Medical Virology: From Pathogenesis to Disease Control
Series Editor: Shailendra K. Saxena

Jyotir Moy Chatterjee
Shailendra K. Saxena *Editors*

Artificial Intelligence in Medical Virology

Springer

Medical Virology: From Pathogenesis to Disease Control

Series Editor

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This book series reviews the recent advancement in the field of medical virology including molecular epidemiology, diagnostics and therapeutic strategies for various viral infections. The individual books in this series provide a comprehensive overview of infectious diseases that are caused by emerging and re-emerging viruses including their mode of infections, immunopathology, diagnosis, treatment, epidemiology, and etiology. It also discusses the clinical recommendations in the management of infectious diseases focusing on the current practices, recent advances in diagnostic approaches and therapeutic strategies. The books also discuss progress and challenges in the development of viral vaccines and discuss the application of viruses in the translational research and human healthcare.

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Artificial Intelligence in Medical Virology

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Foreword

Artificial intelligence (AI) is increasingly being used in medical virology healthcare to improve the diagnosis, treatment, and management of viral diseases. With the increasing amount of data generated from various sources, including electronic medical records, genomics, and imaging, AI has the potential to play a major role in helping healthcare providers make better and more informed decisions.

One of the main applications of AI in medical virology is in the early detection and diagnosis of viral diseases. AI algorithms can be trained to identify patterns and features in medical images and genomics data that are indicative of viral infections. This can help healthcare providers quickly identify viral diseases and start treatment as soon as possible, reducing the risk of serious complications and the spread of the disease.

This book consists of 11 chapters. The first chapter describes the importance of artificial intelligence for global healthcare. The second chapter presents a quick assessment of the impact of the epidemiology of COVID-19 with the help of artificial intelligence. Chapter 3 implemented an approach by using artificial intelligence for developing countries in rural areas problems. The fourth chapter defines the different roles of artificial intelligence to track COVID-19 diseases. In Chap. 5, the authors present a technique using the concept of the k-mean two-way clustering. Chapter 6 provides a new technique to detect the COVID-19 cases from the images of X-rays and CT scans. In their approach, the authors have utilized the deep convolutional neural network. Chapter 7 deals with the concept of Computer Vision which involves Augmented Reality, Virtual Reality, Telehealth, and Digital Radiology. The authors in Chap. 8 present a classification algorithm for Stroke Disease Prediction Model by using ANOVA. A systematic review of the development and evaluation methods of artificial intelligence for COVID-19 detection is given in Chap. 9. Chapter 10 is about a new technique for Disease Detection by utilizing the concept of Machine Learning algorithms in the healthcare industry. The last chapter (Chap. 11) deals with the Deep Autoencoder Neural Networks for Heart Sound Classification.

I hope that this book will provide a useful resource of ideas, techniques, and methods for research on the theory and applications of artificial intelligence in Medical Virology.

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Preface

The proposed book inspects work that has been attempted or is planned, in the fields of artificial intelligence (AI) and virology, with an end goal to advance ongoing and future work, exploration, and health. Fields and techniques tended to incorporate medical biology, bioinformatics, AI, natural language processing, data science, data mining, machine learning (ML), neural networks, and so forth. This book presents an extensive outline of the field, going from its set of experiences and specialized establishments to explicit clinical applications lastly to possibilities. AI is growing across all areas rapidly. Medication, with the accessibility of huge multi-dimensional datasets, fits solid expected headway with the proper tackling of AI. The combination of AI can happen all through the continuum of medication: from fundamental lab revelation to clinical application and medical care conveyance. Incorporating AI inside medication has been met with both excitement and criticism. By seeing how AI functions and fostering an appreciation for the two constraints and qualities, clinicians can outfit its computational ability to smooth out the work process and work on understanding consideration. It additionally gives the chance to develop research techniques past the thing that is right now accessible utilizing conventional factual methodologies. Then again, computer researchers and information experts can give arrangements, however, regularly need simple admittance to clinical knowledge that might assist with centring their endeavours.

The book also discusses progress and challenges in the development of viral vaccines and discusses the application of viruses in translational research and human healthcare. Furthermore, the book discusses AI-mediated diagnosis, and how machine learning can help in the development of drugs to treat the disease.

Chapter 1 explains how the global health sector has suffered from the chronic problem of insufficient resources and is under the pressure of meeting the ever-increasing demand for diverse areas of service. AI is now an additional capacity for a wide range of issues from clinical diagnostic decision-making, conducting medical intervention (e.g. robotic surgery), follow-up clinical surveillance, patient-enabled self-assessment, and basic ill-health management at the community level, and public health AI has facilitated strategic planning, decision-making, and service delivery.

