Integration of Machine Learning Models for Real-Time Detection of Advanced Persistent Threats and Network Intrusions

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personalized care. This chapter explores the critical role of AI models and real-time big data processing in shaping the future of healthcare analytics. Key concepts such as predictive healthcare, big data, machine learning, and AI-driven decision-making are discussed in detail, with a focus on advanced methodologies and tools that enable the processing and analysis of vast healthcare datasets. The chapter highlights the potential of hybrid AI models, cloud and edge computing, and data augmentation techniques in addressing the challenges of healthcare data quality, privacy, and scalability. Additionally, it examines the real-time processing capabilities essential for the timely delivery of insights, enhancing decision-making processes across various healthcare applications. The discussion emphasizes the importance of data preprocessing, integration, and transformation in ensuring high-quality and actionable outcomes. With the increasing demand for precision medicine and personalized healthcare, this chapter provides a comprehensive overview of the intersection between AI, big data, and healthcare, offering valuable insights into current trends, challenges, and future opportunities.

Multi-Protocol Communication Layers for Seamless Integration of Medical Devices in Smart City Infrastructures — 94

N. Aqeela, L. Mohana Kannan

The integration of medical devices within smart city infrastructures was critical for advancing healthcare delivery in urban environments. the seamless communication between heterogeneous medical devices and systems presents a significant challenge due to varying communication protocols and standards. This chapter explores the role of multi-protocol communication layers in overcoming interoperability issues, with a focus on enabling real-time data transmission from medical devices to centralized healthcare systems. It delves into traditional communication protocols such as Ethernet and Bluetooth, alongside emerging technologies like Bluetooth Low Energy (BLE) and 5G, which offer low-power, high-efficiency solutions for medical data exchange.the chapter investigates the impact of network congestion, latency, and middleware solutions in facilitating smooth interoperability among diverse healthcare systems. The importance of selecting appropriate communication protocols based on criteria such as data security, real-time performance, and scalability was also discussed. The chapter aims to provide a comprehensive framework for designing future-proof healthcare systems in smart cities, addressing key challenges, and enabling efficient data exchange across medical devices. Ultimately, this work contributes to the evolution of healthcare systems, enabling improved patient outcomes and enhanced healthcare delivery.

5G Communication Standards and Their Role in Enabling Ultra-Reliable Low-Latency Healthcare Applications — 122

Ravi Mohan, Mohsin Salim Gangat

The advent of 5G communication standards has ushered in a new era of connectivity, significantly impacting various industries and applications, particularly in the realm of healthcare. This book chapter explores the critical role of 5G in enabling ultra-reliable low-latency communication (URLLC) for healthcare applications, with a focus on enhancing patient care, remote monitoring, and real-time diagnostics. With its unparalleled data rates, low latency, and massive connectivity capabilities, 5G addresses the pressing demands of modern healthcare systems that require reliable and timely data transmission.the chapter delves into the evolution of communication standards from 4G to 5G, highlighting the key technical features and architectural advancements that make 5G a transformative technology for healthcare. The integration of advanced technologies such as Software-Defined Networking (SDN), Network Functions Virtualization (NFV), and network slicing was also discussed in detail, illustrating howoptimize the efficiency and flexibility of 5G networks in supporting diverse

healthcare applications. The chapter additionally examines the challenges and solutions associated with achieving URLLC performance, as well as the impact of enhanced mobile broadband (eMBB) on streaming services, virtual reality (VR), and augmented reality (AR) in healthcare settings. By providing a comprehensive overview of the 5G ecosystem, its capabilities, and its potential applications, this chapter offers valuable insights into how 5Grevolutionize healthcare delivery, paving the way for smarter, more efficient, and patient-centric healthcare systems.

