-ray tube and detector can be mounted such that they rotate around the patient.

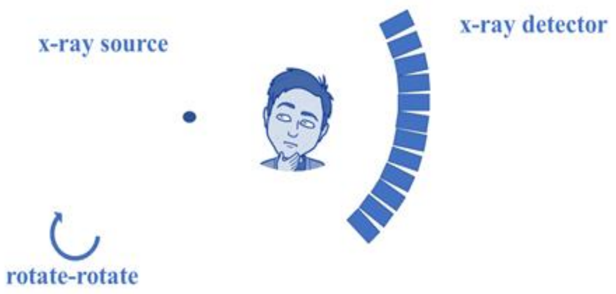


Figure 5: Rotate movement: tube and detector movement of a thirdgeneration scanner.

In 3rd generation CT, a scan takes a few seconds on average compared 2nd generation CT where it was on the order of minutes. 3rd generation CT survived as the base of modern CT for several reasons but mainly the speed of acquisition and mechanical simplicity.So, the modern CT is typically an X-ray source and X-ray detectors mounted in an arc facing the source.

In the sections below we will describe the standard data acquisition methods on these systems.The modern CT systems may even include new configurations such as 2 tubes and 2 detectors mounted on the same gantry.Other state-of-the-art systems now include x-ray detectors large enough to cover an entire organ (e.g. the brain or the heart) in a single rotation of the system.While some have made different classification systems, we believe that all these systems are based on 3rd generation CT where the x-ray source and detector are rigidly mounted on the gantry across from one another. We don't introduce new generation terminology for 2T2D systems or whole organ coverage systems.

3.4 Fourth Generation

The 4th generation CT geometry is considerably different from 3rd generation geometry in that the x-ray detectors surround the entire circle (much like a P.E.T. detector).

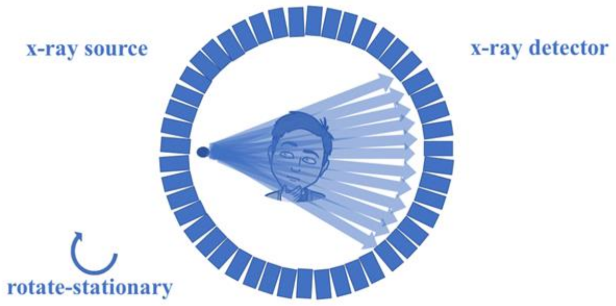


Figure 6: Rotate-only movement: tube movement with stationary detectors of a fourth-generation scanner.

The x-ray source rotates in 4th generation CT and the detector is stationary, so this generation we term rotate-stationary. The scans times were similar on 3rd generation CT and 4th generation CT and 3rd generation CT required many more detector elements (~ three times as many) to cover the full ring around the patient.

3.5 Fifth Generation

The generation of CT which is truly a different acquisition method is that of 5th generation CT. In all of the other methods above there is significant mechanical motion of the parts on the gantry.

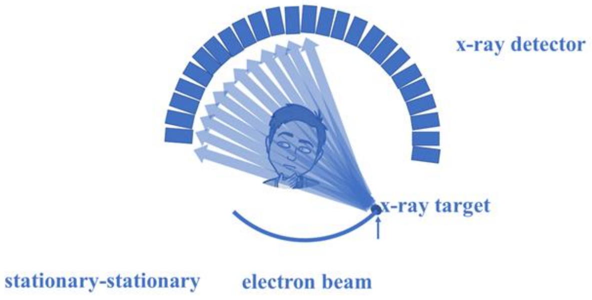


Figure 7: Stationary-Stationary designof a fifth-generation scanner.

In 5th generation CT both the x-ray source material and the detector are stationary. In this sense this is a stationary-stationary design. The x-tube in this design is a scanning x-ray tube, where the electrons are steered magnetically (like in old TVs) rather than physically moving the x-ray tube. This method allows for very fast acquisitions and is ideal for cardiac scanning (with a temporal resolution of a given slice as low as 17ms).

The niche of 5th generation CT was dedicated cardiac scanning. However, these scanners did not have full volumetric coverage and the flux that could be delivered was more limited.
In the end, the third generation CT ended up winning out compared with the relatively niche design of 5th generation CT.Especially when we went wider coverage because you can get higher power on the third generation CT and the gantry rotation time just keeps getting faster and faster.

