

Machine Learning in Biomedical Science and Healthcare Informatics

ARTIFICIAL INTELLIGENCE- BASED SYSTEM MODELS IN HEALTHCARE

Edited by
A. Jose Anand
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Artificial Intelligence-Based System Models in Healthcare

Scrivener Publishing
100 Cummings Center, Suite 541J
Beverly, MA 01915-6106

Machine Learning in Biomedical Science and Healthcare Informatics

Series Editors: Vishal Jain and Jyotir Moy Chatterjee

In this series, an attempt has been made to capture the scope of various applications of machine learning in the biomedical engineering and healthcare fields, with a special emphasis on the most representative machine learning techniques, namely deep learning-based approaches. Machine learning tasks are typically classified into two broad categories depending on whether there is a learning 'label' or 'feedback' available to a learning system: supervised learning and unsupervised learning. This series also introduces various types of machine learning tasks in the biomedical engineering field from classification (supervised learning) to clustering (unsupervised learning). The objective of the series is to compile all aspects of biomedical science and healthcare informatics, from fundamental principles to current advanced concepts.

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WILEY

This edition first published 2024 by John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA and Scrivener Publishing LLC, 100 Cummings Center, Suite 541J, Beverly, MA 01915, USA

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Library of Congress Cataloging-in-Publication Data

ISBN 978-1-394-24249-8

Cover image: Pixabay.Com

Cover design by Russell Richardson

Set in size of 11pt and Minion Pro by Manila Typesetting Company, Makati, Philippines

Printed in the USA

10 9 8 7 6 5 4 3 2 1

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Preface

This book is a groundbreaking exploration of the synergies between artificial intelligence and healthcare innovation. In an era where technological advancements are reshaping the landscape of medical practices, this handbook provides a comprehensive and insightful guide to the transformative applications of AI in healthcare systems. From conceptual foundations to practical implementations, this handbook serves as a roadmap for understanding the intricate relationships between AI-based system models and the evolution of healthcare delivery.

The first part, “Introduction to Healthcare Systems,” delves into the fundamental role of technology in reshaping the healthcare landscape. With a focus on daily life activities, decision support systems, vision-based management, and semantic frameworks, this section lays the groundwork for understanding the pivotal role of AI in revolutionizing traditional healthcare approaches. Each chapter offers a unique perspective, emphasizing the intricate integration of technology into healthcare ecosystems.

The second part, “AI-based System Models in Healthcare Applications,” takes a deep dive into specific applications of AI, ranging from predictive analysis and machine learning to deep learning, image analysis, and biomedical text processing. With a focus on decision-making support systems, this section aims to demystify the complex world of AI algorithms in healthcare, offering valuable insights into their practical implications and potential impact on patient outcomes.

The final section, “Modernization and Future – Healthcare Applications,” addresses the modernization of healthcare practices and envisions the future landscape of AI applications. From medical imaging and diagnostics to predicting ventilation needs in intensive care units, modernizing health record maintenance, natural language processing, chatbots for medical inquiries, secured health insurance management, and glimpses into the future, the handbook concludes by exploring the frontiers of AI-driven healthcare innovations.

The editors and contributors hope this handbook serves as a valuable resource for researchers, healthcare professionals, and technology enthusiasts alike. By understanding the dynamic interplay between AI-based system models and healthcare, we aim to inspire the advancement of cutting-edge solutions that improve patient care, optimize processes, and contribute to the ongoing evolution of healthcare in the digital age. Our deepest thanks go out to Martin Scrivener and Scrivener Publishing for their assistance and the publication of this book.

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Part I

INTRODUCTION TO HEALTHCARE SYSTEMS

Role of Technology in Healthcare Systems

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Abstract

Today's technology is leaps and bounds ahead, transforming every industry. The healthcare sector is no different. The use of medical technology tools safeguards patient safety. Advancement in healthcare technology and hospital management tools has made patient care easy and efficient. Digital records allow repositories of patient data to be created that doctors and researchers can share and use for studying. These data help medical professionals better diagnose causes of illness and the best cure possible. Healthcare technology has made hospital management a lot easier as well. Hospital information system can be used to keep track of medicines in stock and in supply. Technology is not without its uses. When used properly, technology can improve medication safety, foster better communication between clinicians, lower the risk of medical errors, and increase the patient experience overall. New developments in healthcare technology have made it easier for healthcare organizations to communicate better. Information and communication technology has linked medical professional with patients. Numerous health applications have been developed as a result of the use of information technology in healthcare. Using mobile smartphones to quickly and accurately get medical information is beneficial for patients. This app provides doctors with access to medication information to help with diagnosis, problem-solving, and side effect prevention. Patients can consult with specialists anywhere in the world thanks to telemedicine. This chapter covers the importance of technology in healthcare, transformation in healthcare industry, technology impact on healthcare, how can healthcare technology improve patient care, benefits of information technology in healthcare, medical Technologies, groundbreaking advancements in technology in healthcare, innovation and digital transformation.

