

ANALYTICS AND AI FOR HEALTHCARE

# Translational Application of Artificial Intelligence in Healthcare

– *A Textbook*



Edited by Sandeep Reddy



**CRC Press**  
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A CHAPMAN & HALL BOOK

This book provides a very readable introduction into our current understanding of all these issues and affords the opportunity for non-AI experts to appreciate how AI can improve clinical care while being made aware of its current limitations and how these may be overcome.

**Professor Ian Scott**, *Director of Internal Medicine and Clinical Epidemiology, Princess Alexandra Hospital; Professor of Medicine, University of Queensland*

This book is essential because it begins to delineate that pathway to implementation, guiding readers to consider issues beyond predictive performance as they develop the AI applications of the future.

**Professor Wendy W. Chapman**, *Director of the Centre for Digital Transformation of Health, University of Melbourne*

Advances in technology have always been a driver for improved delivery of healthcare. The application of AI in healthcare has the potential to be the driver that will lead to a more effective and efficient healthcare delivery system. This book provides a very lucid overview of the potential applications and benefits, and also addresses the potential challenges in the adoption of AI in healthcare. A sound grounding and understanding of the potential applications of AI will empower clinicians and scientists to adapt and hopefully expand the scope of its application.

**Girish Nair**, *Director of Functional Neurosurgery, The Royal Melbourne Hospital and Head of Unit of Neurosurgery, Western Health*

The hardest part of innovation is not invention but the implementation of new technology. Moreover, clinical medicine, where one mistake may affect the mortality of innumerable people, is one of the most difficult fields to implement emerging technologies. Although it won't teach us the best racing line for the podium, this book shows us the starting grid of the circuit for the ones who want to achieve innovation.

**Tomohiro Kuroda**, *CIO of Kyoto University Hospital, Director of the Center for Digital Transformation of Healthcare, Professor of Graduate School of Medicine, Professor of Graduate School of Informatics, Kyoto University*



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# Translational Application of Artificial Intelligence in Healthcare

In the era of 'Algorithmic Medicine', the integration of Artificial Intelligence (AI) in healthcare holds immense potential to address critical challenges faced by the industry.

Drawing upon the expertise and experience of the authors in medicine, data science, medical informatics, administration, and entrepreneurship, this textbook goes beyond theoretical discussions to outline practical steps for transitioning AI from the experimental phase to real-time clinical integration. Using the Translational Science methodology, each chapter of the book concisely and clearly addresses the key issues associated with AI implementation in healthcare. Covering technical, clinical, ethical, regulatory, and legal considerations, the authors present evidence-based solutions and frameworks to overcome these challenges.

Engaging case studies and a literature review of peer-reviewed studies and official documents from reputed organizations provide a balanced perspective, bridging the gap between AI research and actual clinical practice.



**Sandeep Reddy** is an Artificial Intelligence (AI) in healthcare researcher based at the Deakin School of Medicine, as well as being the founder/chairman of Centre for Advancement of Translational AI in Medicine, a healthcare-focused AI entity. He is also a certified health informatician and World Health Organization-recognised digital health expert. He has a medical and healthcare management background and has completed machine learning/health informatics training from various sources. He is currently engaged in research about the safety, quality and explainability of the application of AI in healthcare delivery, in addition to developing AI models to treat and manage chronic diseases. He has also authored several

articles and books about the use of AI in medicine. Further, he has set up local and international forums to promote the use of AI in healthcare and sits on various international committees which focus on this issue.

## **ANALYTICS AND AI FOR HEALTHCARE**

Artificial Intelligence (AI) and analytics are increasingly being applied to various healthcare settings. AI and analytics are salient to facilitate better understanding and identifying key insights from healthcare data in many areas of practice and enquiry including at the genomic, individual, hospital, community and/or population levels. The Chapman & Hall/CRC Press Analytics and AI in Healthcare Series aims to help professionals upskill and leverage the techniques, tools, technologies and tactics of analytics and AI to achieve better healthcare delivery, access, and outcomes. The series covers all areas of analytics and AI as applied to healthcare. It will look at critical areas including prevention, prediction, diagnosis, treatment, monitoring, rehabilitation and survivorship.

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**Professor Nilmini Wickramasinghe** is Professor of Digital Health and the Deputy Director of the Iverson Health Innovation Research Institute at Swinburne University of Technology, Australia and is inaugural Professor – Director Health Informatics Management at Epworth HealthCare, Victoria, Australia. She also holds honorary research professor positions at the Peter MacCallum Cancer Centre, Murdoch Children’s Research Institute and Northern Health. For over 20 years, Professor Wickramasinghe has been researching and teaching within the health informatics/digital health domain. She was awarded the prestigious Alexander von Humboldt award in recognition of her outstanding contribution to digital health.