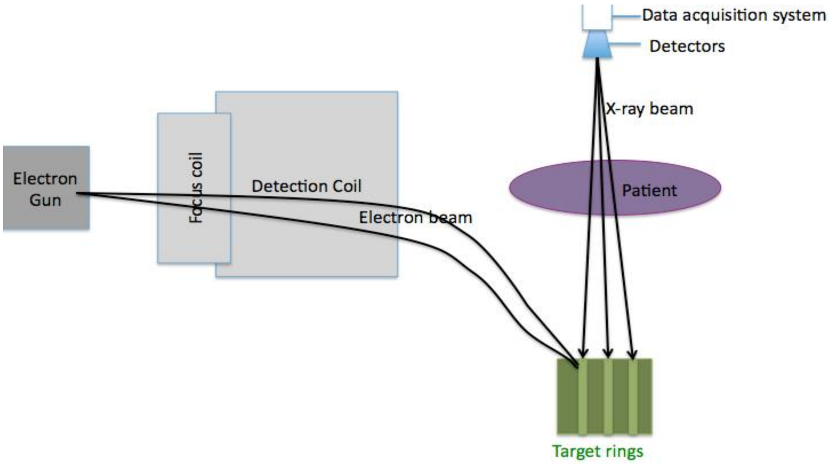


Figure 8: Electron-beam scanners design of a fifth-generation scanner

With the difference in temporal resolution shrinking between what the electron beam CT could provide and what a good third generation CT could provide the 3rd generation geometries have become the heart of modern CT scanners.More so, the fifth-generation scanners are classified as high-speed CT scanners because of millisecond acquisition times.

These scanners are electron-beam scanners (EBCT) in which x-rays are produced from an electron beam in a fan beam configuration that strikes stationary tungsten target rings. The detector rings are in a ±210-degree arc. These scanners were primarily used for cardiac studies. (Jean Essam, 2019)

3.6 Sixth Generation

Generations one through four utilized cables to provide the electricity necessary to move the components of the scanner while also is providingkilo voltage for the x-ray exposure. The cables limited the scanners because the cables could only rotate a certain amount before they had to be “unwound.” The sixth-generation scanner was designed to use slip-ring technology to replace the cables. The slip-ring technology allows continuous rotation of the x-ray tube and detectors around the patient.As the x-ray tube circles around the patient, the patient table is continuously moved through the bore of the gantry. This allows for a continuous set of attenuation data to be obtained in a helical or spiral manner; therefore, this generation of scanner is referred to as a helical/spiral scanner. Spiral scanning differs from conventional CT scanning in that the support table is not stopped at the center of each slice location while the data are collected. (Jean Essam, 2019). More so, the sixth-generation scanners are dual-energy source (two x-ray tubes) (DSCT, DE-CT) that have two sets of detectors that are offset by 90 degrees.

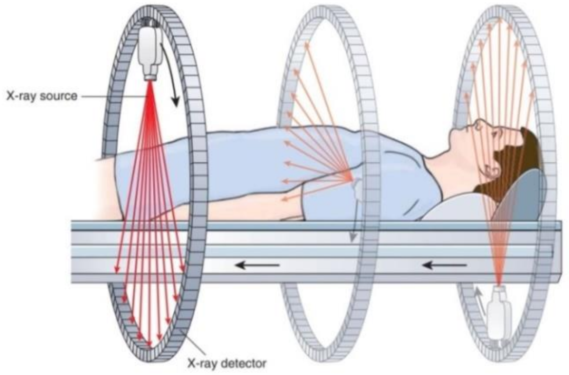


Figure 9: Dual-source CT scanner (DSCT) configuration.

These DSCT scanners provide improved temporal resolution needed for imaging moving structures such as the heart. The original DSCT scanners had several technical challenges and were not widely used. The latest DSCT scanners have solved the technical issues, however, and offer dual-energy capabilities between the two CT tubes. This technology allows a marked decrease in patient radiation dose.

