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Research Paper

A Study On Tomographic Imaging And Its Reconstruction

Computer Science

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ABSTRACT

This paper elaborate the field of tomography and computerized tomography image processing the reconstruction methods. 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[1].

INTRODUCTION

Tomography is a non-invasive imaging technique allowing for the visualization of the internal structures of an object without the superposition of over- and under-lying structures that usually plagues conventional projection images. For example, in a conventional chest radiograph, the heart, lungs, and ribs are all superimposed on the same film, whereas a computed tomography (CT) slice captures each organ in its actual three-dimensional position. Tomography has found widespread application in many scientific fields, including physics, chemistry, astronomy, geophysics, and, of course, medicine. While X-ray CT may be the most familiar application of tomography, tomography can be performed, even in medicine, using other imaging modalities, including ultrasound, magnetic resonance, nuclear-medicine, and microwave techniques[2].

Types of tomography

		biomedicine
Computed Tomography Imaging Spectrometer[5]	Electrical impedance tomography	Positron emission tomography
Confocal microscopy (Laser scanning confocal microscopy)	Electron tomography	Positron emission tomography - computed tomography
Cryo-electron tomography Electrical capacitance tomography	Functional magnetic resonance imaging Laser Ablation Tomography	Quantum tomography Single photon emission computed tomography
Ocean acoustic tomography Optical coherence tomography	Magnetic induction tomography Magnetic resonance imaging or nuclear magnetic resonance tomography	Seismic tomography Thermoacoustic imaging
Optical diffusion tomography	Muon tomography	Ultrasound-modulated optical tomography
Optical projection tomography	Neutron tomography	Ultrasound transmission tomography
X-ray tomography	Zeeman-Doppler imaging	

Computerized Tomography

In day-to-day life, digital images have a key role in the area of computer aided tomography, aerial communications, telecommunication images, synthetic aperture radar, geographical information systems, astronomy etc. In diverse fields, mentioned above, scientists are facing the problem of recovering original images from incomplete, indirect and noisy images. Images get corrupted during acquisition by camera sensors, receivers, environmental conditions, improper lightning, undesirable view angle etc.,. A noisy image appears as spotted, granular, hoary image. Therefore, the problem of recovering an original image from noisy image has received an ever increasing attention in recent years. The recovery of image can be

accomplished by image denoising, a process of estimating the desired image from a corrupted image.

Aim of the paper is to emphasize the problems and solutions in relation to tomographic images which arise in medical field in view of its increasing importance in the present day requirements. In view of this, survey of literature has been done in the area of tomography, wavelets, multiwavelets and various denoising techniques.

X-ray computed tomography (x-ray CT) is a technology that uses computer-processed x-rays to produce tomographic images (virtual 'slices') of specific areas of the scanned object, allowing the user to see inside without cutting. Digital geometry processing is used to generate a three-dimensional image of the inside of an object from a large series of two-dimensional radiographic images taken around a single axis of rotation.[1] Medical imaging is the most common application of x-ray CT. Its cross-sectional images are used for diagnostic and therapeutic purposes in various medical disciplines.[2] The rest of this article discusses medical-imaging x-ray CT; industrial applications of x-ray CT are discussed at industrial computed tomography scanning.

As x-ray CT is the most common form of CT in medicine and various other contexts, the term computed tomographyalone (or CT) is often used to refer to x-ray CT, although other types exist (such as positron emission tomography [PET] and single-photon emission computed tomography [SPECT]). Older and less preferred terms that also refer to x-ray CT are computed axial tomography (CAT scan) and computer-assisted tomography. X-ray CT is a form of radiography, although the word "radiography" used alone usually refers, by wide convention, to non-tomographic radiography.

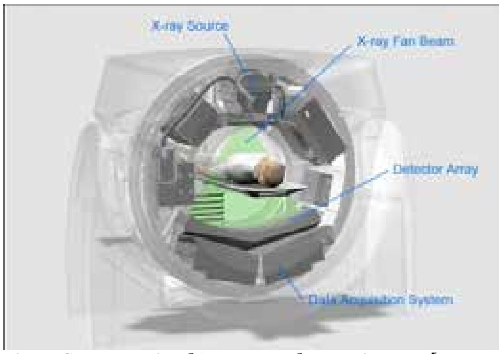

Fig 2: Computerized Tomography Equipment[4

TOMOGRAPHIC IMAGE RECONSTRUCTION

Several preprocessing steps are usually needed before the image reconstruction can take place. For instance, the logarithm must be taken of each x-ray measurement. This is because x-rays decrease in intensity exponentially as they pass through material. Taking the logarithm provides a signal that is linearly related to the characteristics of the material being measured. Other preprocessing steps are used to compensate for the use of polychromatic (more than one energy) x-rays, and multielement detectors (as opposed to the single element shown in Fig. 25-14). While these are a key step in the overall technique, they are not related to the reconstruction algorithms and we won't discuss them further.

