Chapter 14
Research and Developments in Medical Image Reconstruction Methods and its Applications

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ABSTRACT

Image reconstruction from projection is the field that lays the foundation for Medical Imaging or Medical Image Processing. The rapid and proceeding progress in medical image reconstruction, and the related developments in analysis methods and computer-aided diagnosis, has promoted medical imaging into one of the most important sub-fields in scientific imaging. Computer technology has enabled tomographic and three-dimensional reconstruction of images, illustrating both anatomical features and physiological functioning, free from overlying structures.In this chapter, the authors share their opinions on the research and development in the field of Medical Image Reconstruction Techniques, Computed Tomography (CT), challenges and the impact of future technology developments in CT, Computed Tomography Metrology in industrial research & development, technology, and clinical performance of different CT-scanner generations used for cardiac imaging, such as Electron Beam CT (EBCT), single-slice CT, and Multi-Detector row CT (MDCT) with 4, 16, and 64 simultaneously acquired slices. The authors identify the limitations of current CT-scanners, indicate potential of improvement and discuss alternative system concepts such as CT with area detectors and Dual Source CT (DSCT), recent technology with a focus on generation and detection of X-rays, as well as image reconstruction are discussed. Furthermore, the chapter includes aspects of applications, dose exposure in computed tomography, and a brief overview on special CT developments. Since this chapter gives a review of the major accomplishments and future directions in this field, with emphasis on developments over the past 50 years, the interested reader is referred to recent literature on computed tomography including a detailed discussion of CT technology in the references section.

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INTRODUCTION

Images and Visualization have become increasingly important in many areas of Science and technology. Advances in hardware and software have allowed computerized image processing to become a standard tool in many scientific applications. Applications include, although are not restricted to, remote sensing when imaging the earth or a planet, electrical resistivity imaging as a geophysical method to image the underground, SONAR as a sound navigation ranging imaging, Radar imaging, and medical imaging (Chan & Shen, 2005).

Medical imaging technologies provide several of the most powerful diagnostic tools available to modern medical science, Since the introduction of X-ray machines at the end of the 19th century, and the development of imaging devices using internally relating radio nuclides in the middle of the 20th century, diagnostic imaging has been an important tool. Such important innovations are nowadays taking place, however, that they should be characterised as emerging technologies.

Computed Tomography (CT), Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI), Optical imaging, ultrasound, and Electrical Impedance Tomography: all of these techniques have advantages and disadvantages in terms of resolution, cost, safety, sensitivity, specificity, as well as the physiological and metabolic features they can detect. More recently, however, big steps have been taken by integrating different imaging modalities in one system. Combining pathophysiological imaging with high resolution anatomic data allows the result to be much more than the sum of the parts. (Strauss, 2006) describes some of the opportunities and concerns that this marriage of imaging techniques is presenting to future medical practice.

Computerized Tomography (CT) is a major method of biomedical imaging, as well as of industrial non-destructive testing, geophysics, and other areas. Nevertheless, in the last few decades it has observed fast and major new challenges in the field of Medical Imaging. The present CT modalities (X-ray CT, PET, SPECT, MRI, and Ultrasound) have been going through improvements, due to technical and numerical problems. On the other hand, brand new techniques were being developed. The reasons for this advancement are manifold.

For instance, new physiological and metabolic parameters of biological tissues (e.g. stiffness, electrical conductivity, or hemoglobin oxygenation) are attempted to be imaged (Geertsma et al., 2007). Besides, some previously addressed optical and electric parameters (e.g., optical absorption, or electric conductivity) could not bestably imaged by already existing techniques, such as Optical Tomography (OT) or Electrical Impedance Tomography (EIT). Thus, a variety of novel imaging modalities are being developed. A heterogeneity of the so called "hybrid methods" are being introduced and studied. In such techniques, scientist have been developing novel hybrid methods that combine two or more physical types of signals (in most cases, ultrasound and electromagnetic), in the hope of alleviating the deficiencies of each of the types, while taking advantage of their strengths. The most successful example of such a combination is the thermoacoustic tomography also known as Opto-or Photo-Acoustic Tomography (PAT) (Peter & Lenoid, 2008). In the clinical context, medical imaging is generally equated to radiology or "clinical imaging". Research into the application and interpretation of medical images is usually the preserve of radiology and the medical sub-discipline relevant to medical condition or area of medical science (neuroscience, cardiology, psychiatry, psychology) under investigation. Many of the techniques developed for medical imaging also have scientific and industrial applications.

Although the mathematical sciences were used in a general way for image processing, they were of little importance in bio-medical work until the development of Computed Tomography (CT)