3.7 Seventh Generation

The seventh-generation CT scanners are most commonly called multisection or multislice computer tomography (MSCT). Multisection scanners are able to expose multiple detectors simultaneously due to detector technology which permits an array of thousands of parallel bands of detectors to operate at the same time. This coupled with helical scanning drastically reduces the total exam time for an entire chest or abdomen to 15 to 20 seconds.

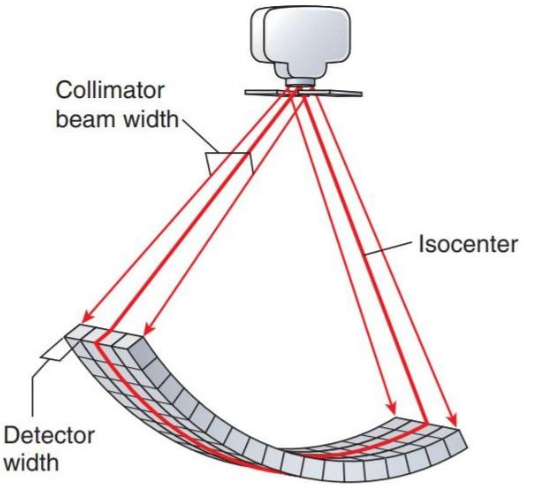


Figure10:Multi section or Multi slice CT scanner (MSCT) configuration

The MSCT is designed to be more efficient, reduce patient exposure to radiation, improve image resolution, and allow unprecedented postacquisition reconstruction of acquired data. Regardless of the generation of CT scanner the latent image is acquired and archived in a similar manner. The exit radiation is detected and converted into a digital signal by the analog-to-digital converter or ADC.Data from many different entrance angles are processed in a computer to determine the transmission and attenuation characteristics of the tissues in the section under examination. The data are stored in a matrix of pixels.

The digital pixel data are processed in a digital-to-analog converter (DAC) before being displayed. The DAC converts the digital data into an analog signal for display.

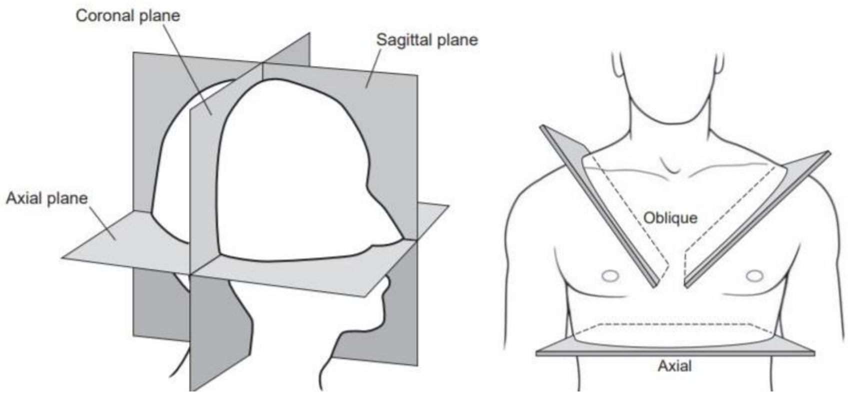
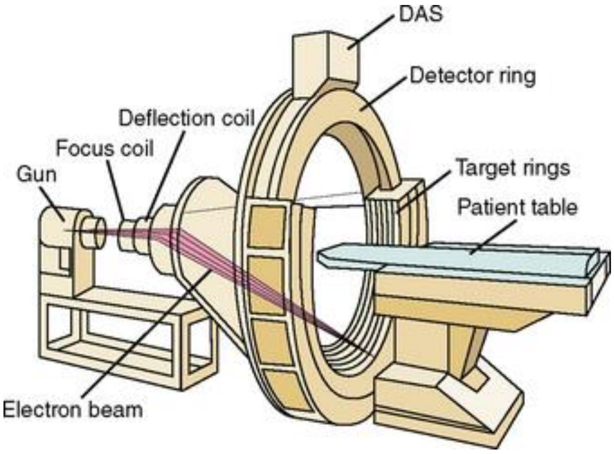


Figure 11: Helical scanning for an entire chest or abdomen

NB: Most scanners in use today are a third-generation variation that has 4 to 320 rows of detectors in a single array. This increase in numbers of detector rows has increased the length of the detector, which requires the x-ray beam to be cone-shaped to encompass the full.