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Keywords: Telemedicine, medical technologies, information technology, health apps, smartphones and digital transformation

1.1 Introduction

The part of technology in the healthcare system is transformative, encompassing a extensive range of tools, systems, and innovations that improve patient care, streamline operations, enhance research, and revolutionize the way healthcare is delivered. In recent decades, the healthcare sector has been undergoing a profound transformation, largely driven by the integration of advanced technologies. The role of technology in the healthcare system has transcended conventional boundaries, revolutionizing how medical services are delivered, managed, and experienced. From digitizing patient records to enabling precise diagnoses through Artificial Intelligence (AI), technology has become an indispensable tool that enhances efficiency, accuracy, accessibility, and patient outcomes. This evolving synergy between healthcare and technology not only streamlines medical processes but also opens up new frontiers of research, treatment, and patient engagement [1]. In this rapidly changing landscape, understanding the multifaceted role of technology in healthcare is pivotal for healthcare professionals, policymakers, and individuals alike, as it shapes the present and future of medical care. The intersection of technology and healthcare has given rise to a transformative era marked by innovations that have redefined the way healthcare is practiced, managed, and experienced. One of the most noteworthy influences is the digitization of patient records and medical data. EHRs have substituted cumbersome paper-based systems, allowing healthcare benefactors to access and share patient evidence seamlessly. This not only enhances efficiency in care delivery but also reduces the likelihood of errors arising from manual data entry [2].

Moreover, the application of AI and Machine Learning (ML) has introduced a new dimension of precision and predictive analytics to healthcare. These technologies can examine vast datasets, aiding in early disease detection, behavior planning, and personalized medicine. Medical imaging, for instance, has been greatly enhanced by AI algorithms that can detect subtle anomalies in X-rays and other scanned images, assisting radiologists in making more accurate diagnoses. Telemedicine and remote monitoring are other remarkable advancements made possible by technology. Patients can now consult healthcare authorities from the comfort of their homes, predominantly advantageous for individuals with imperfect mobility or those residing in inaccessible areas. Wearable devices equipped with

sensors and connected to smartphone apps enable real-time monitoring of vital signs, chronic conditions, and fitness levels, permitting individuals to take proactive control of their health. Hospital administration, resource allocation, and inventory management have been streamlined through integrated software solutions [3]. This optimization not only improves operational efficiency but also contributes to cost savings and resource utilization, ultimately benefitting patient care. Patient engagement and education have been transformed by technology as well. Online platforms, health apps, and informational websites provide patients with valuable resources to learn about their conditions, treatment options, and preventive measures. This democratization of information empowers patients to make knowledgeable decisions about their health and treatment plans. However, the incorporation of technology in healthcare is not without its encounters. Ensuring data security and patient privacy in an increasingly interconnected environment is a critical concern. Cybersecurity measures must continuously evolve to safeguard sensitive medical information from unauthorized access and breaches. Here are some key aspects of the role of technology in the healthcare system [4].

Patient Care and Treatment: Advanced medical devices and technologies enable precise diagnostics and effective treatments, leading to improved patient outcomes. Telemedicine platforms allow remote consultations, expanding access to medical expertise and services. Sensors attached to wearable garments monitor the patient's physiological health parameters in real-time, facilitating proactive interventions for chronic conditions.

EHRs and Data Management: EHRs digitize patient records, making them simply reachable to authorized healthcare providers, improving care coordination and reducing errors. Health information systems and databases centralize patient information, enhancing communication and data sharing among medical teams.

Diagnostic Technologies: AI and ML algorithms process medical data to improve diagnostic accuracy and speed.

Personalized Medicine and Genomics: Genomic sequencing informs custom-made behaviour plans by considering an individual's genetic makeup and disease susceptibility. Precision medicine tailors therapies to patients' unique characteristics, leading to more effective and targeted interventions.

Robotics and Surgical Innovations: Robotic-assisted surgery enhances surgical precision, enabling minimally invasive procedures and quicker recovery times. Teleoperated robots allow expert surgeons to perform procedures on patients located remotely.

Drug Discovery and Development: High-performance computing and AI streamline drug discovery processes, identifying potential drug candidates and accelerating development. Computational modelling predicts drug interactions, efficacy, and adverse effects, reducing trial-and-error approaches.

Health Information Exchange (HIE): HIE schemes empower secure data distribution among healthcare organizations, ensuring continuity of care and improving patient outcomes.

Remote Monitoring and Telehealth: Remote monitoring platforms and telehealth solutions improve patient access to care, especially in underserved areas. Virtual care encompasses teleconsultations, remote monitoring, and digital health tools that enhance patient-provider interactions.

Healthcare IoT and Wearable Devices: Internet of Things (IoT) devices connect medical equipment, wearable devices, and sensors, enabling data collection and analysis for better insights. Wearable devices track physical activity, sleep patterns, and vital signs, promoting proactive health management.

Data Analytics and Population Health: Big data analytics identify health trends, disease outbreaks, and opportunities for preventive interventions at both individual and population levels.

Patient Engagement and Education: Digital platforms provide patients with reliable medical information, encouraging them to participate in their care decisions and adopt healthier lifestyles.

Data Security and Privacy: Technologies like blockchain enhance data security, protecting patient privacy and ensuring compliance with regulations.

Healthcare Administration and Operations: Administrative tasks are streamlined through automated billing, scheduling, and resource allocation systems, reducing administrative burden and errors.

Research and Clinical Trials: Technology accelerates medical research by analyzing large datasets and simulating biological processes. Clinical trials benefit from data-driven patient recruitment, monitoring, and outcomes assessment.

The role of technology in the healthcare system continues to expand and evolve, driven by ongoing innovation. Technology empowers healthcare professionals, improves patient outcomes, enhances operational efficiency, and fosters a patient-centric approach to healthcare delivery [5]. In conclusion, the role of technology in the healthcare system is a dynamic and multifaceted one that encompasses advancements across various fronts.