To deal with the Global Health Crisis (GHC), AI has been used at many levels of the healthcare sector. On the other side, AI has both benefits and drawbacks. As a

result, COVID-19 undertook an evaluation of AI applications and that is explored in Chap. 2.

Chapter 3 is focused on how the inclusion of huge data and the use of AI would help in diagnosis, planning treatment strategies, research, and overall improvement of the rural health system.

Chapter 4 is aimed to highlight various techniques used to track COVID-19 for prognosis and diagnosis and compassioned to find the overall performance, accuracy, correctness, F1 score, dice score, and limitations of these techniques.

Chapter 5 has presented and demonstrated the use of K-Means Two Way and Greedy approaches for the tri-clustering of 3D Gene Expression Data using AI Techniques.

In Chap. 6, a deep convolutional neural network (DCNN) and transfer learning-based approach used for detection of COVID-19 cases from X-ray and CT images are discussed.

Chapter 7 recognizes computer vision from traditional informal community and gives an exhaustive review of computer vision with respect to their utilization, benefits, arrangement, and plan of the general framework design.

In Chap. 8, to predict the chance of a patient developing stroke disease, authors have used ML approaches on a stroke dataset obtained from Kaggle and used the ANOVA (Analysis of variance) feature selection method with and without the following four classification procedures: Logistic Regression, K-Nearest Neighbour, Naïve Bayes, and Decision Tree, after which the dataset was pre-processed.

Chapter 9 mainly contributes to a review providing insights into the researchers and clinicians with the introduction of certain AI concepts responding to the terrific COVID 19 pandemic.

In Chap. 10, a detailed description to the ML concepts which are key contributors in the development of Healthcare 4.0 solutions for disease detection is presented.

Chapter 11 have attempted to analyse the phonocardiogram (PCG) signals by using time-frequency representation and deep learning.

We thank all the authors for their valuable contribution which makes this book possible. Among those who have influenced this project are our family and friends, who have sacrificed a lot of their time and attention to ensure that we remained motivated throughout the time devoted to the completion of this crucial book.

Kathmandu, Nepal — Jyotir Moy Chatterjee
Lucknow, India — Shailendra K. Saxena

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Jyotir Moy Chatterjee

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Artificial Intelligence for Global Healthcare

1

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Abstract

The recent world economic challenging status and widened poor-rich gap have established additional risk for the global population, particularly in low-middle income countries. Artificial intelligence's potential has created an opportunity for the global population health. AI has benefited from the global digital theme that has been central in most of the societies around the world. With growing expectations and acceptance of digital life around the globe, AI is becoming an appealing option/choice within the health sector. AI is increasingly being used in the healthcare sector to improve various aspects of healthcare such as diagnosis, treatment planning, drug discovery, and medical image analysis. The global

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healthcare sector has been plagued by the chronic and persistent problem of insufficient resources and is under pressure to meet the ever-increasing demand for a diverse range of services. AI is now an additional capacity for a wide range of issues from clinical diagnostic decision-making, conducting medical intervention (e.g., robotic surgery), follow-up clinical surveillances, patients enabled self-assessment and basic ill-health management to the community level and public health AI has facilitated strategic planning, decision-making, and service delivery. AI significantly improves outbreak prediction, prevention, and management with a huge impact on population health gain.

Keywords

Artificial Intelligence · Health · Clinical diagnostic decision-making · Clinical surveillances

1.1 Introduction

The world has entered a digital era since the start of the COVID-19 pandemic, with workers from practically every company and worldwide health-care system working remotely. This transition was expected to imitate the advancement occurred during the implementation of public Internet in the 1990s and intended to emphasise its crucial role in digital evolution of global health. Thus, it has been dubbed "the fourth industrial revolution" or "industry 4.0". Its enormous promise for facilitating the global health has been implied progressively in recent years through AI-assisted clinical decision-making. In developed countries, the technology is employed for reducing the non-communicable disease; whereas in low-income countries, it is focusing to prevent or treat infectious diseases (Panch et al. 2019).

The potential applications associated with AI in global health consist of improved health surveillance (including capacitating individuals for self-assessing), clinical decision-making support systems, enabling health workers with different tools for implementing personalised interventions, diagnostic criteria, and more accurate referrals; which are poised to improve clinical care and strengthen his gaining health systems. Like in other areas, the application of artificial intelligence ranging from clinical decision-making to support-chain management is gaining attention during this time of digital growth (Wahl et al. 2018). However, in order to provide high-quality outputs to the exact query, AI-enabled technology requires enormous data sets to support machine learning algorithms (Paul and Schaefer 2020).