This increase in numbers of detector rows has increased the length of the detector, which requires the x-ray beam to be cone-shaped to encompass the full. Third and fourth generation scanner technologies are both used in many health care settings. The fourth generation is a fundamentally different acquisition method, but the resulting image quality is similar to the third generation for most applications, (Andrew, 2023).

4. Structural Design of Computed Tomography (CT) Scan



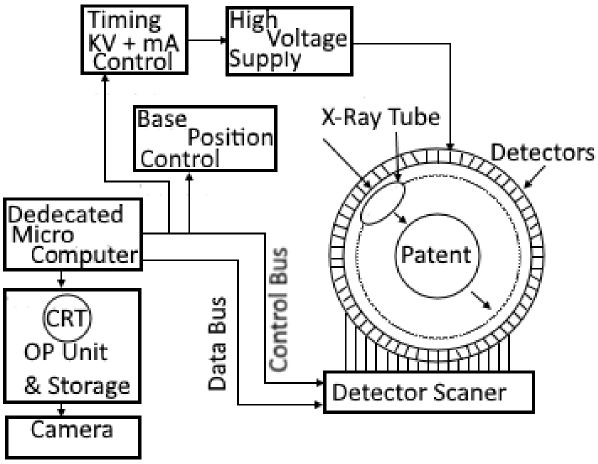


Figure 12: Diagram of CT Scan (Andrew, 2023).

Figure 13: Block diagram of CT Scan (Andrew, 2023)

4.1 System Components

The three major components of the CT scanner are shown in Fig xx, because each component has several subsystems, only a brief description of their main functions is provided in the following sections.

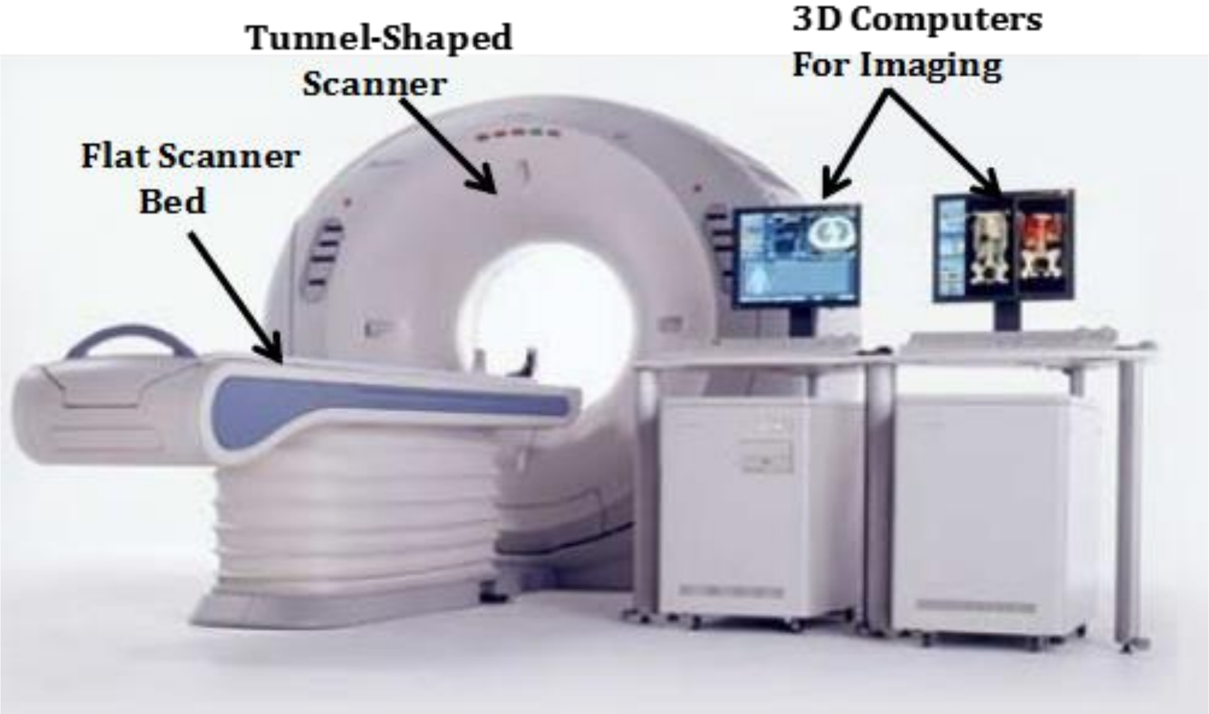


Figure 14: Components of a CT scanner (Andrew, 2023).