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*-A Textbook*

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*-A Textbook*

Edited by  
Sandeep Reddy



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## *Abbreviations*

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- AI     Artificial Intelligence  
A branch of computer science that deals with the creation of intelligent agents, which are systems that can reason, learn, and act autonomously.
- CDS    Clinical Decision Support  
A type of deep learning algorithm that is used for natural language processing and speech recognition.
- CNN    Convolutional Neural Network  
A type of deep learning algorithm that is used for image recognition and natural language processing.
- DL     Deep Learning  
A type of machine learning that uses artificial neural networks to learn from data.
- ML     Machine Learning  
A subset of AI that allows computers to learn without being explicitly programmed.
- PH     Personalized Health  
A type of AI that is used to tailor healthcare interventions to individual patients.
- RD     Drug Discovery  
A type of AI that is used to identify new drug targets and design new drugs.

# 1

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## *An Introduction to Artificial Intelligence*

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### LEARNING OBJECTIVES

- Describe what AI is
- Discuss the various categories of AI
- Describe the various models of AI
- Explain how AI is used in healthcare
- Identify the challenges in the adoption of AI in healthcare

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### Introduction

We currently live in the age of Big Data (Reddy & Cooper, 2021). Over the past few decades, this has been characterized by exponential production, storage, and data sharing. Big data has been described as “high-volume, high-velocity and/or high-variety” information that requires novel and efficient analysis to gain valuable insights (Cappa et al., 2021). The latter part of the description is particularly relevant to the discussion here. As data production has increased significantly, the manual processing of such data to yield actionable insights has become impractical (Reddy & Cooper, 2021). Automated analysis of such data through computational reasoning frameworks has become a more attractive and practical proposition. Artificial Intelligence (AI), a computational reasoning framework, has emerged as a leading technology in the field of data science. AI is an umbrella term representing a group of techniques that replicate aspects of human intelligence, including visual perception, speech recognition and judgement (Lidströmer et al., 2021). While AI is one of the newest fields of engineering, the introduction of the concept can be traced back hundreds of years (Reddy, 2018). However, AI as a formal discipline emerged only in the 1950s. Since then, AI has been used across various sectors and disciplines, including, pertinent to this book, in healthcare, to automate or semi-automate the processing of data and resultant tasks (Reddy & Cooper, 2021).

In healthcare, obtaining information early in the disease process and intervening early and effectively is critical to good medical practice and the achievement of good patient outcomes. Having access to an automated system, trained on relevant data, recognising meaningful relationships intrinsic to the data, and supporting clinical decision-making

would significantly enhance the practice of medicine (Ganguli et al., n.d.; GAO, 2020). The current generation of AI algorithms is far more advanced in their capacity to self-learn and mirror human knowledge than the previous generations (Jordan & Mithcell, 2015). Many AI applications are now trained by using examples of input–output behaviour rather than the manual programming of all anticipated responses. This process has enabled AI’s broader and yet deeper application in intense data environments such as medicine. With such potential for widespread use comes the opportunity and the technical, medical, ethical, legal, and social challenges (Desai, 2020). Over this chapter and those which follow, we will introduce the reader to fundamental concepts of AI, its application in healthcare, the opportunities, the issues associated with AI’s implementation in healthcare and various solutions to address these issues.

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## Description of AI

Considering the popularity and complexity of AI, it is no wonder that one comes across myriad descriptions. However, most of these descriptions have some common themes, including machines or computers, synthetic intelligence, and intelligent agents (Jordan & Mithcell, 2015; Lidströmer et al., 2021; Reddy, 2018). A great starting point in describing or defining AI is understanding its fundamental objective, i.e., for machines to replicate or simulate human-level intelligence (Reddy, 2018). While the objective seems simple, the process is incredibly complex and not standardized, leading to difficulties in describing AI. However, the ‘intelligent agent’ is critical in achieving ‘artificial’ intelligence. These agents can demonstrate intelligent behaviour, which means they are not only capable of perception of their environment but also can undertake practical reasoning and suitable action to achieve their goals. Thus, a definition of AI could be *‘the science of making intelligent machines’*. This definition corresponds to how it had been envisaged by John McCarthy, one of the founding fathers of modern AI (Reddy et al., 2019). Another approach to defining AI is to consider the actions of AI, such as emulating features of human intelligence (including reasoning, complex task processing, decision-making, communication, knowledge representation and so forth) and the process requiring utilization of computer programming and machines. Based on this, one could also define AI as ‘machines simulating human intelligence’.

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## AI Categories

As with the definition of AI, one can come across various categories of AI. Some categories relate to functionalities; others are based on capabilities and applications (Bartneck et al., 2021a; Lidströmer et al., 2021; Reddy, 2018). However, others classify AI based on its application areas, such as natural language processing, computer vision, robotics and so on (Jordan & Mithcell, 2015; Reddy et al., 2019). For the purpose of this introductory chapter, we consider all these classifications. In the first categorization, we describe AI