Processing unit

Processing unit performs image reconstruction. They are algorithms for reconstruction of the images from the information obtained by detectors.

The image of the section of the object irradiated by the X-ray, is reconstructed from a large number of measurements of attenuation coefficient. It gathers together all the data coming from the elementary volumes of material through the detectors.

The typical CT image is composed of 512 rows, each of 512 pixels, i.e., a square matric of 512 x 512 = 262144 pixels (one for each voxel). In the process of image, the value of attenuated coefficient for each voxel corresponding to these pixel needs to be calculated.

Back Propagation: Each image point is surrounded by a halo-shaped star that degrades the contrast and blurs the boundary of the object. To avoid this, the method of filtered back projection is used. The action of the filter function is such that the negative value created is the filtered projection, when projected backwards, is removed and an image is produced, which is the accurate representation of the original object.

Fourier Reconstruction: In the spatial domain, CT reconstruction involves the relationship between a two-dimensional image and its set of one-dimensional views. By taking the two-dimensional Fourier transform of the image and the one-dimensional Fourier transform of each of its views, the problem can be examined in the frequency domain. As it turns out, the relationship between an image and its views is far simpler in the frequency domain than in the spatial domain.

Iterative Technique: all the pixels in the image array are set to some arbitrary value. An iterative procedure is then used to gradually change the image array to correspond to the profiles. An iteration cycle consists of looping through each of the measured data points. The measured sample is compared with the sum of the image pixels along the ray pointing to the sample. If the ray sum is lower than the measured sample, all the pixels along the ray are increased in value.

Likewise, if the ray sum is higher than the measured sample, all of the pixel values along the ray are decreased. After the first complete iteration cycle, there will still be an error between the ray sums and the measured values. Iterative techniques are generally slow, but they are useful when better algorithms are not available

Viewing System

Display subsystems consist of a display controller, image memory, digital-to-analog convertor (DAC), and monitor (CRT). As described elsewhere, CT image data consist of numbers among -1000 to 3000. The human eye, however, cannot distinguish between more than 256 gray levels. The digital numbers are converted to analog signals using an eight-bit DAC, and a window level control is used to control the mapping of CT numbers into gray levels. Software for calculating the mean and standard deviation within a region and for image manipulations such as filtering and magnification is often included as part of the display program.

Storage unit

Picture are stored in digital form and are stored in disks, CD's, etc. Hard copy print outs can also be made in gray scale or color shades.

Magnetic Resonance Imaging/MRI

Magnetic resonance imaging (MRI) is an imaging technique used primarily in medical settings to produce high quality images of the inside of the human body.

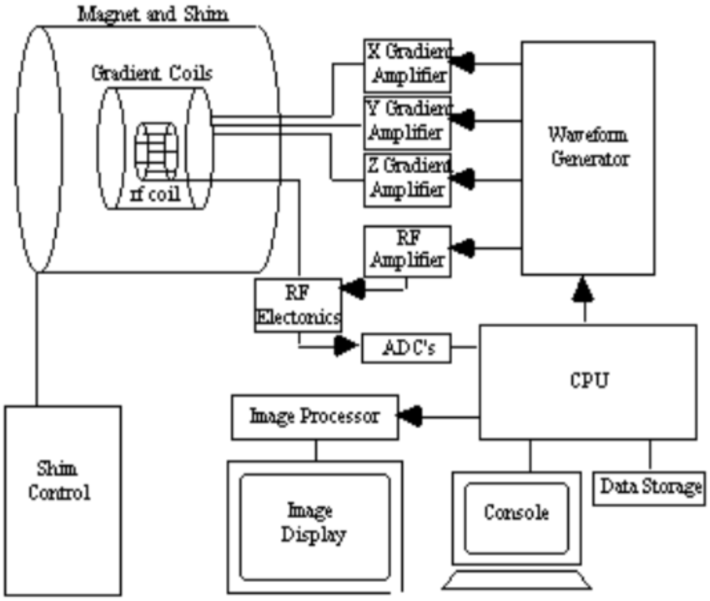
MRI is based on the principles of nuclear magnetic resonance (NMR).

The technique uses a very powerful magnet to align the nuclei of atoms inside the body, and a variable magnetic field that causes the atoms to resonate, a phenomenon called nuclear magnetic resonance. The nuclei produce their own rotating magnetic fields that a scanner detects and uses to create an image.

Principle

The human body is mostly water. Water molecules (H20) contain hydrogen nuclei (protons), which become aligned in a magnetic field. An MRI scanner applies a very strong magnetic field (about 0.2 to 3 teslas), which aligns the proton "spins."

The scanner also produces a radio frequency current that creates a varying magnetic field. The protons absorb the energy from the variable field and flip their spins. When the field is turned off, the protons gradually return to their normal spin, a process called precession. The return process produces a radio signal(NMR signals) that can be measured by receivers in the scanner and made into an image.