Another area where AI-driven therapies have been evaluated in the global health setting is morbidity and mortality risk assessment. These treatments are mostly based on machine learning classification tools, and they often consider different machine learning techniques to find the best method for recognising risk. This method has also been utilised in hospitals to predict illness severity in dengue fever and malaria patients and youngsters with acute infections. Researchers have used this method to measure the likelihood of cognitive sequelae in children following malaria infection

and calculate the probability of TB treatment failure (Phakhounthong et al. 2018; Kwizera et al. 2019).

As a result, health systems will play a critical role in driving the development of AI-based solutions and reaping their advantages. Artificial intelligence has accelerated development in the deployment of such technologies in advanced economies, but low- and middle-income nations face significant hurdles in developing and deploying such advances (Paul and Schaefer 2020).

Irrespective to the influences of social variables on the outcome, the future of public health relies on the technical aspects of artificial intelligence. However, before applying AI concepts to global health on a big scale, such issues must be addressed (Khoury et al. 2016).

Bias in the data used for machine training is starting to have an impact on the health industry. Computer vision algorithms, for example, can categorise photographs of skin lesions as cancerous or benign, resulting in quick, accurate, and non-invasive diagnosis. Image classifiers, on the other hand, may function differently on darker skins, contributing to health inequalities across populations. Smaller sample numbers from dark-skinned patients are often included in dermatological data sets, and dark-skinned individuals are often found at later stages of disease, both of which can contribute to more frequent misdiagnosis. This form of bias can be mitigated by ensuring that the training data is representative of the patients who will be using the tools. However, this is not a simple problem to solve. Artificial intelligence-based products' conclusions get encoded with the intricacies of the setting in which training data is obtained, limiting their capacity to function in a variety of geographical, ethnic, and economic circumstances (Haenssle et al. 2018).

Defects in the quality, completeness, and equality of health data pose special hazards in the age of artificial intelligence. Errors in data recording might lead to misguided actions and resource allocation in low-resource nations. Even when machine learning techniques deliver accurate findings, their existing capabilities, such as risk screening, diagnosis, and future danger assessment, frequently give only potentially actionable data. Information used to inform only a few discrete treatments is unlikely to result in positive health-care results.

There are several ways which may result in the failure of machine learning-based system, because of that a systematic approach is needed to make advancements in global health care including creating relevant and accurate solutions. Investment in global health requires implementing strategies that work for global population who use them by prioritising the health system investments. Quality can be improved by focusing on completeness, accuracy, and representativeness, using data generated through investments in health management information systems; equity can be maintained by increasing the representation of data used to develop machine learning-based tools from poor and marginalised groups; and safeguards can be established by focusing on maintenance of standards for ensuring representativeness and transparency of training data sets and processes for examining the working of automated clinical-decision support tools. In addition, investment should be made only when the health care system is strong enough to support machine learning tools

and is capable to making results into action (Kwizera et al. 2019; Haenssle et al. 2018).

Artificial intelligence can be applied differently across population and its application throughout the health system should maintain and prioritise equity during the processes including improving the efficiency and effectiveness of services, enabling the personalised interventions and matching preventive services to individual needs; through which the scope of public health significance can be potentially broaden. In case of the development of these technologies, a large data set is required which should be representative of the population and in turn must benefit everyone by collaborating private-sector profit motives with social responsibility and public-health advances. In order to create the partnership with private sector in the application of AI in public health, public health organisations need to take the lead, which will produce tangible benefits and protections for the health institutions by developing specific contacting instruments, which in turn focuses on the populations they serve (Wahl et al. 2018).

1.2 Role of Artificial Intelligence (AI) in Public Health

AI is important in the context of public health since it has a variety of applications and can accomplish challenging jobs with minimal effort and accuracy.

Few as such include:

- Make appointments
- Assist doctors with disease diagnosis
- Assist in surgical procedures
- Make therapy and drug recommendations
- Assist people in digitally resolving their problems, and often more (Table 1.1)

1.2.1 Health Protection

1.2.1.1 Disease Detection

- Oncology

Table 1.1 Areas of public health with the use of artificial intelligence

Health protection	Health promotion	Improving the efficiency of health-care services
• Disease detection • Data pattern analysis for near-real-time surveillance	• Offering individualised and focused health recommendations based on a person's risk profile and behavioural tendencies	• The use of artificial intelligence to find abnormalities in screening procedures like mammography or cervical cytology; automated evidence synthesis facilitated by machine learning

Source: Panda and Bhatia (2018)