Chapter 1
Introduction to Next-Generation Biomedical Imaging

Maruf Ahmad
https://orcid.org/0000-0002-2724-7009
Centurion University of Technology and Management, Bhubaneswar, India

Anurag Luharia
https://orcid.org/0000-0001-6051-1636
Datta Meghe Institute of Higher Education and Research, India

Fauzia Khan
Integral University, Lucknow, India

ABSTRACT

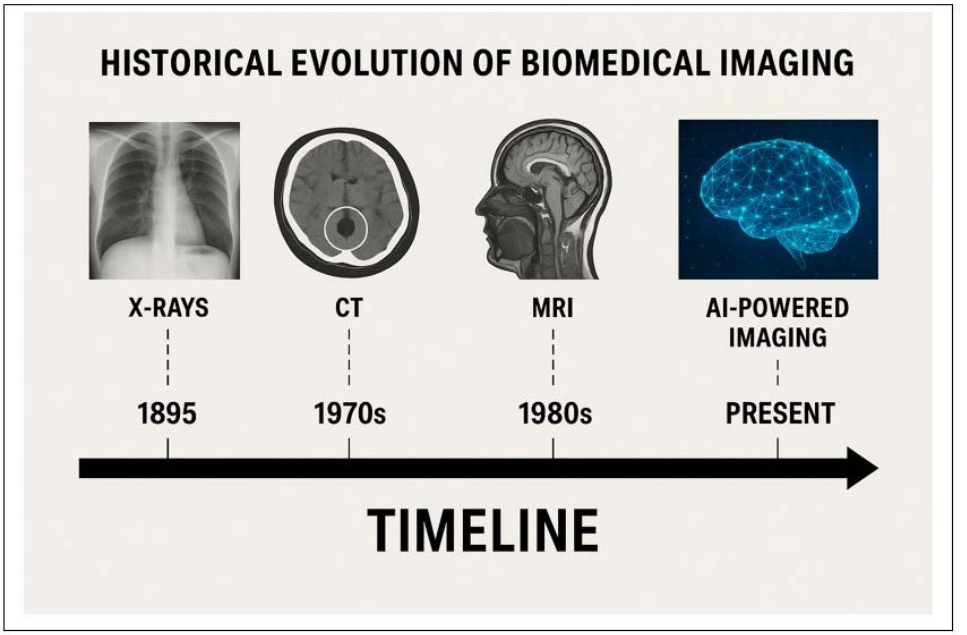
Biomedical imaging has long been vital for revealing the human body's inner workings with remarkable precision. Now, a new era of imaging technology is set to revolutionize healthcare. This chapter explores next-generation biomedical imaging, featuring breakthroughs like photon-counting CT (PCCT), ultra-high-field MRI, and advanced molecular imaging that push resolution and specificity boundaries. Artificial intelligence plays a pivotal role, with machine learning and deep learning transforming image reconstruction, analysis, and interpretation. The chapter also highlights multimodal imaging, which integrates structural and functional data for a deeper understanding of complex diseases. Beyond innovations, practical applications are discussed, including early disease detection, minimally invasive procedures, and precision medicine. By bridging cutting-edge research with clinical practice, this introduction provides a roadmap for medical professionals and researchers to navigate the transformative future of biomedical imaging in diagnosis and treatment.

DOI: 10.4018/979-8-3373-0903-3.ch001

1. INTRODUCTION

From the earliest days of X-rays to the more advanced AI-powered modalities that are now being developed, the biomedical imaging field has undergone tremendous change. It started with X-rays, which were the first to transform medical diagnosis and paved the way for other imaging technologies, such as CT and MRI As shown in **Fig.1**. These have helped in the improvement of the quality of images as well as provided physicians with more tools for diagnoses. As seen, deep learning algorithms when applied to imaging may improve image processing and reconstruction and thus offer an avenue for a more precise diagnosis and effective treatment.(Showrov et al., 2024)

Figure 1. Evolution of Biomedical Imaging



Despite these advances, medical imaging still faces a number of challenges. The first is the massive amounts of data generated by modern imaging techniques. With the increasing digital and high-resolution nature of imaging, data volumes can easily exceed terabytes, making storage, retrieval, and analysis procedures cumbersome. (Scholl et al., 2011) Moreover, medical image interpretation is often qualitative, leading to inconsistent diagnosis results. With efforts made to establish quantitative imaging biomarkers, it is an effort towards standardizing picture interpretation and