RADemics

AI and IoT Based Epidemic Surveillance Systems for Early Detection and Smart Containment of Infectious Diseases

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Abstract

The increasing frequency and severity of infectious disease outbreaks demand intelligent surveillance systems capable of early detection and real-time response. Leveraging Artificial Intelligence (AI) and the Internet of Things (IoT), next-generation epidemic monitoring frameworks are transforming conventional public health strategies into adaptive, data-driven ecosystems. This chapter presents an in-depth exploration of AI-powered algorithms, IoT-enabled sensor networks, and data integration models that collectively enhance disease outbreak forecasting, automated symptom detection, and spatio-temporal anomaly identification. Special emphasis is placed on the role of machine learning models, including deep learning and transfer learning, for processing heterogeneous health data collected from wearables, mobile applications, environmental sensors, and social media platforms. The study also highlights the contributions of natural language processing (NLP) techniques in extracting actionable intelligence from unstructured textual sources such as news feeds, chatbot interactions, and public forums. In addition, the integration of edge computing, privacy-preserving analytics, and robust validation frameworks ensures the reliability, scalability, and ethical deployment of these AI-IoT systems across varied geographic and socio-economic contexts. Challenges related to model generalizability, data standardization, and regional disparities are examined through comparative case studies, offering a roadmap for the practical implementation of intelligent surveillance solutions. By synthesizing technological advancements with epidemiological needs, this chapter provides a comprehensive foundation for the development of resilient and responsive public health infrastructures. The findings support the transition toward proactive outbreak containment strategies that are precise, timely, and equitable.

Keywords: Epidemic Surveillance, Artificial Intelligence, Internet of Things, Early Detection, Natural Language Processing, Anomaly Detection

Introduction

The increasing frequency of infectious disease outbreaks in recent decades has challenged global healthcare systems, exposing critical limitations in early warning and containment mechanisms [1]. Traditional epidemiological models often rely on manual reporting and centralized data collection, which can result in delays and underreporting, particularly in regions with limited surveillance infrastructure [2]. As pathogens continue to evolve and spread across borders rapidly, there is a compelling need for modernizing epidemic surveillance systems. Integrating emerging technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) offers a promising path to bridge these gaps [3]. These technologies enable real-time data acquisition, intelligent processing, and automated alerts that collectively strengthen outbreak preparedness and response [4]. By harnessing distributed sensing and autonomous analytics, epidemic intelligence can be transformed into a proactive, adaptive, and highly scalable system capable of functioning across diverse healthcare environments [5].

AI technologies, particularly machine learning and deep learning models, have demonstrated significant potential in processing large volumes of complex, multimodal health data [6]. These models can detect subtle patterns, learn from evolving disease trends, and make accurate predictions about infection trajectories [7]. When combined with IoT-enabled devices—such as wearable biosensors, mobile health platforms, and remote diagnostic tools—these systems can monitor physiological changes, behavior patterns, and environmental conditions in real time [8]. This synergy between AI and IoT allows for dynamic risk assessment and timely identification of high-risk zones. Furthermore, cloud-based platforms can aggregate data from various sources, enabling centralized analysis while edge computing supports localized decision-making in low-latency settings [9]. Together, these technologies can significantly reduce response time during the critical early phase of an outbreak [10].