RADemics

IoT Sensors for Biomarker Monitoring in Cancer Patients

Everest Shiwach, P. Venkat Rao
D N COLLEGE, NARSIMHA REDDY ENGINEERING COLLEGE

IoT Sensors for Biomarker Monitoring in Cancer Patients

[1]Everest Shiwach, Associate Professor, Botany Department, D N College, Meerut, Uttar Pradesh. everestmalik@gmail.com

[2]P. Venkat Rao, Professor, Physics, Narsimha Reddy Engineering College, Hyderabad, Telangana, India. professor.venkatrao@gmail.com

Abstract

Cancer management was undergoing a significant transformation through the integration of continuous monitoring technologies that enable real-time assessment of disease progression, therapeutic response, and recurrence risk. Conventional diagnostic approaches based on intermittent clinical evaluations often fail to capture dynamic biological changes, creating a demand for continuous and data-driven healthcare solutions. IoT-enabled biosensing systems provide a scalable framework for capturing cancer-related biomarkers using wearable, implantable, and lab-on-chip devices, facilitating uninterrupted monitoring of physiological and molecular signals. These systems support early detection of abnormal biomarker variations, enabling timely clinical interventions and improved patient outcomes. Integration of cloud and edge computing infrastructures ensures efficient data acquisition, storage, and transmission, while artificial intelligence techniques enhance interpretation of complex multimodal datasets for predictive oncology applications. The convergence of digital health technologies with clinical information systems enables longitudinal tracking of patient-specific biomarker profiles, strengthening precision medicine approaches and personalized therapy optimization. The technological progress, challenges related to sensor accuracy, interoperability, cybersecurity, and large-scale clinical validation continue to limit widespread adoption. Advancements in nanotechnology, smart biosensors, and machine learning are expected to overcome these barriers and enhance system reliability. This chapter provides a comprehensive overview of IoT-based biomarker monitoring systems in cancer care, focusing on biosensor technologies, system architecture, clinical applications, and future research directions.

Keywords: Internet of Things, Cancer Biomarkers, Biosensors, Precision Oncology, Artificial Intelligence, Digital Health Systems

Introduction

Cancer remains one of the most complex and heterogeneous diseases, characterized by uncontrolled cellular proliferation, genetic instability, and progressive systemic involvement [1]. Conventional diagnostic and monitoring approaches rely heavily on periodic laboratory investigations, imaging techniques, and clinical evaluations that provide only intermittent snapshots of disease status [2]. Such fragmented assessment frameworks often fail to capture rapid molecular and physiological changes occurring within tumor environments [3]. The increasing burden of cancer worldwide necessitates a shift toward continuous monitoring systems capable of delivering real-time insights into disease dynamics [4]. Advances in biomedical engineering and

computational technologies have enabled the emergence of data-centric healthcare models, where continuous sensing and intelligent analytics support more responsive clinical decision-making. Within this evolving landscape, biosensor-driven monitoring frameworks have gained prominence due to their ability to detect subtle biological variations associated with tumor development and progression [5].

Integration of digital technologies into healthcare has introduced the concept of connected medical ecosystems, where patient data was continuously generated, transmitted, and analyzed through networked devices [6]. The emergence of the Internet of Things has played a central role in enabling this transformation by linking biosensors, wearable devices, and medical platforms into unified monitoring systems [7]. In oncology, this connectivity supports continuous tracking of cancer-associated biomarkers such as circulating tumor DNA, proteins, metabolites, and physiological indicators [8]. These interconnected systems allow real-time data acquisition from diverse biological sources, creating a comprehensive representation of patient health status [9]. The ability to integrate heterogeneous data streams enhances clinical understanding of tumor behavior and supports early detection of abnormal changes that indicate disease progression or treatment resistance [10].

Cancer biomarkers serve as essential indicators of biological processes related to tumor initiation, growth, and therapeutic response [11]. These biomarkers encompass genomic alterations, proteomic expressions, metabolic signatures, and physiological signals that collectively reflect disease activity. Continuous monitoring of such markers enables dynamic assessment of cancer progression rather than reliance on static diagnostic measurements [12]. Molecular biomarkers such as circulating tumor DNA provide high-resolution insights into genetic mutations and tumor evolution, while protein-based markers reflect disease burden and therapeutic response [13]. Metabolic changes associated with tumor microenvironments offer additional layers of diagnostic information, supporting more comprehensive disease profiling [14]. Physiological indicators, including variations in temperature, oxygen saturation, and heart rate variability, contribute indirect but valuable insights into systemic effects of malignancy and treatment interventions [15].