4.2 COMPUTER

The Computer provides the connection between the CT technologist and different parts of the imaging framework. The computer framework utilized in CT has four fundamental capabilities: control of Data acquisition, picture reproduction, capacity of picture information, and picture display. Data acquisition is the technique by which the patient is filtered/ scanned. The technologist should choose among various boundaries, like examining in the traditional or helical mode, before the commencement of each scan. During execution of the information obtaining framework (DAS), the Computer is associated with sequencing the generation of x-ray, turning the detector on and off at appropriate intervals, moving information, and observing the framework activity, i.e. monitoring the system operation. The recreation of a CT picture relies upon the large numbers of mathematic tasks expected to digitize and reproduce the raw data. This image reconstruction is achieved involving an exhibit processor that goes about as a particular PC to perform mathematic estimations quickly and productively, liberating the host computer for different exercises. Currently, CT units can obtain examines in under 1 second and require only a few seconds more for image reconstruction. The host computer in CT has restricted capacity limit, so picture information can be put away just for temporarily. Other capacity components are important to consider long haul information capacity and recovery. After recreation, the CT picture information can be moved to another capacity medium like optical plates. CT studies can be eliminated from the restricted memory of the host computer and stored independently, a process termed archiving. The pictures displays are shown on a screen. At this point, the technologist or doctor can speak with the host computer to see explicit pictures; post pictures on a scout; or carry out picture control procedures, for example, zoom, control contrast and brightness,, and picture investigation strategies.

4.3 GANTRY AND TABLE

The gantry is a circular device that houses the x-ray tube, DAS, and detector array. Helical CT units also house the continuous slip ring and high-voltage generator in the gantry. The structures housed in the gantry collect the necessary attenuation measurements to be sent to the computer for image reconstruction. The x-ray tube used in CT is similar in design to the tubes used in conventional radiography, but it is specially designed to handle and dissipate excessive heat units created during a CT examination. Most CT x-ray tubes use a rotating anode to increase heat dissipation. Many CT x-ray tubes can handle around 2.1 million heat units (MHU), whereas advanced CT units can tolerate 4 to 5 MHU. The detectors in CT function as image receptors. A detector measures the amount of radiation transmitted through the body and converts the measurement into an electrical signal proportional to the radiation intensity. The two basic detector types used in CT are scintillation (solid-state) and ionization (xenon gas) detectors. Current detectors use scintillation (solid-state) detectors.

The gantry can be tilted forward or backward up to 30 degrees to compensate for body part angulation. The opening within the center of the gantry is termed the aperture. Most apertures are about 28 inches (71.1 cm) wide to accommodate a variety of patient sizes as the patient table advances through it. For certain head studies, such as studies of facial bones, sinuses, or the sellaturcica, a combination of patient positioning and gantry angulation results in a direct coronal image of the body part being scanned. The table is an automated device linked to the computer and gantry. It is designed to move in increments (index) according to the scan program. The table is an extremely important part of a CT scanner. Indexing must be accurate and reliable, especially when thin slices (1 or 2 mm) are taken through the area of interest. Most CT tables can be programmed to move in or out of the gantry, depending on the examination protocol and the patient.

CT tables are made of wood or low-density carbon composite, both of which support the patient without causing image artifacts. The table must be very strong and rigid to handle patient weight and at the same time maintain consistent indexing. All CT tables have a maximum patient weight limit; this limit varies by manufacturer from 300 to 600 lb (136 to 272 kg). Exceeding the weight limit can cause inaccurate indexing; damage to the table motor; and even breakage of the tabletop, which could cause serious injury to the patient. Accessory devices can be attached to the table for various uses. A special device called a cradle is used for head CT examinations. The head cradle helps hold the head still; because the device extends beyond the tabletop, it minimizes artifacts or attenuation from the table while the brain is being scanned. It can also be used in positioning the patient for direct coronal images.

