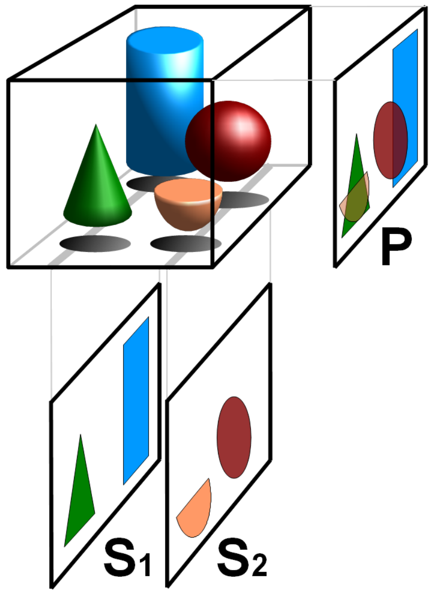
Tomography

Tomography refers to imaging by sections or sectioning, through the use of any kind of penetrating wave. A device used in tomography is called a **tomograph**, while the image produced is a **tomogram**. Tomography as the computed tomographic (CT) scanner was invented by Sir Godfrey Hounsfield, and thereby made an exceptional contribution to medicine. The method is used in radiology, archaeology, biology, atmospheric science, geophysics, oceanography, plasma physics, materials science, astrophysics, quantum information, and other sciences. In most cases it is based on the mathematical procedure called tomographic reconstruction.



Basic principle of tomography: superposition free tomographic cross sections S_1 and S_2 compared with the projected image P

Etymology

The word *tomography* is derived from Ancient Greek τόμος *tomos*, "slice, section" and γράφω *graphō*, "to write".

Description

In conventional medical X-ray tomography, clinical staff make a sectional image through a body by moving an X-ray source and the film in opposite directions during the exposure. Consequently, structures in the focal plane appear sharper, while structures in other planes appear blurred. By modifying the direction and extent of the movement, operators can select different focal planes which contain the structures of interest. Before the advent of more modern computer-assisted techniques, this technique, developed in the 1930s by the radiologist Alessandro Vallebona, proved useful in reducing the problem of superimposition of structures in projectional (shadow) radiography.

In a 1953 article in the medical journal *Chest*, B. Pollak of the Fort William Sanatorium described the use of planography, another term for tomography.

Modern tomography

More modern variations of tomography involve gathering projection data from multiple directions and feeding the data into a tomographic reconstruction software algorithm processed by a computer.[1] Different types of signal acquisition can be used in similar calculation algorithms in order to create a tomographic image. Tomograms are derived using several different physical phenomena listed in the following table:Wikipedia:Citation needed

Physical phenomenon	Type of tomogram
X-rays	CT
gamma rays	SPECT
radio-frequency waves	MRI
Electrical Resistance	ERT
electron-positron annihilation	PET
electrons	Electron tomography or 3D TEM
muons	Muon tomography
ions	atom probe
magnetic particles	magnetic particle imaging

Some recent advances rely on using simultaneously integrated physical phenomena, e.g. X-rays for both CT and angiography, combined CT/MRI and combined CT/PET.

The term *volume imaging* might describe these technologies more accurately than the term *tomography*. However, in the majority of cases in clinical routine, staff request output from these procedures as 2-D slice images. As more and more clinical decisions come to depend on more advanced volume visualization techniques, the terms *tomography/tomogram* may go out of fashion.Wikipedia:Citation needed

Many different reconstruction algorithms exist. Most algorithms fall into one of two categories: filtered back projection (FBP) and iterative reconstruction (IR). These procedures give inexact results: they represent a compromise between accuracy and computation time required. FBP demands fewer computational resources, while IR generally produces fewer artifacts (errors in the reconstruction) at a higher computing cost.[1]

Although MRI and ultrasound are transmission methods, they typically do not require movement of the transmitter to acquire data from different directions. In MRI, both projections and higher spatial harmonics are sampled by applying spatially-varying magnetic fields; no moving parts are necessary to generate an image. On the other hand, since ultrasound uses time-of-flight to spatially encode the received signal, it is not strictly a tomographic method and does not require multiple acquisitions at all.

Synchrotron X-ray tomographic microscopy

A new technique called synchrotron X-ray tomographic microscopy (SRXTM) allows for detailed three-dimensional scanning of fossils.

Types of tomography

Name	Source of data	Abbreviation	Year of introduction
Atom probe tomography	Atom probe	APT	
Computed Tomography Imaging Spectrometer[2]	Visible light spectral imaging	CTIS	
Confocal microscopy (Laser scanning confocal microscopy)	Laser scanning confocal microscopy	LSCM	
Cryo-electron tomography	Cryo-electron microscopy	Cryo-ET	
Electrical capacitance tomography	Electrical capacitance	ECT	
Electrical resistivity tomography	Electrical resistivity	ERT	
Electrical impedance tomography	Electrical impedance	EIT	1984
Electron tomography	Electron attenuation/scatter	ET	
Functional magnetic resonance imaging	Magnetic resonance	fMRI	1992
Laser Ablation Tomography	Laser Ablation & Fluorescent Microscopy	LAT	2013
Magnetic induction tomography	Magnetic induction	MIT	
Magnetic resonance imaging or nuclear magnetic resonance tomography	Nuclear magnetic moment	MRI or MRT	
Muon tomography	muons		
Neutron tomography	Neutron		
Ocean acoustic tomography	Sonar		
Optical coherence tomography	Interferometry	OCT	
Optical diffusion tomography	Absorption of light	ODT	
Optical projection tomography	Optical microscope	OPT	
Photoacoustic imaging in biomedicine	Photoacoustic spectroscopy	PAT	
Positron emission tomography	Positron emission	PET	
Positron emission tomography - computed tomography	Positron emission & X-ray	PET-CT	
Quantum tomography	Quantum state		
Single photon emission computed tomography	Gamma ray	SPECT	
Seismic tomography	Seismic waves		
Thermoacoustic imaging	Photoacoustic spectroscopy	TAT	
Ultrasound-modulated optical tomography	Ultrasound	UOT	
Ultrasound transmission tomography	Ultrasound		
X-ray tomography	X-ray	CT, CATScan	1971
Zeeman-Doppler imaging	Zeeman effect		

Discrete tomography and Geometric tomography, on the other hand, are research areasWikipedia:Citation needed that deal with the reconstruction of objects that are discrete (such as crystals) or homogeneous. They are concerned with reconstruction methods, and as such they are not restricted to any of the particular (experimental) tomography methods listed above.

References

[1] Herman, G. T., Fundamentals of computerized tomography: Image reconstruction from projection, 2nd edition, Springer, 2009
[2] Ralf Habel, Michael Kudenov, Michael Wimmer: Practical Spectral Photography (http://www.cg.tuwien.ac.at/research/publications/2012/Habel_2012_PSP/)

External links

- International Journal of Imaging and Robotics (http://www.ceser.in/iji.html)
- International Journal of Tomography & Statistics (IJTS) (http://www.ceser.in/ijts.html)
- Microtomography/Synchrotron tomography (http://www.bronnikov-algorithms.com/downloads/Andrei.Bronnikov_Image_reconstruction.pdf)

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