RADemics

Cloud-Based Management of Cancer Imaging and Patient Data

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Abstract

Rapid advancements in medical imaging technologies, artificial intelligence, and digital healthcare infrastructures have significantly transformed modern oncology practices, generating enormous volumes of heterogeneous cancer-related data that require secure, scalable, and intelligent management frameworks. Conventional healthcare storage systems and standalone oncology information platforms encounter substantial limitations associated with data fragmentation, restricted interoperability, inadequate scalability, delayed accessibility, and high infrastructure maintenance costs. Cloud computing emerged as a transformative technological paradigm capable of addressing these challenges through distributed computing architectures, centralized imaging repositories, real-time accessibility, and high-performance analytical environments. This book chapter presents a comprehensive exploration of cloud-based management frameworks for cancer imaging and patient data within contemporary oncology ecosystems, with emphasis on the evolution of cancer data management, cloud-native oncology infrastructures, workflow design in cloud oncology systems, multimodal imaging data integration techniques, and Artificial Intelligence-assisted clinical decision support systems. The discussion critically examines advanced technologies including cloud-native PACS architectures, Vendor Neutral Archives (VNAs), DICOM interoperability standards, federated learning, blockchain-enabled healthcare security, edge-cloud collaborative computing models, and scalable cloud infrastructures supporting intelligent oncology applications. Particular focus has been placed on multimodal cancer imaging integration involving Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), digital pathology, radiomics, genomic analytics, and cloud-based precision oncology frameworks for automated tumor detection, predictive analytics, treatment response evaluation, and personalized therapy planning. Major challenges associated with cybersecurity, patient privacy protection, regulatory compliance, interoperability barriers, ethical governance, and large-scale healthcare data harmonization across distributed clinical environments have also been critically analyzed. The chapter highlights the growing significance of intelligent cloud-native ecosystems in enhancing diagnostic accuracy, strengthening multidisciplinary collaboration, accelerating translational oncology research, and improving patient-centered cancer care delivery through data-driven healthcare infrastructures.

Keywords: Cloud Computing, Cancer Imaging, Artificial Intelligence, Oncology Informatics, Medical Image Management, Precision Medicine

Introduction

Cancer continues to represent one of the most significant healthcare challenges across the world, creating substantial clinical, social, and economic burdens within healthcare systems. Continuous growth in cancer incidence rates, increasing aging populations, lifestyle-related risk factors, and environmental influences have intensified the demand for advanced diagnostic and therapeutic infrastructures capable of supporting efficient oncology care [1]. Modern oncology practices rely heavily on digital technologies for accurate disease detection, tumor characterization, therapy planning, and longitudinal patient monitoring. Medical imaging technologies including Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), mammography, ultrasound imaging, and digital pathology contribute extensively to clinical decision-making processes in cancer diagnosis and treatment management [2]. These imaging modalities generate extremely large and heterogeneous datasets containing anatomical, physiological, metabolic, and molecular information associated with disease progression and therapeutic response. Expansion of imaging resolutions, three-dimensional visualization systems, and image-guided treatment planning procedures significantly increased data complexity within oncology environments [3]. Conventional hospital-based information systems frequently encounter difficulties in managing large-scale cancer datasets due to storage limitations, fragmented infrastructures, restricted interoperability, delayed accessibility, and insufficient computational capabilities [4]. Continuous generation of oncology imaging data therefore created an urgent requirement for scalable, intelligent, and highly interconnected healthcare infrastructures capable of supporting efficient storage, retrieval, transmission, and analysis of patient information across distributed healthcare ecosystems [5].

Rapid digital transformation within healthcare environments accelerated adoption of cloud computing technologies in medical informatics and oncology data management systems. Traditional oncology infrastructures depended primarily on localized servers, standalone Picture Archiving and Communication Systems (PACS), and institution-centered storage architectures that limited collaboration among healthcare providers and research organizations [6]. Expansion of multidisciplinary cancer care, telemedicine services, precision oncology initiatives, and collaborative biomedical research created increasing demand for distributed healthcare infrastructures capable of supporting real-time data accessibility and seamless information exchange [7]. Cloud computing introduced scalable computational frameworks through virtualization technologies, elastic storage mechanisms, distributed processing architectures, and centralized cloud repositories supporting efficient management of high-volume oncology datasets [8]. Cloud-native healthcare environments strengthened operational flexibility by enabling healthcare organizations to access advanced computing resources without extensive investments in physical infrastructure maintenance and hardware expansion. Integration of cloud technologies with Electronic Health Records (EHRs), Vendor Neutral Archives (VNAs), laboratory information systems, and radiology workflows improved interoperability among healthcare departments and facilitated centralized management of multimodal patient information [9]. Remote accessibility of cloud-enabled oncology systems also strengthened tele-oncology services and enabled collaborative treatment planning involving oncologists, radiologists, pathologists, surgeons, and clinical researchers located across geographically distributed institutions [10].