4.4 Operator's Console

The operator's console is the point from which the technologist controls the scanner. A typical console is equipped with a keyboard for entering patient data and a graphic monitor for viewing the images. Other input devices, such as a touch display screen and a computer mouse, may also be used. The operator's console allows the technologist to control and monitor numerous scan parameters. Radiographic technique factors, slice thickness, table index, and reconstruction algorithm are some of the scan parameters that are selected at the operator's console.

Before starting an examination, the technologist must enter the patient information. A keyboard is still necessary for some functions.

One of the most important functions of the operator's console is to initiate the process to store or archive the images for future viewing. To produce hard copies of images in the form of film, the most commonly used filming device is the laser printer. Most modern imaging departments now have picture archiving and communications systems (PACS) that are used to store and retrieve soft copy (digital) images.

4.5 Operations of CT scanner

1. High voltage supply drive the X-ray tube that can be mechanically rotated along the circumference of a gantry
2. Patients is lying in a tube in the center of gantry
3. The X-rays passes through the patient and produces an image on detectors, which are fixed in a place around the circumference of the gantry in a large quantity.
4. Microcomputer senses the position of tube in the gantry and samples the output of the detector scanner which is opposite to the x-ray tube.
5. A calculation based on the data of a computer scan of the tube is made by the computer.
6. The output unit then produces a visual image of a transverse plane cross the section of patient.
7. Output may be displayed on the cathode ray tube or photographed with a camera to produce a hard copy record.

5. Diagnostic Applications

The original CT studies were used primarily for diagnosing neurologic disorders. As scanner technology advanced, the range of applications was extended to other areas of the body. The most commonly requested procedures involve the head, chest, and abdomen. CT is the examination of choice for head trauma; it clearly shows skull fractures and associated subdural hematomas. CT examinations of the head are one of the first tests performed on patients being evaluated for stroke or cerebrovascular accident where evidence of hemorrhage must be ruled out. CT imaging of the central nervous system can show infarctions, hemorrhage, disk herniation, craniofacial and spinal fractures, and tumors and other cancers. CT imaging of the body excels at showing soft tissue structures within the chest, abdomen, and pelvis. Among the abnormalities shown in this region are metastatic lesions, aneurysms, abscesses, and fluid collections from blunt trauma.

6. Types of CT scan Machine

There are different types of CT scan machines available, and they differ based on their technology and purpose, (Dr.Ravin, 2023). Here are some of the most common types of CT scan machines:

- **Conventional CT scans:** One of the first types of CT scanners was conventional CT scanners, commonly referred to as spiral or helical CT scanners. They make a series of 2D images of the body using a focused x-ray beam, which are then merged by a computer to provide a precise 3D image.
- **Spiral CT scans:** In order to produce accurate 3D images of the body, spiral CT scans, sometimes referred to as helical CT scans, use a sophisticated form of CT scanner that continuously spirals. A spiral CT scanner rotates constantly around the patient, creating a continuous stream of pictures that are merged to form a more detailed 3D image of the body rather than taking discrete "slices" of the body as with traditional CT scans. Spiral CT scanners come in two primary varieties**:** single-slice and multi-slice. Multi-slice scanners employ multiple rows of detectors to produce higher-quality images more quickly than single-slice scanners using a single row of detectors to make images.
- **Dual Energy CT Scanner:** Dual-energy CT scanners, sometimes referred to as spectral CT scanners**,** are a type of CT device that can concurrently collect two sets of data at various energy levels. As a result, the scanner can provide more precise and detailed images by differentiating between various types of tissue depending on their composition and density.
- **Multi-Slice CT scanner:** MSCT scanners are equipped with many rows of detectors, allowing them to record more image data with each X-ray tube rotation. As a result, scan times can be shortened and 3D images can be produced. MSCT scanners can produce images **with** sub-millimeter resolution**,** which allows them to capture incredibly minute features within the body.

