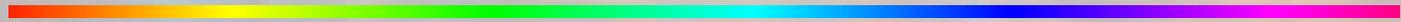


Technical English

For Information and Communication
Engineering

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Unit Seven



Computerized Tomographic
Imaging



概述

- 计算机层析成像的基本原理
- Hounsfield的发明及其意义
- X射线CT和衍射CT
- CT技术的应用领域





tomography

断层成像术

transmission

透射

reflection

反射

diagnostic

诊断

unprecedented

前所未有的，空前的

attenuation

衰减

coefficient

系数

radioisotope

放射性同位素

resonance

共振

lend oneself to

有助于，适宜于

borehole

钻孔

celestial

天空的

terrestrial

integral

积分

diffract

衍射，绕射

cross-sectional

断面的，截面的



breakneck	极快的，很危险的
algebraic	代数的
backprojection	反向投影
unambiguous	不模糊的，不含糊的
anatomical	解剖学的
cylinder	柱体，圆柱
isotope	同位素
viz. (拉丁语 <i>videlicet</i>)	就是说（可读 namely ）
scatter	散射
inhomogeneity	不均匀性
refractive index	折射率
variation	变种
avalanche	雪崩
bibliography	参考书目
cite	引述，引用



通过从许多不同方向照射物体，根据透射或反射的数据对物体断面成像

Tomography refers to the cross-sectional imaging of an object from either transmission or reflection data collected by illuminating the object from many different directions. The impact of this technique in diagnostic medicine has been revolutionary, since it has enabled doctors to view internal organs with unprecedented precision and safety to the patient.

它使医生能以前所未有的精度和对病人的安全性看到体内的器官。



The first medical application utilized x-rays for forming images of tissues based on their x-ray attenuation coefficient. More recently, however, medical imaging has also been successfully accomplished with radioisotopes, ultrasound, and magnetic resonance; the imaged parameter being different in each case.

后来利用放射性同位素、超声、磁共振也成功地获得了医学图像，在每一种情况下用不同的参数成像。



lend themselves to
有助于，适宜于

还有大量的非医学应用也可使用计算机层析成像方法。

There are numerous non-medical imaging applications which lend themselves to the methods of computerized tomography.

Researchers have already applied this methodology to **the mapping of** underground resources via cross-borehole imaging, **some specialized cases of** cross-sectional imaging for nondestructive testing, **the determination of** the brightness distribution over a celestial sphere, **and three-dimensional imaging** with electron microscopy.¹

1. 通过钻孔成像测绘地下资源
2. 无损检测中断面成像的某些特殊案例
3. 确定天球面上的亮度分布
4. 电子显微镜三维成像



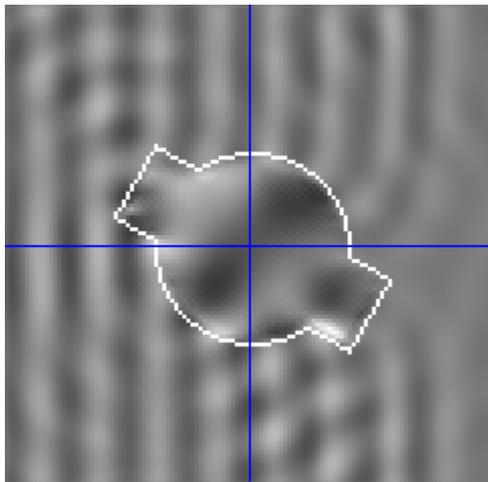
Fundamentally, tomographic imaging deals with reconstructing an image from its projections. In the strict sense of the word, a projection at a given angle is the integral of the image in the direction specified by that angle, as illustrated in **Figure 7.1**.

某一角度的投影是图像在该角度所定义的方向上的积分



在宽泛的意义上

However, **in a loose sense**, projection means the information derived from the transmitted energies, when an object is illuminated from a particular angle; **the phrase “diffracted projection”** may be used when energy sources are diffracting, as is the case with ultrasound and microwaves.²



若辐射源是衍射性的如超声波或微波，可使用“衍射投影”一词。



对于如何根据投影数据重建图象这一问题的解要追溯到1917年Radon的论文

Although, from a purely mathematical standpoint, the solution to the problem of how to reconstruct a function from its projections dates back to the paper by Radon in 1917, the current excitement in tomographic imaging originated with Hounsfield's invention of the x-ray computed tomographic scanner for which he received a Nobel prize in 1979.³

