


Chapter 9

Machine Learning and Emerging Technologies in Cancer Care

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ABSTRACT

Cancer is the second-leading global cause of death (>10M/year), posing complex economic and social burdens. Current treatments—conventional (chemo, radio) and advanced (targeted, immuno)—are limited by high cost, toxicity, lack of precision, and unpredictable patient response. An urgent paradigm shift requires leveraging Artificial Intelligence (AI) and Machine Learning (ML). AI/ML drives breakthroughs in the entire oncological care pathway: enabling precise diagnosis, robust prognosis, and individualized prediction of therapeutic response via multi-omics analysis. The future of oncology must be defined by AI-powered precision to solve the problem of variable efficacy and achieve universal access to effective care.

1. INTRODUCTION

Cancer remains one of the biggest health challenges for humanity, affecting millions of individuals and families annually. The World Health Organization and

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the International Agency for Research on Cancer estimates suggest that cancer is responsible for over 10 million deaths annually, making it the second-highest cause of death, behind only cardiovascular diseases, with about 18 million mortalities every year (Sung et al., 2021). These numbers indicate the impact of cancer on the economy and human health, not merely through loss of lives, but also through long periods of patient treatment, health systems, and psychological impact on patients and caregivers. Furthermore, cancer is not a single disease but comprises hundreds of types and subtypes, each having different symptoms and treatments. These challenges make cancer a major risk factor for humanity, requiring serious efforts from all stakeholders, including healthcare professionals, researchers, local governments, and international organizations.

Traditional cancer treatment approaches, such as chemotherapy, radiotherapy, and surgery, have helped countless individuals overcome cancer and live healthy lives. Although these approaches remain focused on current oncology, they suffer from several limitations, including high costs, toxicity, limited precision, variable patient responses to the same treatments, and, in some cases, ineffectiveness for certain patients. Some more recent approaches include targeted therapy and immunotherapy. However, these approaches also have their own limitations, including high cost, inaccessibility for poor and underdeveloped communities, and variable efficacy across patients. To this end, there is a high need for innovative approaches for cancer diagnosis, prognosis, therapeutic interventions, and post-surgery care.

1.1. Artificial Intelligence in Oncology

Recent advancements in algorithms, hardware, and the increasing availability of large datasets have led to unprecedented growth in artificial intelligence, particularly in its subdomains of machine learning and deep learning (DL), over the past decade. Researchers have applied AI to nearly every domain and solved problems that were previously considered unsolvable. The healthcare community has also reaped significant benefits from the use of AI. Some major applications of AI in healthcare include medical imaging (Esteva et al., 2017), drug discovery (Vamathevan et al., 2019), personalized medicine (Kourou et al., 2015), clinical decision support (Sutton et al., 2020), and robotic surgery (Hashimoto et al., 2018). While statistical methods of prediction require predefined assumptions as a prerequisite, machine learning algorithms can directly learn complex nonlinear functions from the underlying data to make accurate predictions on unseen data. This learning and prediction ability is particularly useful in oncology, where clinical decision-making often involves

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