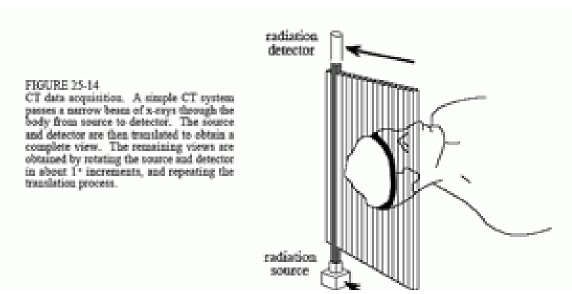

Fig 25-14 a simple CT system[5].

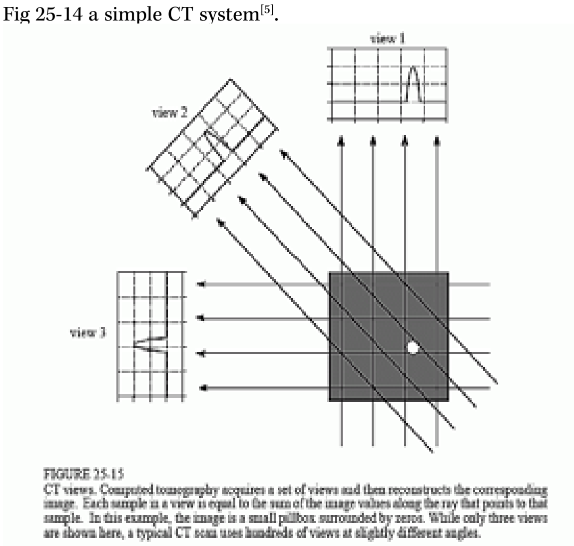

Fig 25-15: The relationship between the measured views and the corresponding image[5]-

Figure 25-15 illustrates the relationship between the measured views and the corresponding image. Each sample acquired in a CT system is equal to the sum of the image values along a ray pointing to that sample. For example, view 1 is found by adding all the pixels in each row. Likewise, view 3 is found by adding all the pixels in each column. The other views, such as view 2, sum the pixels along rays that are at an angle.

There are four main approaches to calculating the slice image given the set of its views. These are called CT reconstruction algorithms. The first method is totally impractical, but provides a better understanding of the problem. It is based on solving many simultaneous linear equations. One equation can be written for each measurement. That is, a particular sample in a particular profile is the sum of a particular group of pixels in the image. To calculate unknown variables (i.e., the image pixel values), there must be independent equations, and therefore N^2 measurements. Most CT scanners acquire about 50% more samples than rigidly required by this analysis. For example, to reconstruct a 512×512 image, a system might take 700 views with 600 samples in each view. By making the problem over determined in this manner, the final image has reduced noise and artifacts. The problem with this first method of CT reconstruction is computation time. Solving several hundred thousand simultaneous linear equations is an daunting task.

The second method of CT reconstruction uses iterative techniques to calculate the final image in small steps. There are several variations of this method: the Algebraic Reconstruction Technique (ART), Simultaneous Iterative Reconstruction Technique (SIRT), and Iterative Least Squares Technique (ILST). The difference between these methods is how the successive corrections are made: ray-by-ray, pixel-by-pixel, or simultaneously correcting the entire data set, respectively. As an example of these techniques, we will look at ART.

To start the ART algorithm, 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. For each measured value, the following question is asked: how can the pixel values in the array be changed to make them consistent with this particular measurement? In other words, 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. This is because the changes made for any one measurement disrupts all the previous corrections made. The idea is that the errors become smaller with repeated iterations until the image converges to the proper solution.

Iterative techniques are generally slow, but they are useful when better algorithms are not available. In fact, ART was used in the first commercial medical CT scanner released in 1972, the EMI Mark I. We will revisit iterative techniques in the next chapter on neural networks. Development of the third and forth methods have almost entirely replaced iterative techniques in commercial CT products.