当前在断层成像方面令人激动的成就源自Hounsfield发明的X光CT扫描，他因此项发明而于1979年获得了诺贝尔奖。



有可能得到精度达千分之一的高质量断面图象

He shared the prize with Allan Cormack who independently discovered some of the algorithms. His invention showed that **it is possible to compute high-quality cross-sectional images with an accuracy now reaching one part in a thousand in spite of the fact that the projection data do not strictly satisfy the theoretical models underlying the efficiently implementable reconstruction algorithms.**⁴

投影数据并未严格满足有效实现重建算法赖以成立的理论模型



His invention also showed that it is possible to process a very large number of measurements (now approaching a million for the case of x-ray tomography) with fairly complex mathematical operations, and still get an image that is incredibly accurate.

仍然可获得非常精确的图像



可以说自从Hounsfield的发明以来，X光CT成像技术的改进在很大程度上要归功于重建算法方面的发展。

It is fair to say that the breakneck pace at which x-ray computed tomography images improved after Hounsfield's invention was in large measure owing to the developments that were made in reconstruction algorithms.⁵ Hounsfield used algebraic techniques, and was able to reconstruct noisy looking 80×80 images with an accuracy of one part in a hundred.

重建大小为 80×80 的噪声颇大的图像，精度为百分之一



随后是卷积反向投影算法在这种成像中的应用

This was followed by the application of convolution backprojection algorithms, first developed by Ramachandran and Lakshminarayanan and later popularized by Shepp and Logan, to this type of imaging. These later algorithms considerably reduced the processing time for reconstruction, and the image produced was numerically more accurate.



X射线层析成像扫描装置的制造商开始生产能重建256×256和512×512图像的系统，

As a result, commercial manufacturers of x-ray tomographic scanners started building systems capable of reconstructing 256×256 and 512×512 images that were almost photographically perfect (in the sense that the morphological detail produced was unambiguous and in perfect agreement with the anatomical features).

所形成的形态细节清晰可辨，并与解剖结果完全一致，在这一意义上这些图像几乎达到了照相术上完美的程度。



在X射线CT取得巨大成功的情况下

Given the enormous success of x-ray computed tomography, it is not surprising that in recent years much attention has been focused on extending this image formation technique to nuclear medicine and magnetic resonance on one hand; and ultrasound and microwaves on the other.

近年来更多的注意力集中于将这一成像技术进行扩展



在于重建人体内放射性同位素分布的断面图像

In nuclear medicine, our interest is **in reconstructing a cross-sectional image of radioactive isotope distributions within the human body**; and in imaging with magnetic resonance we wish to reconstruct the magnetic properties of the object. **In both these areas, the problem can be set up as reconstructing an image from its projections of the type shown in Figure 7.1.**

在这两个领域都可以建立起基于图7.1中这类投影来重建图像的问题。



用超声波和微波作能源时情况有所不同

This is not the case when ultrasound and microwaves are used as energy sources, although the aim is the same as with X-rays, viz., to reconstruct the cross-sectional image of, say, the attenuation coefficient.⁶ X-rays are non-diffracting, i.e., they travel in straight lines, whereas microwaves and ultrasound are diffracting.

尽管其目的和X射线CT相同，即重建某一参数（例如衰减系数）的断层图像



当使用衍射源照射物体时，尽管当场的不均匀范围远大于波长并用折射率作为成像参数时，可以满足于直线传播的假设，波实际上是向四面八方散射的。

When an object is illuminated with a diffracting source, the wave field is scattered in practically all directions, although **under certain conditions** one might be able to get away with the assumption of straight line propagation; **these conditions being satisfied when the inhomogeneities are much larger than the wavelength and when the imaging parameter is the refractive index.**⁷

在某些条件下...

这些条件是：场的不均匀范围远大于波长，并用折射率作为成像参数



由不均匀性引起的波散射

For situations when one must take diffraction effects (inhomogeneity caused scattering of the wave field) into account, tomographic imaging can in principle be accomplished with the algorithms based on the Fourier diffraction theorem.