The magnet

The various magnets used are permanent magnets(C-Fe alloys), electromagnets, resistive magnets(Al strips) and superconducting magnets(NbTi).

RF transmitter /detector system

The RF transmitter system activates the nuclei so that they emit the NMR signals. The system consists of a RF generator, RF transmitter, RF power amplifier and RF transmitting coils. He RF pulses from coils fall on the patient.

The Detection system detects the nuclear magnetization and generates an output signal for processing by the computer. The system consists of receiving coils, matching networks, amplifiers, filters and ADC.

The receiver coil surrounds the areas of interest, picks NMR signals and converts to output voltage.

Gradient system

It is used to obtain spatial distribution information. The strength of the field is proportional to the density of hydrogen nuclei in that plane.

Imager system

It consists of the computer, display system and control console.

Computer does image processing, timing and control of RF and gradient pulse sequences. A high speed mini computer collects the NMR signals, corrects, recomposes, displays and stores it. An array processor does FFT.

The display section ahs high resolution monitor, image memory and panel indicators.

Advantages

The advantages of MRI include:

- the ability to image without the use of ionizing radiation (x-ray) unlike CT scanning

- images may be acquired in multiple planes (Axial, Sagittal, Coronal, or Oblique) without repositioning the patient. CT images have only relatively recently been able to be recontructed in multiple planes with the same spatial resolution
- MRI images demonstrate superior soft tissue contrast than CT scans and plain films making it the ideal examination of the brain, spine, joints and other soft tissue body parts
- some angiographic images can be obtained without the use of contrast material, unlike CT or conventional angiography

- advanced techniques such as diffusion, spectroscopy and perfusion allow for specific tissue characterisation rather than merely 'macroscopic' imaging
- functional MRI allows visualisation of both active parts of the brain during certain activities and understanding of the underlying networks

Ultrasonic imaging systems

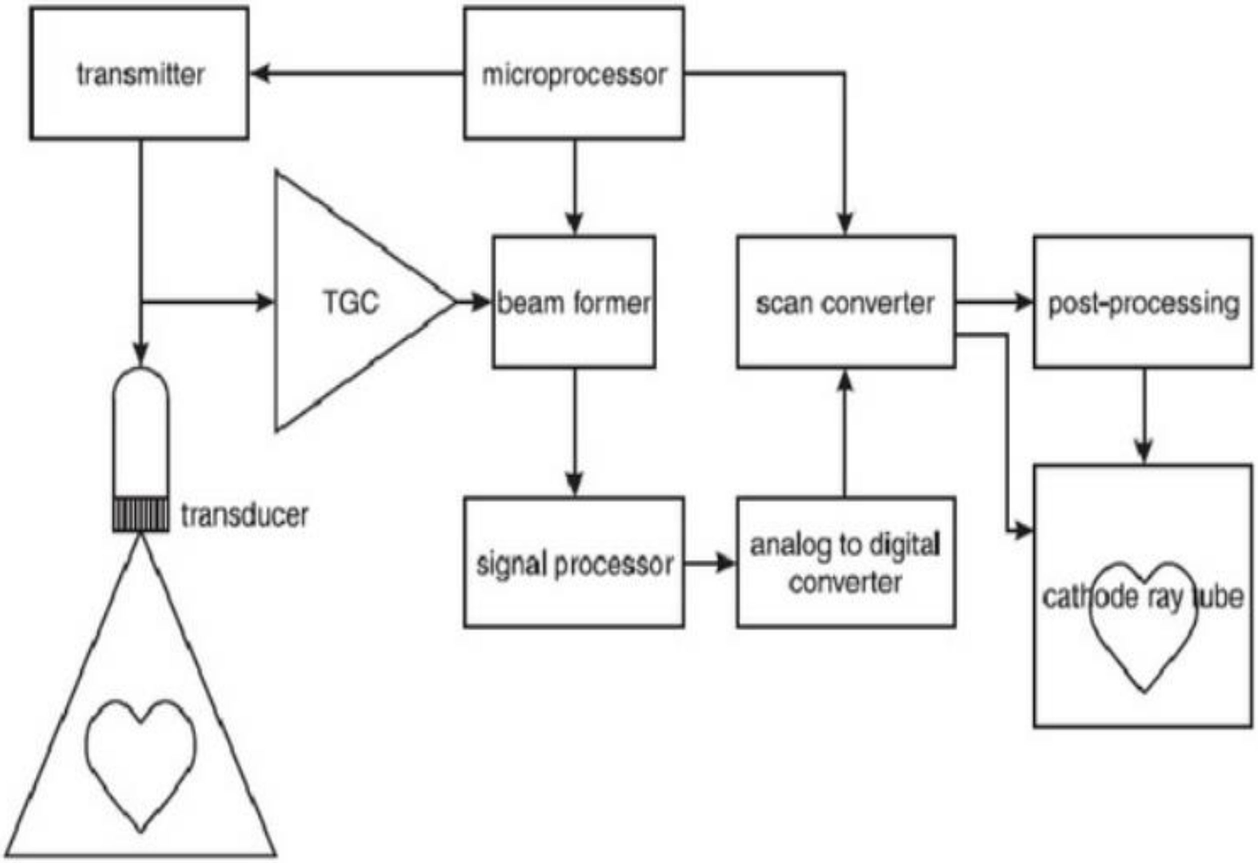
Ultrasound refers to acoustical wave of frequency 20-20000HZ above. They are generated from piezo electric crystals like quartz, Rochelle salt, lead zirconate,etc.

