

Special Issue on Algorithms and Applications of Machine Learning Techniques for Healthcare

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1. Introduction

Machine learning, as a core subfield of artificial intelligence, enables computational systems to learn from data and emulate aspects of intelligent human behavior. Its effectiveness has already been demonstrated across a wide range of domains, including virtual personal assistants [1,2], autonomous systems [3,4], intelligent surveillance [5,6], recommendation platforms [7,8], and early warning and alert mechanisms [9,10]. These successful applications illustrate the transformative potential of machine learning and its growing impact on everyday life.

Building on these advances, machine learning has emerged as a key enabling technology in modern healthcare. Its capacity to analyze large and complex datasets has driven significant progress in areas such as clinical decision support [11], disease diagnosis [12], patient monitoring [13], and personalized medicine [14]. As healthcare systems worldwide face increasing demands for efficiency, accuracy, and accessibility, machine learning-based solutions offer promising tools to support clinicians and improve patient outcomes.

Despite the growing body of research, the integration of machine learning techniques into real-world healthcare environments remains limited. Challenges related to data quality, model interpretability, ethical considerations, and clinical validation continue to hinder widespread adoption. In response, this Special Issue aims to advance the state of the art in machine learning for healthcare by presenting recent research that addresses both methodological innovation and practical application.

2. Overview of Contents

This Special Issue brings together seventeen peer-reviewed articles that were carefully evaluated and selected for publication by expert reviewers. The main contributions of the accepted papers are summarized below.

The first article focuses on improving the efficiency and accuracy of skin cancer diagnosis through machine learning techniques. The authors propose an integrated approach that combines feature reduction and ensemble learning with deep neural networks, enabling reliable classification of skin lesions as malignant or benign. Experimental results on widely used dermatological datasets demonstrate the effectiveness of the proposed method, highlighting its potential to reduce diagnostic costs, minimize reliance on medical expertise, and support faster decision-making in clinical practice.

The second article presents a comprehensive review of machine learning models based on wearable device data for predicting and monitoring symptoms of major depressive disorder. Focusing primarily on wrist-worn devices, the article highlights the clinical potential of these approaches for treatment monitoring, early intervention, and preventive care. At the same time, it critically discusses current limitations related to methodological



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heterogeneity, reproducibility, and generalizability, emphasizing the need for standardized evaluation frameworks and more robust study designs to enable reliable clinical adoption.

The third article addresses the challenge of noise degradation in low-dose computed tomography imaging, a key limitation that affects diagnostic accuracy despite reduced radiation exposure. The authors propose a vision transformer-based denoising model enhanced with an attention mechanism designed to preserve edges and fine anatomical structures. Evaluations across multiple datasets and comparisons with state-of-the-art approaches demonstrate the robustness and efficiency of the proposed method, highlighting its potential for improving image quality in low-dose CT while maintaining clinical and computational feasibility.

The fourth contribution tackles the challenge of data scarcity and bias in artificial intelligence models for colorectal cancer detection. The authors propose a novel data augmentation strategy based on text-to-image synthesis using fine-tuned generative models to produce realistic synthetic colonoscopy images. By demonstrating improvements in both classification and segmentation tasks, the study highlights the potential of AI-generated medical data to enhance model robustness, reduce bias, and support more reliable and inclusive colorectal cancer detection in clinical practice.

The fifth article examines the security and reliability of deep learning models in healthcare, addressing critical vulnerabilities that threaten patient safety and trust in AI-driven systems. Focusing on breast cancer detection, the study presents a unified framework for evaluating the impact of multiple attack scenarios, including adversarial, evasion, and data poisoning attacks. By quantitatively assessing post-attack performance degradation, the contribution highlights the importance of systematic vulnerability analysis and provides valuable insights toward the development of more resilient and trustworthy AI solutions for healthcare applications.

The sixth article explores the use of foundation models for semantic segmentation in medical imaging, aiming to simplify and accelerate the segmentation process for clinical use. By leveraging the video segmentation capabilities of the Segment Anything Model 2, the authors propose an approach that dramatically reduces the need for user prompts while maintaining competitive segmentation accuracy. The results demonstrate that large pre-trained models can offer efficient and accessible alternatives to task-specific deep learning solutions, lowering technical and resource barriers for advanced medical image segmentation.

The seventh contribution explores the application of machine learning for early prediction of Acute Aortic Syndrome using large-scale emergency department data. By integrating extensive clinical records and evaluating multiple classifiers and feature selection strategies, the study achieves exceptionally high predictive performance. The results highlight the potential of data-driven models to support early detection of life-threatening cardiovascular conditions and to inform future research in emergency medicine.

The eighth contribution applies machine learning techniques to analyze and forecast cancer trends in Canada using large-scale epidemiological data. By combining traditional statistical models with deep learning approaches, the study provides accurate projections of cancer incidence across regions, genders, and age groups. The findings offer valuable insights for public health planning and policy-making, demonstrating the potential of hybrid machine learning models to support data-driven decision-making in cancer prevention and healthcare resource allocation.