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Syeda Sadia Tabassum , P. Malar

Federated Learning (FL) has emerged as a promising solution for privacy-preserving collaborative machine learning in decentralized networks, particularly within healthcare systems. This book chapter explores the integration of FL in urban health monitoring, emphasizing the critical role of privacy-preserving techniques to mitigate risks associated with sensitive health data. With the increasing adoption of decentralized healthcare networks, privacy concerns related to data sharing and model updates have become paramount. This chapter addresses key privacy threats in Federated Learning, such as adversarial attacks, data leakage, and malicious model manipulation, while proposing robust mitigation strategies. The application of differential privacy, secure aggregation protocols, and anonymization techniques was discussed, alongside their challenges in maintaining model accuracy and performance. Additionally, the chapter highlights the trade-off between privacy preservation and computational overhead, underscoring the need for efficient solutions that balance both. Through a comprehensive analysis, this chapter offers insights into the future of Federated Learning in healthcare, advocating for stronger privacy guarantees, secure collaboration, and the advancement of machine learning models to enable effective urban health monitoring.

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Asma Anjum, Senivarapu Ankit Reddy

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Asma Anjum , Mo. Ateeb Ansari

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G. M. Satyaseelan, Veer Sudheer Goud

The integration of artificial intelligence (AI) and adaptive communication systems within smart city healthcare frameworks holds transformative potential for chronic disease management. As urban populations face increasing challenges from the prevalence of chronic conditions, AI-driven solutions enable real-time, personalized healthcare, optimizing patient outcomes and resource efficiency. This chapter explores the application of AI algorithms and adaptive communication strategies in the continuous monitoring of chronic diseases such as diabetes, cardiovascular diseases, and respiratory disorders. Emphasis was placed on the role of wearable devices, realtime data processing, and low-latency communication networks, which facilitate timely intervention and improve treatment precision. Additionally, the chapter examines case studies that demonstrate the successful implementation of AI-powered health systems in urban environments, highlighting their effectiveness in personalized care, predictive analytics, and healthcare optimization. The convergence of AI, adaptive communication, and smart city infrastructure presents significant opportunities to enhance chronic disease management, reduce healthcare burdens, and ensure sustainable urban health systems. Key challenges, including data privacy, scalability, and integration with existing healthcare infrastructure, are also discussed, offering insights into the future of AI-powered urban healthcare.

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Anshad A.S, Bimal Nepal

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performance and battery longevity. The impact of hybrid communication systems and seamless handoff protocols was also analyzed, highlighting their potential in reducing energy consumption while ensuring uninterrupted service. The challenges posed by security protocols and their trade-offs in energy efficiency are examined, with an emphasis on achieving a balance between safety and power usage. This chapter provides a comprehensive overview of the current research and future directions in low-power communication systems, with a view to enabling more efficient, secure, and sustainable wearable health monitoring technologies.

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Ravi Mohan, S. Kanimozhi

The rapid expansion of the Internet of Things (IoT) in healthcare has introduced revolutionary advancements in patient care, enabling real-time monitoring, efficient diagnosis, and enhanced treatment protocols. Machine-to-Machine (M2M) communication within healthcare IoT networks serves as the backbone of this transformation, facilitating seamless data exchange between medical devices, healthcare professionals, and patients. challenges such as power consumption, resource constraints, security concerns, and scalability remain critical obstacles in the widespread adoption of M2M-based healthcare systems. This chapter explores the fundamentals of M2M communication, focusing on its role in scalable healthcare IoT networks, with an emphasis on the integration of low-power communication protocols, real-time data transmission, and device interoperability. The discussion extends to the real-world applications of M2M in critical healthcare services, including emergency medical systems, remote patient monitoring, and chronic disease management.the chapter delves into emerging trends, such as the use of artificial intelligence and edge computing, to address the limitations of current systems. Ultimately, it offers valuable insights into overcoming the technical barriers and optimizing M2M communication to enhance healthcare delivery.

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Seepuram Srinivas Kumar, S. Hamsareka

The rapid advancements in urban health infrastructure necessitate robust and proactive maintenance strategies to ensure system reliability, efficiency, and safety. Predictive maintenance, powered by deep learning models, has emerged as a transformative approach, enabling real-time fault detection, failure prediction, and optimization of maintenance schedules. This chapter explores the integration of Internet of Things (IoT) sensors and multi-modal data with deep learning algorithms to address the unique challenges in anomaly detection and predictive maintenance of urban health systems. Key challenges, such as handling heterogeneous data sources, ensuring data quality, and developing hybrid deep learning models for improved accuracy, are examined in detail. Additionally, innovative solutions like data fusion techniques, real-time alert systems, and multimodal predictive frameworks are presented. The chapter emphasizes how these advancements enhance system resilience, minimize downtime, and improve operational efficiency. Through detailed analysis and practical insights, this chapter provides a comprehensive framework for leveraging deep learning in predictive maintenance, ensuring sustainable and reliable urban health infrastructure.

