Chapter 6
Advancing Healthcare With AI-Enhanced Point-of-Care Biosensor Devices:
Smart Biosensing Platforms Empowered by AI for Rapid and Decentralized Diagnostics

Kutay Icoz
https://orcid.org/0000-0002-0947-6166
Abdullah Al Salem University, Kuwait

ABSTRACT

This chapter examines the integration of artificial intelligence (AI) with point-of-care (PoC) biosensor technologies, emphasizing their role in enhancing diagnostic accuracy, automation, and accessibility. It explores the core components of biosensors and how AI-driven algorithms improve sensitivity, specificity, and real-time data interpretation. Applications in wearable and non-invasive biosensors, chronic disease management, infectious disease detection, and personalized health monitoring are discussed. The chapter presents real-world case studies involving microfluidic biosensors, lab-on-a-chip systems, and AI-based signal processing tools. It also addresses key challenges such as data privacy, regulatory compliance, and model interpretability. By highlighting current capabilities and future directions—including multi-omics integration and predictive analytics—this chapter offers a comprehensive overview of how AI-enhanced biosensors are transforming modern healthcare.

DOI: 10.4018/979-8-3373-1772-4.ch006

INTRODUCTION

This chapter presents a *narrative literature review and interdisciplinary discussion* on the emerging integration of artificial intelligence (AI) with point-of-care (POC) biosensor technologies. While both AI and biosensors have seen significant individual advancement over the past decade, their convergence remains nascent. Most AI-enhanced biosensor platforms are still in laboratory development or early-stage clinical trials, and their broader potential in real-world diagnostics is yet to be fully realized (Genc et al., 2024; Icoz, Akar, et al., 2020; Jackson et al., 2016).

The chapter is written for a diverse audience of clinicians, engineers, researchers, and healthcare administrators interested in understanding how AI can augment biosensing capabilities and improve decentralized, patient-centered healthcare delivery. It aims to fill a critical gap in the literature: although numerous studies explore AI in diagnostics and the advancement of biosensors separately, few resources offer an integrated, cross-disciplinary perspective.

Biosensors, analytical devices that detect specific biochemical targets by coupling a biological recognition element (e.g., enzyme, antibody, aptamer) with a transducer, have evolved significantly—from benchtop instruments to portable, real-time systems. Advances in flexible electronics, nanomaterials, and microfluidics have further expanded their capabilities and adaptability.

When integrated with AI, biosensors become intelligent diagnostic systems capable of automated signal interpretation, pattern recognition, and real-time decision support. These technologies enable a wide range of applications—from infectious disease diagnostics to chronic disease monitoring—particularly in settings lacking centralized laboratory infrastructure (Qureshi et al., 2023; C. Wang et al., 2023; Yammouri & Ait Lahcen, 2024).

This chapter offers a structured, cross-sectional review of technological advances, practical implementations, and key challenges associated with AI-enhanced biosensors. Its unique contribution lies in connecting technical innovations with real-world deployment considerations, including ethical design, regulatory frameworks, and healthcare accessibility—particularly in low-resource environments.

The chapter also aligns with the broader goals of the volume, *Intersecting AI and Medicine for Improved Care and Administrative Efficiency*, by emphasizing the role of smart diagnostics in streamlining clinical workflows, enabling early interventions, and supporting healthcare equity.

The structure of this chapter is as follows:

- **Section 2** introduces the fundamental technologies of biosensors and explains how AI enhances signal processing, data interpretation, and sensor performance.

A Survey of Unsupervised Learning in Medical Image Registration
Xin Songand Huan Yang (2022). *International Journal of Health Systems and Translational Medicine (pp. 1-7).*
www.irma-international.org/article/a-survey-of-unsupervised-learning-in-medical-image-registration/282701

Sociocultural Influences of the Psychological Responses of the COVID-19 Pandemic in India

Jaskeerat Kaur Thakral (2024). *Change Dynamics in Healthcare, Technological Innovations, and Complex Scenarios (pp. 171-187).*
www.irma-international.org/chapter/sociocultural-influences-of-the-psychological-responses-of-the-covid-19-pandemic-in-india/340341