- **Cone-Beam CT Scanner:** Cone-Beam CT is a modified version of conventional CT scanning. The CBCT scanner uses a cone-shaped X-ray beam that spins around the patient instead of a fan-shaped X-ray beam to take several images that are then combined to create a 3D volume of the patient. CBCT scanners can be utilised in a variety of settings, including orthopaedics, radiology, and interventional treatments. However, dentistry and maxillofacial imaging is where they are most frequently used.
- **Photon- Counting CT Scanner:** Newer CT scanners called photon-counting CT scanners (PCCT) use cutting-edge detector technology to enhance image quality, cut radiation exposure, and open up new clinical applications. Photon-counting detectors (PCDs), which can determine the energy of individual x-ray photons, are used in PCCT scanners. Improved contrast resolution is the result of being able to distinguish between tissues of different densities and measuring the x-ray beam with greater precision.
- **Portable CT scanner:** Instead of having the patient transported to the machine, portable CT scanners are compact devices that may be transported to the patient's location. They are frequently employed in emergency and critical care settings when quick and simple imaging is required, as well as in distant or resource-constrained locations where a stationary CT scanner may not be available. According to Wikipedia, some portable scanners are limited by their bore size and therefore mainly used for head scans. They do not have image viewing capabilities directly on the scanner.
- Some portable scanners are limited by their bore size and therefore mainly used for head scans. They do not have image viewing capabilities directly on the scanner and does not replace the fixed CT suite.

7. Improvement

According to Alissa Czyz, the editor of imagines site, during its 25-year history, CT has made great improvements in speed, patient comfort, and resolution. As CT scan times have gotten faster, more anatomy can be scanned in less time. Faster scanning helps to eliminate artifacts from patient motion such as breathing or peristalsis. CT exams are now quicker and more patient-friendly than ever before. As a matter of fact, there was so much enthusiasm around the newly introduced magnetic resonance (MR) imaging that predictions of MR taking over CT imaging were accepted by many. Tremendous research and development has been made to provide excellent image quality for diagnostic confidence at the lowest possible x-ray dose.

There are many factors that contributed to the success of CT, and there are multiple ways to summarize the technological advancements over the past 30 years. These advances can be examined based on their clinical impact, performance improvements, or the underline technologies themselves. From a clinical impact point of view, coronary CT angiography (CCTA) is no doubt one of the major driving forces for many technological developments. It demands fast data acquisition to freeze the heart’s motion, superior spatial resolving power to characterize small pathologies, and sufficient coverage to enable imaging of the entire heart over one or a few cardiac cycles. Nearly all technological advancements over the years have contributed in one way or another to the success of CCTA today. Of course, stringent requirements for other clinical applications, such as trauma, oncology, and stroke, also played key roles in the technology development, (Jiang et al., 2021)

Modern CT scanners provide anatomy-aligned reconstructions and advanced visualizations as part of standard image reconstruction tasks, and even automated identification and quantification of pathological processes are on their way to routine integration into the CT workflow. The rapid development of virtual reality and augmented reality has and will continue to impact many radiology departments, ranging from training to operation, and new workflows. Interestingly, despite all technological advances and improvements, all modern CT scanners are still based on the third-generation rotate–rotate geometry.

Recently, quantitative CT analysis has shown promising results in objective and accurate assessment of lesion and the prediction of outcome. The results showed significant difference in density distribution according to the scanner manufacturers, and thus suggest that the manufacturer should be standardized to conduct the quantitative analysis on the brain CT images, (S. -B. Lee et al, 2017)

8. Contribution to Knowledge

This research work provides detailed information on the origin, development and history of the CT scan towards improving human health diagnosis. It also show how the technology work towards improving diagnosis and treatment of common conditions such as injury, cardiac disease, stroke, and improving patient’s placement into appropriate areas of care, such as intensive care units. Therefore, these painless scans don’t require much preparation and can be done quickly in emergency situation.

Finally, when CT Scans are used, it produces detailed images of many structures inside the body, including the internal organs, blood vessels and bones.

9. Finding

The origin and history of Computer tomography (CT) scan was researched and present around the concept of improving human health diagnosis- including damage to bones, injuries to internal organ, problem with blood flow, stroke and cancer. More than 30 years later, CT has not only survived the challenges from other imaging modalities but has moved to the frontline of hospital’s diagnostic imaging.