The last two reconstruction algorithms are based on formal mathematical solutions to the problem. These are elegant examples of DSP. The third method is called filtered back projection. It is a modification of an older technique, called **backprojection** or **simple backprojection.** Figure 25-16 shows that simple

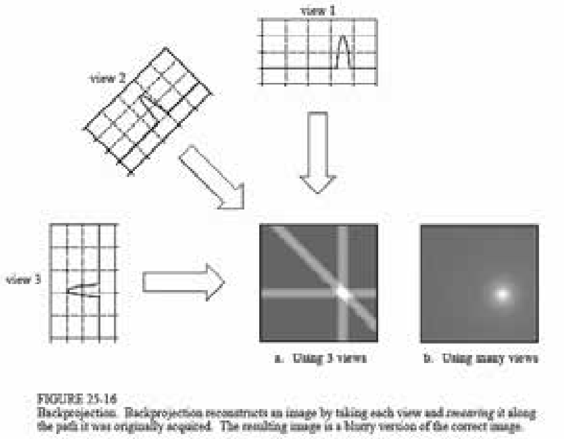

Fig 25-16 Backprojection.

backprojection is a common sense approach, but very unsophisticated. An individual sample is backprojected by setting all the image pixels along the ray pointing to the sample to the same value. In less technical terms, a backprojection is formed by smearing each view back through the image in the direction it was originally acquired. The final backprojected image is then taken as the sum of all the backprojected views.

While backprojection is conceptually simple, it does not correctly solve the problem. As shown in (b), a backprojected image is veryblurry. A single point in the true image is reconstructed as a circular region that decreases in intensity away from the center. In more formal terms, the point spread function of backprojection is circularly symmetric, and decreases as the reciprocal of its radius.

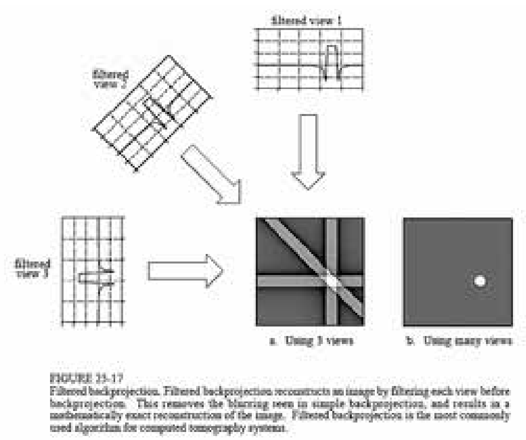

Fig 25-17 Filtered backprojection.

Filtered backprojection is a technique to correct the blurring encountered in simple backprojection. As illustrated in Fig. 25-17, each view is filtered before the backprojection to counteract the blurring PSF. That is, each of the one-dimensional views is convolved with a one-dimensional filter kernel to create a set of filtered views. These filtered views are then backprojected to provide the reconstructed image, a close approximation to the "correct" image. In fact, the image produced by filtered backprojection is identical to the "correct" image when there are an infinite number of views and an infinite number of points per view.

Advantages of Computerized Computed Tomography

There are several advantages that CT has over traditional 2D medical radiography. First, CT completely eliminates the superimposition of images of structures outside the area of interest. Second, because of the inherent high-contrast resolution of CT, differences between tissues that differ in physical density by less than 1% can be distinguished. Finally, data from a single CT imaging procedure consisting of either multiple contiguous or one helical scan can be viewed as images in the axial,coronal, or sagittal planes, depending on the diagnostic task. This is referred to as multiplanar reformatted imaging.

CT is regarded as a moderate- to high-radiation diagnostic technique. The improved resolution of CT has permitted the development of new investigations, which may have advantages; compared to conventional radiography, for example, CT angiography avoids the invasive insertion of a catheter. CT colonography (also known as virtual colonoscopy or VC for short) may be as useful as a barium enema for detection of tumors, but may use a lower radiation dose. CT VC is increasingly being used in the UK as a diagnostic test for bowel cancer and can negate the need for a colonoscopy.

CONCLUSION

This paper has been given a knowledge about the tomography and computerized tomography. This is one of the very fascinating area for research by using a digital image processing techniques. Readers are getting the knowledge and researchers may consider this paper to start their work in tomography image processing. In future work that will give some more depth knowledge about the tomography.

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