Medical ultrasound imaging consists of using high pitched sound bouncing off tissues to generate images of internal body structures.

The ultrasound waves (pulses of sound) are sent from the transducer, propagate through different tissues, and then return to the transducer as reflected echoes. The returned echoes are converted back into electrical impulses by the transducer crystals and are further processed in order to form the ultrasound image presented on the screen.

Ultrasonic Imaging Instrumentation

Image on the next page



Transducer position data is given to computer.

The computer calculates the depth gain compensation and sends the data to signal processing unit. Receiver also sends signals to SPU.

Echoes from body surface are collected by receiver circuit, converted into digital signals and stored in memory. These signals are color coded and converted into analog signals. These signals are fed into video section of TV monitor where it is displayed.

High speed ADC helps in digitization of high frequency signals.

Display Modes

A mode is an operational state that a system has been switched to. A normal mode occurs when all parts of a system oscillate with the same frequency. For ultrasound imaging, different modes are used to examine the arterial/venous system, heart, pancreas, urinary system, ovaries, spinal cord, joints, and more. The different types of modes can be controlled by the operator or tech.
The various display modes are A Mode/Scan, B Mode/Scan, TM Mode Scan**.**

1. A-mode (A=amplitude)

The amplitude of reflected ultrasound is displayed on an oscilloscope screen. A-Mode consists of a x and y axis, where x represents the depth and y represents the Amplitude. The A-mode is now used only in ophtalmology.

2. M-mode (M=motion)

M-Mode, or Motion Mode (also called Time Motion or TM-Mode), is the display of a one-dimensional image that is used for analyzing moving body parts commonly in cardiac and fetal cardiac imaging. This can be accomplished by recording the amplitude and rate of motion in real time by repeatedly measuring the distance of the object from the single transducer at a given moment. The single sound beam is transmitted and the reflected echoes are displayed as dots of varying intensities thus creating lines across the screen. Nowadays, the integration of 2D and M-mode images is possible. Due to its excellent temporal resolution (high sampling rate), M-mode is extremely valuable for accurate evaluation of rapid movements.

3. B-mode (B=brightness)

This is now the essential imaging modality in the diagnostic ultrasound. B-Mode is based on brightness with the absence of vertical spikes. Therefore, the brightness depends upon the amplitude or intensity of the echo. There is no y axis on B-Mode, instead, there is a z axis, which represents the echo intensity or amplitude, and a x axis, which represents depth. B-Mode will display an image of large and small dots, which represent strong and weak echoes, respectively.

An amplitude of the reflected ultrasound signals is converted into a gray scale image. Owing to the wide gray scale (most of the ultrasound machines use 256 shades of gray) even very small differences in echogenicity are possible to visualize.

Thermographic Equipment

Medical Thermography (digital infrared thermal imaging - DITI) is used as a method of research for early pre-clinical diagnosis and control during treatment of homeostatic imbalances.

Thermography is a non-invasive, non-contact tool that uses the heat from your body to aid in making diagnosis of a host of health care conditions. Thermography is completely safe and uses no radiation.

Thermography is used to determine areas of the body that have irregular blood flow. It is commonly used by sports physicians and veterinarians to determine areas of the body that have inflammation.

This equipment usually has two parts, the IR camera and a standard PC or laptop computer. These systems have only a few controls and relatively easy to use.

Monitors are high-resolution full color, isotherm or grey scale, and usually include image manipulation, isothermal temperature mapping, and point-by-point temperature measurement with a cursor or statistical region of interest. The systems measure temperatures ranging from 10° C - 55° C to an accuracy of 0.1° C. Focus adjustment should cover small areas down to 75 x 75mm.

Utilising high-speed computers and very accurate thermal imaging cameras, the heat from your body is processed and recorded in the computer into an image map which can then be analyzed on screen, printed or sent via email.

Application

- Breast pathologies
- Extra-Cranial Vessel Disease
- Neuro-Musculo-Skeletal
- Vertebrae (nerve problems/arthritis)
- Lower Extremity Vessel Disease