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AI-BASED DIAGNOSTICS IN ONCOLOGY: ADVANCING EARLY DETECTION AND PERSONALIZED TREATMENT OF CANCER

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Abstract. Artificial Intelligence (AI) is revolutionizing oncology by improving the early detection and diagnosis of cancer. Cancer remains one of the leading causes of mortality worldwide, driving the need for innovative approaches in research and treatment. Artificial intelligence (AI) has emerged as a powerful tool in oncology, with the potential to revolutionize cancer diagnosis, treatment, and management. Through advanced technologies such as Machine Learning (ML), Deep Learning (DL), Computer Vision (CV), and Natural Language Processing (NLP), AI enables faster, more accurate, and data-driven medical decisions. This article reviews recent advancements in AI applications within cancer research, focusing on early detection through computer-aided diagnosis, personalized treatment strategies, and drug discovery. Additionally, we discuss the importance of integrating social determinants of health to optimize cancer care. Despite these advancements, challenges such as data quality, algorithmic biases, and clinical validation remain, limiting widespread adoption. The review concludes with a discussion of the future directions of AI in oncology, emphasizing its potential to reshape cancer care by enhancing diagnosis, personalizing treatments and targeted therapies, and ultimately improving patient outcomes.
Keywords: artificial intelligence [AI], oncology, cancer detection, deep learning, computer-aided diagnosis, personalized medicine, nanomedicine, immunotherapy, algorithmic bias, health equity.

Introduction

Cancer, an illness that can affect people from all walks of life, is an intricate worldwide health concern that continues to require attention. Cancer is a disease that affects people regardless of age and causes suffering all around the world. Cancer is the second most prevalent cause of mortality worldwide, accounting for one in six deaths in 2020, according to the World Health Organization (WHO) [1].

Artificial intelligence (AI) is a technology that involves the use of algorithms and mathematical models to analyze and process large and complex information. Diagnosis, patient response analysis of the disease before and after treatment, etc. are some of the clinical applications of AI. However, few factors contribute to the slow adoption of AI in healthcare. They require strict regulatory requirements that hinder implementation of new technologies. The new algorithms require heavy clinical trials for reasonable accuracy and efficiency. Features that AI can extract from a medical image include the size, shape, and texture of the organ or tissue. It can recognize abnormalities in growth, dimension, and thickness to detect diseases and tumors. Due to a varied patient population, developing an AI model with salient features is a challenging task.

Main Body

1. AI in Early Cancer Detection

Early detection is one of the most significant applications of AI in oncology. Machine learning algorithms, especially deep learning and convolutional neural networks (CNNs), have demonstrated exceptional performance in analyzing medical imaging such as MRI, CT scans,

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and mammograms. AI-based diagnostic systems can detect early tumor growth, classify cancerous and non-cancerous lesions, and provide real-time assessments for radiologists. For example, AI-assisted mammography has improved breast cancer detection accuracy while reducing false positives. Such innovations can significantly enhance early diagnosis and patient prognosis. Similarly, in lung cancer, AI systems trained on CT scan data can accurately differentiate between benign and malignant nodules. These advancements not only enhance the accuracy of detection but also reduce diagnostic workload and support radiologists in making faster and more consistent decisions.

2.Computer-aided diagnosis and predictive analytics

Computer-aided diagnosis (CAD) combines AI with medical imaging to provide a second opinion that complements physicians' expertise. CAD systems use pattern recognition, image segmentation, and predictive analytics to detect abnormalities and classify disease severity. Machine learning algorithms analyze patient data—including imaging, genetic information, and lab tests—to predict tumor behavior, recurrence risks, and treatment responses. For instance, predictive AI models can forecast the likelihood of metastasis or resistance to certain chemotherapy drugs. In prostate and colorectal cancers, CAD tools have shown diagnostic accuracy comparable to expert pathologists. These systems are particularly valuable in resource-limited regions where access to specialized oncologists is limited. By integrating multiple data sources, CAD enhances early decision-making and supports personalized care pathways.

3.AI in personalized and precision treatment in oncology

AI is central to the development of personalized or precision oncology, where treatment is tailored to the unique characteristics of each patient. Instead of relying on standardized treatment protocols, AI-driven models analyze genomic, proteomic, and clinical data to identify patient-specific cancer markers. This allows oncologists to predict how a patient will respond to certain therapies and adjust treatment accordingly. For example, AI algorithms can identify specific mutations in genes such as BRCA1 and BRCA2 that influence breast and ovarian cancer progression. Furthermore, AI systems assist in designing personalized radiotherapy plans by calculating optimal radiation doses based on tumor location and tissue sensitivity. This data-driven approach minimizes side effects, improves treatment efficacy, and ensures a more patient-centered approach to cancer care.

Conclusion

AI is no longer a secondary adjunct in oncology—it is becoming an essential, intrinsic component in advancing cancer therapeutics. Beyond diagnosis, AI enables personalized treatment planning, fine-tuned radiation dosing, enhanced robot-assisted surgeries, and discovery of novel therapeutic targets via data-intensive drug development pipelines. On the patient management front, AI-powered wearables and virtual assistants facilitate real-time remote monitoring, boost treatment adherence, and detect complications early.

In clinical research, AI optimizes study design, patient stratification, and recruitment through real-time eligibility checks. Yet despite these advancements, challenges remain in achieving universal clinical adoption. Concerns about algorithm transparency, reproducibility, and interpretability underscore the need to build trust among providers and patients. Critical data-related challenges—bias, inequity, security, and interoperability—must be addressed, particularly as biased training data risks exacerbating existing health disparities across demographics and regions. A multidisciplinary ecosystem—uniting AI researchers, oncologists, ethicists, regulators, and patient advocates—is essential to create equitable, transparent, and clinically valuable AI deployment standards. Medical education must evolve to equip future

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healthcare professionals with the skills to responsibly apply AI in clinical practice. The future of AI in oncology lies not in replacing healthcare professionals but in empowering them with smarter, faster, and more accurate tools to improve patient outcomes and reshape the landscape of cancer care.

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