RADemics

Real-Time Health Analytics Using Edge AI and Cloud-Based IoT Systems

Jonnakuti Rakesh Babu, S. Prabakaran
Chalapathi Institute of Technology, V.S.B Engineering College

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[1]Jonnakuti Rakesh Babu, Assistant Professor, Department of Computer Science and Engineering, Chalapathi Institute of Technology, Mothadaka, Andhra Pradesh, India. raakesh540@gmail.com

[2]S. Prabakaran, Assistant Professor, Department of Computer Science and Engineering, V.S.B Engineering College, Karur, Tamil Nadu, India. mokipraba@gmail.com

Abstract

Rapid advancement of connected medical devices and intelligent computing technologies has transformed modern healthcare monitoring and decision-support systems. Continuous streams of physiological data generated by wearable sensors and smart medical equipment demand efficient analytical frameworks capable of delivering timely and accurate clinical insights. Real-time health analytics supported by hybrid edge–cloud architectures offers a promising solution for processing large volumes of biomedical data while maintaining low latency and high system responsiveness. Edge computing enables localized processing of health signals close to sensing devices, facilitating rapid anomaly detection and immediate alert generation. Cloud platforms complement this capability by providing scalable storage, large-scale data management, and advanced machine learning model training for healthcare applications. Integration of artificial intelligence with IoT infrastructures strengthens predictive healthcare analytics and supports intelligent monitoring of patient health conditions. Discussion within this chapter focuses on architectural design, data processing frameworks, lightweight AI models, and performance optimization strategies for distributed healthcare analytics systems.

Keywords: Edge AI, Internet of Things (IoT), Real-Time Health Analytics, Edge–Cloud Architecture, Healthcare Data Analytics, Smart Healthcare Systems.

Introduction

Digital transformation within healthcare environments has accelerated through rapid growth of connected sensing technologies, intelligent data analytics, and distributed computing infrastructures [1]. Healthcare systems increasingly rely on continuous monitoring solutions capable of capturing physiological information from patients during both clinical treatment and remote observation scenarios .Wearable sensors, smart medical devices, and implantable monitoring technologies generate large streams of biomedical data associated with vital signs, activity patterns, and physiological behavior. Expansion of such data-driven healthcare infrastructures supports early disease detection, long-term chronic condition monitoring, and preventive medical care [2]. Real-time analysis of health data strengthens clinical decision support by enabling timely identification of abnormal physiological patterns that require medical attention. Development of Internet of Things–enabled healthcare systems has therefore introduced a paradigm where interconnected devices operate collaboratively to capture, transmit, and analyze

patient health information across distributed environments [3]. Medical sensors placed on the human body continuously measure parameters including heart rate, blood pressure, respiratory activity, blood oxygen saturation, and body temperature. Integration of these sensing technologies with intelligent computing platforms supports automated interpretation of biomedical signals and strengthens responsiveness of healthcare monitoring frameworks [4]. Continuous generation of health information creates opportunities for predictive healthcare analytics capable of identifying disease risk factors before severe symptoms emerge. Such technological capabilities contribute to transformation of healthcare services from reactive treatment models toward proactive and personalized medical care [5]. Intelligent healthcare infrastructures supported by advanced analytics therefore enable improved patient safety, enhanced medical efficiency, and increased accessibility of healthcare services across geographically distributed populations.

Conventional healthcare analytics frameworks primarily rely on centralized cloud computing infrastructures for storing and processing large volumes of biomedical information [6]. Cloud platforms provide high-performance computational resources and scalable storage environments capable of handling extensive healthcare datasets generated by modern medical devices. Large-scale health records, diagnostic imaging archives, and biomedical signal repositories operate efficiently within cloud-based infrastructures [7]. Clinical research initiatives, predictive modeling, and large-scale epidemiological studies benefit from such centralized computational capabilities. Cloud environments support complex machine learning algorithms and deep learning frameworks used for medical image interpretation, disease classification, and health risk prediction [8]. Analytical models operating within cloud infrastructures analyze historical patient records alongside real-time physiological data to generate insights that assist clinicians in treatment planning and medical diagnosis. Continuous integration of healthcare information across hospitals, diagnostic laboratories, and research centers strengthens collaborative medical research and enables population-level health analytics. Expansion of digital health records and remote patient monitoring systems further increases demand for robust data processing infrastructures capable of managing high-volume healthcare information [9]. Centralized healthcare analytics also enables long-term storage of medical histories and treatment outcomes, providing valuable data resources for longitudinal health studies and clinical performance evaluation. Cloud computing platforms therefore serve as foundational components supporting modern healthcare data ecosystems and enabling large-scale analytical processing of medical information generated through IoT-enabled healthcare networks [10].