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TOPICAL REVIEW

A novel approach in cancer diagnosis: integrating holography microscopic medical imaging and deep learning techniques—challenges and future trends

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Abstract

Medical imaging is pivotal in early disease diagnosis, providing essential insights that enable timely and accurate detection of health anomalies. Traditional imaging techniques, such as Magnetic Resonance Imaging (MRI), Computer Tomography (CT), ultrasound, and Positron Emission Tomography (PET), offer vital insights into three-dimensional structures but frequently fall short of delivering a comprehensive and detailed anatomical analysis, capturing only amplitude details. Three-dimensional holography microscopic medical imaging provides a promising solution by capturing the amplitude (brightness) and phase (structural information) details of biological structures. In this study, we investigate the novel collaborative potential of Deep Learning (DL) and holography microscopic phase imaging for cancer diagnosis. The study comprehensively examines existing literature, analyzes advancements, identifies research gaps, and proposes future research directions in cancer diagnosis through the integrated Quantitative Phase Imaging (QPI) and DL methodology. This novel approach addresses a critical limitation of traditional imaging by capturing detailed structural information, paving the way for more accurate diagnostics. The proposed approach comprises tissue sample collection, holographic image scanning, preprocessing in case of imbalanced datasets, and training on annotated datasets using DL architectures like U-Net and Vision Transformer(ViT's). Furthermore, sophisticated concepts in DL, like the incorporation of Explainable AI (XAI) techniques, are suggested for comprehensive disease diagnosis and identification. The study thoroughly investigates the advantages of integrating holography imaging and DL for precise cancer diagnosis. Additionally, meticulous insights are presented by identifying the challenges associated with this integration methodology.

1. Introduction

Medical imaging plays a vital role in detecting and diagnosing cancer by providing valuable insights into the presence, location, and characteristics of abnormalities within the body[1]. Multiple imaging modalities, such as 'Magnetic Resonance Imaging (MRI),' 'Computer Tomography (CT),' 'Ultrasound,' and 'Positron Emission Tomography (PET),' offer critical insights into the presence, precise location, and other characteristics of tumors within the body [2]. These imaging techniques are readily available, budget-friendly, associated with minimal radiation exposure, and provide rapid outcomes, making them suitable for regular screenings and initial assessments. However, it is essential to acknowledge that these techniques are limited to depth information, three-dimensional views of biological structures, or other detailed anatomical information. Thus, despite their simplicity and cost-effectiveness, these imaging methods have limitations in performing in-depth analysis in fields like biology and medicine. Although these imaging