Chapter 8
Applications, Challenges, and Future Prospects of Enhancing Medical Imaging With Neural Networks

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ABSTRACT

Acute and accurate disease diagnosis is of utmost significance in modern healthcare but is generally not possible with conventional imaging techniques. As AI-based techniques offer higher diagnostic accuracy and speed, their adoption is increasingly becoming vital. Through automated processing, recent advances in deep

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learning have revolutionized medical imaging, enhancing anomaly identification, organ segmentation, and disease detection. Convolutional neural networks (CNNs), generative adversarial networks (GANs), transformer models, hybrid models, and more are introduced in this chapter. Revolutionary methods like Federated Learning (FL) and Self-Supervised Learning (SSL) are also discussed, along with their usage in different imaging modalities. The chapter also discusses issues including data sparsity, model interpretability, and ethics. A detailed case study on the application of transfer learning for medical image classification also showcases the capability of artificial intelligence to augment clinical diagnosis.

INTRODUCTION

Artificial intelligence (AI) has transformed healthcare by changing how we identify, treat, and keep track of patients by enabling more individualized treatments and generating more accurate diagnoses. This technology is significantly enhancing healthcare research and results. Artificial neural networks (ANNs) and other machine-learning techniques are being employed by medical organizations for improving patient care while lowering costs. Over a few decades, technologies like X-ray, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound have changed drastically, providing early detection of underlying diseases with more accuracy (Figure 1). These advancements have helped in taking care of the patient by providing the timely diagnosis that saves lives. The emerging deep learning networks for medical image analysis have proved their capabilities by providing automated, accurate, cost-effective and efficient diagnosis (Chan et al., 2020). From pattern recognition or organ segmentation to disease detection, Neural networks like Convolutional Neural Networks (CNNs), Generative Adversarial Networks (GANs), and transformer models have shown their remarkable performances. For example, incorporating neural networks into medical imaging has been shown to predict not only prognosis but also treatment responses in case of gastric cancer (Fu et al., 2023). This helped deliver personalized medical interventions helping the patient outcomes. Similarly, a study (Chan et al., 2020) shows that these using these networks reduced the time to read and understand the images of digital breast tomosynthesis (DBT) by more than 50%.