The ninth article provides a comprehensive review of advanced signal processing techniques for structural health monitoring, with a particular focus on time–frequency analysis, adaptive decomposition, and deconvolution methods. By systematically discussing classical and modern approaches for analyzing nonlinear and non-stationary signals, the

study offers valuable insights into their applicability for condition monitoring and fault diagnosis. This contribution serves as a useful reference for researchers seeking to apply data-driven and machine learning-oriented techniques to complex monitoring problems in healthcare-related and engineering system.

The tenth article addresses the need for reliable diagnostic tools during the COVID-19 pandemic by proposing an advanced hybrid deep learning model for SARS-CoV-2 detection from computed tomography images. The study introduces a unified architecture that combines convolutional and graph-based feature extraction with vision transformer-based classification, enabling a rich representation of both local and global image patterns. Experimental results demonstrate superior diagnostic performance compared to existing approaches, highlighting the effectiveness of hybrid neural architectures for medical imaging tasks and their potential applicability beyond COVID-19 diagnosis.

The eleventh article investigates the interpretability of convolutional neural networks for glaucoma prediction using Shapley value-based explanations. To address the high computational cost of Shapley methods, the authors propose a discretization strategy that partitions medical images into clinically meaningful regions, enabling more efficient explanation generation. The study reveals important insights into the limitations of current explainability approaches, highlighting potential mismatches between model reasoning and clinical expectations, and raising critical considerations for the trustworthy deployment of deep learning models in ophthalmology.

The twelfth article focuses on automated hippocampal segmentation from brain MRI to support accurate brain-age estimation and early detection of neurodegenerative processes. Leveraging a self-configuring deep learning framework, the proposed pipeline enables reliable extraction of hippocampal volumes from high-resolution imaging data. By integrating neuroanatomical knowledge with data-driven learning, this contribution highlights the role of advanced segmentation models as a foundation for predictive neuroscience and early risk assessment in aging-related conditions.

The thirteenth article addresses the challenge of segmenting pigmented skin lesions with ambiguous or poorly defined borders, a common limitation in melanoma analysis. The authors propose a region-based segmentation framework that redefines lesion boundaries and leverages superpixel representations combined with transformer-based embeddings and spatial context modeling. By integrating local and global information, the approach significantly improves segmentation performance in challenging border regions, demonstrating the potential of structured, region-level representations to enhance computer-assisted diagnosis in dermatology and related medical imaging tasks.

The fourteenth article examines the effects of Iyengar yoga postures on autonomic nervous system activity using multimodal data collected from wearable sensors. By applying interpretable machine learning models, the study reveals that even subtle postural variations and micro-movements can induce measurable autonomic responses. The findings highlight the relevance of fine-grained physiological and kinematic features for understanding mind-body practices and suggest new opportunities for personalized biofeedback and data-driven yoga-based health interventions.

The fifteenth article evaluates the effectiveness of an educational intervention designed to improve evidence-based management of benign paroxysmal positional vertigo in clinical practice. Using interrupted time series analysis, the study demonstrates significant and sustained improvements in the use of recommended diagnostic and therapeutic maneuvers following the intervention. The findings highlight the value of targeted educational strategies for enhancing clinical adherence to best practices, while also indicating that additional measures may be required to reduce unnecessary imaging in routine care.

The sixteenth article presents a real-time deep learning framework for pneumonia detection from chest X-ray images, emphasizing both diagnostic accuracy and model interpretability. Built on a YOLO-based architecture and enhanced with targeted preprocessing and visual explanation techniques, the proposed approach enables precise localization of clinically relevant features while maintaining high computational efficiency. The results demonstrate strong performance across multiple datasets and highlight the importance of explainable and robust AI solutions for supporting reliable clinical decision-making in respiratory disease diagnosis.

The seventeenth article addresses the scalability challenges of record linkage by combining large language models with traditional blocking strategies. By integrating semantic capabilities of LLMs with efficient data partitioning, the proposed approach significantly reduces computational costs while simultaneously improving matching accuracy. The results underscore the continued relevance of classical data integration techniques and demonstrate how they can be effectively enhanced through modern machine learning models for large-scale, real-world applications, including healthcare data management.

3. Conclusions

The research presented in this Special Issue reflects the breadth and maturity of current efforts at the intersection of machine learning and healthcare. The collected contributions span a wide range of applications, methodologies, and clinical contexts, highlighting both technological advances and practical considerations such as efficiency, interpretability, robustness, and security. Together, these works not only demonstrate the transformative potential of machine learning in healthcare but also underscore the challenges that must be addressed to enable reliable and responsible real-world adoption. We hope this Special Issue will inspire further research, interdisciplinary collaboration, and innovation, contributing to the continued advancement of intelligent healthcare systems.

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