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Yogeshver Prasad Sharma, E. Sudha

Infrastructure systems are increasingly reliant on data-driven approaches to predict, manage, and mitigate risks. the integration of diverse, heterogeneous data sources often presents challenges, particularly in terms of data quality, alignment, and representation. The ability to extract actionable insights from such complex data depends on overcoming several critical hurdles, such as data transformation, handling imbalanced datasets, and ensuring the robustness of predictive models. This chapter explores advanced methods for harmonizing infrastructure data, with a focus on techniques for managing missing values, reducing noise, and synchronizing temporally misaligned data.

Additionally, the role of ensemble techniques in addressing class imbalance in risk prediction models was examined, emphasizing their ability to enhance prediction accuracy and reliability. Through a combination of statistical methods, machine learning algorithms, and data transformation strategies, this chapter provides a comprehensive overview of contemporary approaches to infrastructure risk analysis. Key challenges, including the impact of temporal misalignment, noise reduction, and the integration of multiple data formats, are addressed, with practical solutions and methodologies for overcoming these barriers. This chapter serves as a guide for researchers and practitioners seeking to advance the capabilities of infrastructure systems through improved data analysis techniques and predictive modeling.

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N. Sowmya, Sachin Sambhaji Patil

The integration of quantum communication protocols into cloud-based healthcare systems promises to revolutionize the way sensitive medical data was transmitted, stored, and accessed. As healthcare organizations increasingly rely on cloud infrastructures to manage vast amounts of patient data, the security of this information becomes paramount. Quantum communication offers unprecedented levels of security, utilizing quantum key distribution (QKD) and entanglementbased methods to protect data from interception and unauthorized access. This chapter explores the critical role of quantum communication protocols in securing cloud-based healthcare systems, focusing on the challenges and opportunities presented by quantum technologies. It examines the need for robust encryption methods to protect sensitive medical data and ensure privacy compliance in the face of evolving cyber threats. The chapter also discusses hybrid quantumclassical systems, which combine the benefits of both quantum and classical protocols to enhance scalability and efficiency in cloud environments. Additionally, the limitations of current quantum hardware, such as photon loss and decoherence, are addressed, along with strategies to mitigate these challenges. The importance of training healthcare professionals and cloud engineers in quantum communication technologies was also emphasized to ensure effective implementation and ongoing maintenance of secure healthcare infrastructures. By highlighting the transformative potential of quantum communication for predictive healthcare models, this chapter provides a comprehensive overview of the future of healthcare security in the cloud.

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Saurabh Srivastava, R. Jegadeesh Kumar

The integration of Artificial Intelligence (AI)-augmented communication frameworks with healthcare systems has become a transformative approach to enhancing the efficiency, scalability, and responsiveness of modern healthcare networks. As healthcare IoT devices proliferate, the need for intelligent communication systems capable of processing vast volumes of real-time data has escalated. This chapter explores the design, implementation, and challenges of AI-enhanced communication technologies in smart healthcare networks, focusing on the synergistic interplay between AI, Internet of Things (IoT), and data analytics. Key areas covered include AI-driven predictive maintenance for healthcare infrastructures, the role of machine learning in optimizing network reliability, and the critical importance of user-centered design in developing intuitive systems for healthcare professionals and patients. The chapter also highlights case studies demonstrating the successful deployment of AI-based systems in various healthcare settings, emphasizing the impact on patient outcomes and operational efficiency. Addressing the technical and operational challenges of integrating IoT devices with AI

systems, this work provides a comprehensive roadmap for overcoming interoperability issues, ensuring data security, and leveraging big data analytics for actionable insights. Ultimately, the chapter positions AIaugmented communication frameworks as a cornerstone of the next generation of smart healthcare networks, offering a vision for a more connected, efficient, and data-driven healthcare ecosystem.