Chapter 6
Biomedical Image Processing and Analysis

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ABSTRACT

Since 1960's digital image processing has been a popular field of research and applications. Among the various applications like physics, security, photonics, biomedical, astronomy, remote sensing, ecological, environmental, etc.; biomedical is one of the many important areas people are focusing on. So for the intelligent analysis of multimedia information like biomedical image has is the thrust area of this chapter. This chapter therefore would aid both biomedical engineers and non-technical people using the tools to get an overview. This chapter mainly concentrates on bio-medical imaging. The medical testing abbreviations and terms like X-ray, MRI, SPECT, PET, Ultrasonography, CFI, optical and IR Imaging SEM, TEM, etc. are discussed here. They mainly concentrate on images of internal structure of living organisms which are not accessible by standard imaging techniques. Moreover, this helps non-technically oriented people to get an overview of the bio-medical aspects.

INTRODUCTION

The different biomedical imaging modalities have been discussed here. Most of these techniques are very common in our day to day lives but in spite of using them we are not aware of the mechanism of these systems and the image analysis procedures. So, brief explanations are provided here to the extent that is needed to understand the imaging properties of the individual modalities and their requirements with respect to processing and analysis of measured data. No attempt has been made to go deeper into the physical background of these individual modalities, nor has the technical construction been described of the respective imaging systems. The purpose here is solely to explain those features of each modality that determine its imaging properties and limitations, and to comment on intrinsic signal and image data processing and analysis, as well as on typical parameters of the provided image data. This should lead

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the reader to an understanding of the reasons behind the application of this or another data processing approach in the frame of every modality. Moreover, as this chapter is targeted to the general audience who might not be too accustomed to high level of mathematics involved in these modalities and their image analysis techniques. Therefore very negligible amount of mathematical terms have been involved in this chapter (Bijnens, 1997; Dawant & Zijdenbos, 2000; Fenster & Downey, 2000; Hrivnák, 1986; Kilian, Jan, & Bijnens, 2000; Reiber, 2000; Sheehan, Wilson, Shavelle, & Geiser, 2000; Stegmann, Wepf, & Schroder, 1999; Wahl, 2002; Woodward, 1995; Xu, Pham, & Prince, 2002; Bloch, 1946; Purcell, Torrey, & Pound 1946; Lauterbur, 1973; Hahn, 1950; Mansfield, 1977; Anger, 1958; Namekava, Kasai, Tsukamoto, & Koyano, 1982; Petrán, Hadravsky, Egger, & Galambos, 1968; Hounsfield, 1973).

The biomedical imaging systems can be classified into the following categories according to basic imaging criteria:

- X-ray projection radiography
- Digital subtractive angiography (DSA)
- X-ray computed tomography (CT)
- Magnetic resonance imaging (MRI) tomography
- Nuclear imaging (planar gamma-imaging, SPECT, PET)
- Ultrasonography (USG)
- Optical and Infrared (IR) Imaging
- Electron microscopy
- Electrical impedance tomography (IT)

All these modalities are not used exclusively in medicine; many of them find applications in other areas too i.e. in technology and industry (material engineering, micro- and nanotechnology, nondestructive testing), as well as in research and science, such as in biology, ecology, archaeology, etc. (Boone, 2000; Bronzino, 1995; Bushberg, Seibert, Leidholdt, & Boone, 2002; Cho, Jones, & Singh, 1993; Krestel, 1990; Rowlands, & Yorkston, 2000; Yaffe, 2000). Here in this chapter these modalities are briefly discussed, providing some overview in this field.

X-Ray Projection Radiography

Since Roentgen's discovery of the x-rays in the last decade of the 19th century, x-ray projection radiography is the oldest and simplest medical imaging modality as far as the imaging principle concerns. It is normally considered as a point radiator as the source of radiation is of negligible dimension. Here the image is formed of intensity values of the x-rays modified by passing through the imaged object, e.g., a part of the patient's body. The resulting image contains information on the complete three-dimensional volume projected on the two-dimensional plane of the detecting panel (originally a fluorescent screen, film, or image amplifier, currently also a type of digital flat-panel detector). Every pixel in the resulting image ideally represents the intensity of the incident x-ray that carries the information on the total attenuation along the respective ray. The resulting image can be interpreted as a mixture of images of planes parallel with the projection plane (Boone, 2000).

Normally the individual planes are imaged in different scales. It is impossible to separate the image information on the individual planes algorithmically, as the information of individual contributions to ray attenuation is missing. Usually, this is a (principally difficult) task for the radiologist analyzing the