层析成像原则上可以用基于Fourier衍射定理的算法实现



结合课文的思考题

- **What is the mathematical basis of computerized tomography?**
- **Name some non-medical applications of CT.**
- **What is the fundamental difference between X-ray CT and CT using diffracting sources?**



Exercises

- **Medical imaging systems have evolved to the point where it is possible to see certain anatomical structures with very fine detail. High-resolution CT systems, for example, now allow organs to be visualized at resolutions approaching the sub millimeter level. Better still, fusion of data from different imaging modalities can yield images of the structural and functional relationships of such organs.**
- **医学成像系统已发展到可以精细地看见某些解剖学结构的水平了。例如现在高分辨率CT观看器官已能接近亚毫米的水平。更进一步的是，不同成像机制得到的数据融合可产生反映这些器官结构和功能相互关系的图像。**
- **Modality: 形态、形式、样式**



Exercises

- **Many visualization packages incorporate volume rendering, a technique used for 3D visualization of structures such as the heart and lungs. Produced by projecting rays from multiple angles of view through the volumetric data set, rendered objects can then be scaled and rotated about x , y and z axes to produce animated 3D displays.**
- **许多可视化软件包含了体积绘制，这是一种用于将心脏和肺这样的结构进行三维可视化的技术。通过将射线经体积数据集从不同视角投影，可以将被绘制的对象缩放，并围绕 x 、 y 、 z 轴旋转，产生三维动画显示。**



Exercises

- **In many medical applications, however, it is not necessary to understand data within 2D data sets or to visualize data in 3D. Sometimes, for example, physicians only need to understand how the surface of structures are composed. Because of this, most software packages incorporate algorithms to allow structures such as bones to be displayed as 3D shaded surfaces.**
- **然而在许多医学应用中，并不需要去理解二维数据集或者将数据进行三维可视化。例如有时医生只需要了解某种结构的表面是如何构成的。因此大多数软件包含有将结构（例如骨骼）显示为有明暗层次的三维表面的算法。**



Exercises

- **In many imaging applications, physicians need to see the geometric relationships between anatomical structures. To do so, software packages may include techniques that allow multiple surface or volume rendered images to be rapidly displayed, thus producing the illusion of motion. This is especially useful in studying the heart, for example, where sequences of moving images can indicate loss of muscle function.**
- **在许多成像应用中，医生要观察解剖学结构之间的几何关系。为此软件可包括使多个表面或体积绘制的图像快速显示的技术，从而产生运动感。这对研究某些脏器例如心脏尤其有用，这里运动图像序列可指示肌肉功能的减弱。**



Exercises

- As DoD urgently wanted military command and control networks that could survive a nuclear war, ARPA was charged with inventing a technology that could get data to its destination reliably even if arbitrary part of the network disappeared as a result of a nuclear attack.
 - DoD urgently needed networks of military command and control that would not be crippled in a nuclear war
 - DoD urgently needed both the military command and the control networks that could save a nuclear war
 - DoD desperately wanted the ability of commanding and controlling the networks in case of a nuclear war
 - DoD eagerly wanted to make military command, and to control the network so that they could keep working in a nuclear war



Exercises

- This wavelength division multiplexed operation offers the potential for a fiber information-carrying capacity that is many orders of magnitude in excess of what can be obtained using copper cables or a wideband radio system.

- great many times larger in magnitude than

- greatly magnified in comparison with

- ordered many times in the magnitude exceeding

- much more economical in terms of magnitudes than



Exercises

- Over recent years this potential has largely been realized in the costs of the optical fiber transmission medium that for bulk purchases is now becoming competitive with copper wires.
 - that is specifically for purchases, and is becoming superior to copper wires
 - that is bulkily comparable in price with copper wires
 - that is competing with copper wires in terms of the scale of purchases
 - that is becoming a challenge to copper wires when bought in a large quantity



Exercises

- Optical fibers are immune to electromagnetic interference and there is no cross talk.
 - are mutually related to electromagnetic interference
 - are resistive against electromagnetic interference
 - are prone to electromagnetic interference
 - are easy to take in electromagnetic interference



Exercises

- Any small deformations in the height or width of the pulses are irrelevant since it is only necessary to know whether the pulse is present or absent in order to retrieve the original message.
 - to reform the original information
 - to recover the original signal
 - to re-obtain the original information
 - to represent the original signal



Exercises

- Assembly language is a machine-specific language that uses symbolic instructions rather than the binary equivalents in the machine language for that machine.
 - language dedicated to a special computer
 - language applicable to particular processors
 - language installed in a specific machine
 - language independent of any computer