Finally, success of the CT scan up to Seven generation was because of advancement of technology toward CT scan performance and clinic impact, especially diagnosis of cardiac (heart) diseases

10. Conclusion

On October 11, 1979, almost exactly 8 years after the first patient’s CT scan at Atkinson-Morley Hospital, it was announced that the Nobel Prize in Physiology or Medicine would be jointly awarded to Allan Cormack and Godfrey Hounsfield for the “development of computer-assisted tomography.”The announcement reported: “It is no exaggeration to state that no other method within x-ray diagnostics within such a short period of time has led to such remarkable advances in research and in a multitude of applications."(**Schulz et al, 2021)** It is remarkable that neither Hounsfield, an engineer, nor Cormack, a physicist, the two recipients of the 1979 Nobel Prize in Physiology and Medicine, had a doctorate in any field of medicine or science, or really a background in physiology and medicine.

The development of CT also led to a new unit of measure, the Hounsfield unit (HU). The disruptive initial innovation that led to the tremendous advance that is CT was the work of individuals, especially Hounsfield, who came from outside radiology. While modern CT scanners are getting closer to the in-plane spatial resolution of radiography and fluoroscopy, that level of spatial detail was simply not possible in the early 1970s.

Reference

Amar Bhidé ,SrikantDatar and Katherine Stebbins, 2021 "Case Histories of Significant Medical Advances: Development of Computed Tomography"

Amber Diagnostics, "the different types of CT Machine" https://www.amberusa.com/blog/types-of-ct-machines/

Andrew Murphy, 2023 "CT scanner (evolution)" published on 23 Mar 2023. https://radiopaedia.org/articles/ct-scanner-evolution

Brian Nett,2020 "Animated CT Generations [1st, 2nd, 3rd, 4th, 5th Gen CT] for Radiologic Technologists".https://howradiologyworks.com/ctgenerations/

Chosose Doctor admin "Computerized Tomography – CT Scan"| Posted on: 15 November, 2016 04:54 am.https://blog.chuzdr.com/ct-scan/

Ravin Sharma, 2023 "What Are Types Of CT Scan Machines?" 01 May 2023 https://www.ganeshdiagnostic.com/blog/what-are-types-of-ct-scan-machines.

Edmund S. Higgins, 2021 "The Conversation : Fifty Years Ago, the First CT Scan Let Doctors See Inside a Living Skull" published October 1, 2021 https://www.smithsonianmag.com/innovation/fifty-years-ago-the-first-ct-scan-let-doctors-see-inside-a-living-skull-180978792/

Gaylek. Wright and Michael L. Grey, 2020 "Computed Tomography "https://radiologykey.com/computed-tomography-8/

Jean Essam , 2019 "CT SCAN Concept and Operation (P1)" published Jul 23,2019. https://www.linkedin.com/pulse/ct-scan-concept-operation-p1-jean-essam.

Jiang Hsieh, Thomas Flohr, "Computed tomography recent history and future perspectives," J. Med. Imag. 8(5) 052109 (11 August 2021) https://doi.org/10.1117/1.JMI.8.5.052109

Melissa Conrad Stöppler andCharles Patrick Davis, 2020, "CT Scan (Computerized Tomography, CAT Scan)" https://www.medicinenet.com/cat_scan/article.htm

Schulz RA, Stein JA, Pelc NJ. How CT happened: the early development of medical computed tomography. J Med Imaging (Bellingham). 2021 Sep;8(5):052110. doi: 10.1117/1.JMI.8.5.052110. Epub 2021 Oct 29. PMID: 34729383; PMCID: PMC8555965.

Wells, P. N. T. (2005). "Sir Godfrey Newbold Hounsfield KT CBE. 28 August 1919 – 12 August 2004:

Elected F.R.S. 1975”. Biographical Memoirs of Fellows of the Royal Society. 51: 221–235. doi:10.1098/rsbm.2005.0014.

Young, Ian (Jan 2009). “Hounsfield, Sir Godfrey Newbold (1919–2004)”. Oxford Dictionary of National Biography (Online ed.). doi:10.1093/ref:odnb/93911

S. -B. Lee, E. -J. Jeong, Y. Son and D. -J. Kim, "Classification of computed tomography scanner manufacturer using support vector machine," 2017 5th International Winter Conference on Brain-Computer Interface (BCI), Gangwon, Korea (South), 2017, pp. 85-87, doi: 10.1109/IWW-BCI.2017.7858167. https://ieeexplore.ieee.org/document/7858167/citations#citations