Chapter 13
Electrical Impedance Tomography (EIT): A Harmless Medical Imaging Modality

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ABSTRACT

Looking into the human body is very essential not only for studying the anatomy and physiology, but also for diagnosing a disease or illness. Doctors always try to visualize an organ or body part in order to study its physiological and anatomical status for understanding and/or treating its illness. This necessity introduced the diagnostic tool called medical imaging. The era of medical imaging started in 1895, when Roentgen discovered the magical powerful invisible rays called X-rays. Gradually the medical imaging introduced X-Ray CT, Gamma Camera, PET, SPECT, MRI, USG. Recently medical imaging field is enriched with comparatively newer tomographic imaging modalities like Electrical Impedance Tomography (EIT), Diffuse Optical Tomography (DOT), Optical Coherence Tomography (OCT), and Photoacaustic Tomography (PAT). The EIT has been extensively researched in different fields of science and engineering due to its several advantages. This chapter will present a brief review on the available medical imaging modalities and focus on the need of an alternating method. EIT will be discussed with its physical and mathematical aspects, potentials, and challenges.

INTRODUCTION

Visualizing the interior of the human body is very essential for studying its anatomy as well as physiology but also for diagnosing a disease or illness. Doctors have always been interested to visualize the organs or body parts for studying their physiological and anatomical status for diagnosing and treating its illness which insisted the doctors to search for a diagnostic tool called medical imaging. The era of medical imaging started in 1895, when Roentgen discovered the magical and powerful invisible rays called X-rays which were unexpectedly found in his laboratory to be useful for visualizing the tissue contrast on photography plates called planar radiography.

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After that the medical imaging field introduced X-Ray Computed Tomography (X-Ray CT), Gamma Camera, Positron emission tomography (PET), Single-Photon Emission Computed Tomography (SPECT), Magnetic Resonance Imaging (MRI), UltraSonoGraphy (USG). Recently medical imaging field is enriched with comparatively newer tomographic imaging modalities with electric current and light signals. The computed tomography which use the electric signal is called Electrical Impedance Tomography (EIT) whereas the other tomographic methods which use the light signal can be found in form of Diffuse Optical Tomography (DOT), Optical Coherence Tomography (OCT), PhotoAcaustic Tomography (PAT), and others. The EIT has been extensively researched in different field of science and engineering for more than three decades due to its several advantages over other tomographic imaging modalities. Being a very fast, low-cost, radiation free, nonionizing, noninvasive, portable tomographic imaging technique EIT is studied and applied in medical imaging, industrial process tomography, chemical engineering, civil engineering, defense field, geosciences, oceanography, manufacturing technology, MEMS and thin film technology, microbiology and biotechnology and so on. This chapter will present the physical and mathematical aspects of the EIT technology along with its potentials and challenges. The chapter will start with a brief introduction to the medical imaging technologies and summarize the available conventional medical imaging techniques. Starting from the invention of X-rays, the chapter will discuss about few of the main imaging modalities in brief to understand their working principle, advantages and limitations. The chapter emphasizes on the medical imaging modalities working on the Computed Tomography (CT) principle. The computed tomography is discussed in detail considering the X-Ray CT as the basic CT imaging modality. The present scenario of the medical imaging is discussed with their own advantages and disadvantages. The chapter also discusses about the nuclear medicine technologies with the examples of the available emission tomographic modalities used in clinics and hospitals. After a brief review on the available medical imaging modalities the chapter summarizes their advantages and limitations and focuses on the need of an alternating method. As an alternating medical imaging modality Electrical Impedance Tomography (EIT) is proposed and discussed in detail. It's working principle, methodology, physical significance are discussed along with its advantages over the existing medical imaging techniques.

BACKGROUND

Doctors always looked for a safe, effective, reliable, low cost and fast imaging modality to visualize human body parts for studying its physiological and anatomical status for clinical diagnosis. A number of medical imaging modalities have been introduced for better visualization or for a particular advantage in medical or clinical aspects. The imaging modalities such as X-Ray Planner Radiography, X-Ray CT, Gamma Camera, SPECT, PET, MRI, USG, and so forth have been employed for clinical investigations and diagnosis and treatments since for long while. All these imaging methods have their own advantages and limitations. Although the above mentioned techniques are found very popular in modern medical diagnosis but still all of these techniques are found with several limitations and challenges which are still under research. Researcher are also trying to invent a medical imaging modality with most of the desired advantages as not a single of these available modalities is found with all required advantages sought by clinicians and doctors. Moreover all the methods are always found with a number of disadvantages or some limitations which direct the doctors to study the patient with a number of imaging modality for better diagnosis. CT, SPECT, PET, though provide better image quality, use the ionizing radiation and hence those