Chapter 16
Biomedical Imaging Techniques

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ABSTRACT

Biomedical imaging techniques had significantly improved the health care of patients. Image guided therapy has reduced the high risk of human errors with improved accuracy in disease detection and surgical procedures. The chapter provides an overview of existing imaging methods and current imaging approaches and their potential to unravel the challenges in medical field. First part of the chapter picture outs the basic concepts and mechanism of various imaging techniques that are currently in use. The second part explains about the features of image processing system and future trends in image guided therapy extended with a short discussion on radiation exposure in medical imaging. The authors trust the chapter to be beneficial to the beginners in the area of medical science and to the clinicians.

INTRODUCTION

Image and video processing finds its broad application in medical science. Biomedical imaging techniques have their prominent role both in diagnostic and therapeutic arenas. These techniques had significantly helped to improve the health care of patients. Image guided therapy has drastically reduced the high risk of human errors with improved accuracy in disease detection and surgical procedures. The history of medical imaging started since 1890's, gradually raised in 1980's and considerably explored in recent years with technological advancements. The main objective of this chapter is to provide a basic knowledge to the novices of various biomedical imaging on techniques and their advancements in today's world.

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BACKGROUND

Discovery of X-rays by Wilhelm Conrad Rontgen was the beginning era for medical imaging. In 1895, Wilhelm Conrad Rontgen discovered the occurrence of electromagnetic radiation in the wavelength range while undertaking an experiment with Hittorf – Crookes tube. He named the new ray as X-rays, with which he took the first picture of his wife Anna Bertha's hand. The X-rays were later developed by William Coolidge with the invention of Coolidge tube which gave more powerful visualization of deep-rooted anatomy and tumours. Use of Coolidge tube with tungsten filament by Coolidge was one of the biggest exploitation of X-rays in the field of radiology. In 1946, Nuclear magnetic Resonance (NMR) in a condensed matter was discovered by Felix Bloch and Edward Purcell. This was the initial footstep towards the discovery of Magnetic Resonance Imaging (MRI).

With the advent of NMR, Raymond Vahan Damadian proposed the first MR body scanner in 1969. He discovered that tumour can be distinguished from normal cells using NMR. Godfrey Hounsfield came up with the idea to create an object in slices using X- rays at various angles around the object. He built the first prototype Computed Tomographic (CT) scanner and obtained first CT image of a preserved human brain. The first MRI body scanner on humans came into picture in 1977. With the assist of mathematics, and computer algorithms and with technological expansion in digital and communications system, new imaging techniques were developed. This moulded biomedical imaging to be an interdisciplinary field which collaborate physicist, biologist, mathematician, pharmacologist and computational biologist.

IMAGING TECHNIQUES

The basic principles of all imaging techniques are same. A beam of wave passes through the body/area under diagnosis, transmits or reflects back the radiation which will be captured by a detector and processed to get an image pattern. The type of wave differs for different modalities. CT involves the use of X-rays, whereas radio frequency waves and gamma rays are used for MRI and SPECT (Single-Photon Emission Computed Tomography) respectively.

Conventional Film Radiography

With the development of X-rays, the first radiographic image was obtained through conventional film radiography. Conventional radiography contains X-ray film placed in between two screen supports and fluorescent screens. The setup is placed in between a couple of cassettes as shown in Figure 1. A beam of X-ray passes though the human body, hits the fluorescent screen and produces a photographic image pattern. The film is later removed, processed and developed with automated chemical film processor (Brant & Helms, 2012) in a dark room and a visible image pattern is obtained.

Computed Radiography

Conventional film radiography was modified with the use of a reusable phosphor imaging plate and was named as Computed Radiography (CR). Instead of film cassette, a photostimulable phosphor imaging plate was placed in the cassette. The radiographic shadow falls, gets projected on the imaging plate and the plate is placed on a reading device or a CR reader. The reading device consists of a helium neon laser