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AI and IoT Enabled Smart Drug Delivery Systems with Automated Medication Adherence Monitoring

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Abstract

The convergence of Artificial Intelligence (AI) and the Internet of Things (IoT) is transforming conventional drug administration practices into highly responsive, patient-centric systems. Smart drug delivery platforms, powered by wearable and implantable technologies, are enabling precision medicine through real-time monitoring, personalized dosage control, and automated medication adherence tracking. This chapter presents a comprehensive examination of the technological foundations, architectural components, and intelligence layers that underpin modern smart medication systems. Core aspects explored include sensor fusion methodologies for enhanced physiological data accuracy, cloud-to-edge synchronization models for continuous and secure communication, and embedded hardware such as IoT-enabled infusion pumps and wearable transdermal patches for controlled drug release. Emphasis is placed on the importance of robust data acquisition and preprocessing techniques, particularly in managing incomplete and noisy sensor streams, to support reliable decision-making. The integration of AI algorithms facilitates adaptive therapy personalization, early anomaly detection, and behavior-driven adherence interventions. Furthermore, interoperability challenges, security requirements, and regulatory compliance considerations are addressed to provide a holistic view of deploying such systems in real-world healthcare environments. The chapter concludes by identifying existing research gaps and proposing future directions toward scalable, secure, and intelligent drug delivery infrastructures. The multidisciplinary approach adopted in this work offers critical insights for researchers, engineers, and healthcare professionals aiming to enhance therapeutic efficacy and optimize patient engagement through next-generation healthcare technologies.

Keywords: Smart Drug Delivery, Internet of Things (IoT), Artificial Intelligence (AI), Medication Adherence, Sensor Fusion, Edge Computing

Introduction

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) in healthcare is fostering a paradigm shift in how medications are delivered, monitored, and managed [1].

Traditional drug administration techniques often suffer from inefficiencies such as non-adherence, dosing errors, and lack of personalized therapy, especially in the management of chronic diseases [2]. Smart drug delivery systems, driven by embedded intelligence and real-time data analytics, are increasingly recognized as pivotal components in the evolution of digital therapeutics [3]. These systems are designed to offer tailored medication regimens by capturing and processing continuous physiological data, thereby supporting decisions based on patient-specific needs [4]. AI algorithms enhance the decision-making process by identifying patterns in health data and predicting optimal dosing intervals, while IoT infrastructure facilitates remote monitoring, automation, and communication among interconnected medical devices. The result is a closed-loop system capable of not only delivering drugs precisely but also adjusting treatments dynamically in response to real-time changes in a patient's condition [5].

The proliferation of wearable biosensors and implantable devices has further catalyzed advancements in smart drug delivery [6]. Devices such as microneedle patches, smart pills, and infusion pumps are now embedded with compact electronics that enable drug administration based on physiological feedback [7]. These platforms monitor parameters such as glucose levels, blood pressure, heart rate, and hydration status to trigger precise dosing schedules, minimizing the risks associated with overmedication or missed doses [8]. The continuous feedback loop established by such systems enhances therapeutic efficacy while reducing the need for frequent clinical interventions, these intelligent devices provide valuable longitudinal health data that can inform future clinical decisions and refine personalized treatment models [9]. Their ability to function in ambulatory environments also makes them highly suitable for patients requiring home-based or long-term care. The integration of wireless communication protocols ensures that these systems remain connected to cloud servers or edge gateways, allowing healthcare providers to remotely supervise treatment adherence and intervene promptly when deviations are detected [10].