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Editorial

Emerging Applications and Translational Challenges for AI in Healthcare

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The past decade has witnessed an explosive growth in the development and use of artificial intelligence (AI) across diverse fields. While the precise trajectory of AI's evolution is complex and multi-faceted, it is discernible that it has been shaped by several key, interconnected technological trends, including the paradigm shift to generative AI [1,2], the emergence of foundation models [3], and the rise of human-centred AI approaches [4], along with incremental improvements in AI generalisability and explainability [5], data transparency and privacy [6], automated AI [7], and edge AI [8], among others.

Healthcare is no exception. In fact, AI is at the forefront of driving pivotal changes in the healthcare sector, opening up innovative and enhanced methods of care delivery. It holds the potential to have profound impacts on contemporary healthcare challenges. By leveraging AI, we can uncover patterns within vast clinical datasets and develop sophisticated computational reasoning methods that support human decision making.

This editorial accompanies the Special Issue titled "Advances in AI for Health and Medical Applications", which endeavours to spotlight the cutting-edge developments of AI in the healthcare and medical fields. This Special Issue proudly features twelve manuscripts that have been meticulously selected for publication, encompassing a diverse array of original research and review articles. Detailed below are the contributions (contributions 1–12), which span from theoretical frameworks to practical applications, addressing everything from diagnosis and treatment to healthcare management and public health.

The advancements in AI from a technical perspective have been noteworthy. For instance, Roychowdhury introduced an innovative Nested-U Multi-Class Segmentation Network (NUMSnet) model for the semantic segmentation of 3D medical image stacks, and it outperformed the state-of-the-art U-Net models. In contrast, Taj et al. made an important contribution to the theorical framework by demonstrating how to generate and maintain motivation. Their work advances the personalisation and adaptivity of digital interventions through behaviour change techniques, thereby assisting designers in making their mechanism of action more explicit.

Several studies have highlighted novel uses of AI methods to improve disease screening and diagnosis. For instance, Qu and Xiao incorporated the attention mechanism into a multimodal Convolution Neural Network (CNN) model to predict the O^6-methylguanine DNA methyltransferase (MGMT) promoter methylation status, a crucial biomarker for predicting chemotherapy response in brain tumour patients. Bardihi et al. reviewed the latest research on the use of deep learning to enhance colorectal polyp detection, providing a comparative analysis of various algorithms across multiple datasets. Furthermore, Uddin et al. conducted an extensive comparison of machine learning algorithms for the detection of type 2 diabetes, pinpointing specific features indicative of the disease. This work holds potential for the effective identification of individuals at risk of diabetes, ensuring timely intervention and patient care.

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In recent years, COVID-19 has precipitated a profound shift in the digital landscape, revolutionising numerous facets of daily life, with healthcare being the most significantly impacted. To assist the care management of COVID-19 patients, Feng et al. utilised deep learning to detect and segment lung lesions from chest CT scans, thereby automating the assessment and prediction of patient severity and assisting in patient triage. Conversely, Castillo-Olea et al. applied machine learning to pinpoint the significant early-stage variables in COVID-19 patients. The pandemic has made it clear that hospital resources are finite and face substantial challenges in crisis situations such as COVID-19. This underscores the difficulties in the healthcare management of vulnerable patients due to their risk of infection. For example, managing patients infected with HIV during the pandemic was particularly challenging. To address such challenges, Cingolani et al. introduced an innovative e-Clinical platform, driven by a machine learning system capable of predicting HIV-related alerts. This platform facilitates remote patient management, carefully considering the real needs of patients and ensuring vigilant monitoring of the crucial aspects of care for people living with HIV/AIDS (PLWH) to maintain an adequate standard of care.

The work by Zhou et al. is particularly noteworthy for its exploration into the correlation between temperature fluctuations and emergency department (ED) visitations. They innovatively employed a machine learning model to predict daily ED attendance rates. The development of AI-based analytics tools also opens up new avenues for public health research, facilitating a more nuanced comprehension of public health issues and fostering the design of targeted prevention strategies, enhanced models of healthcare delivery, and community engagement initiatives. Building upon this foundation, Putri et al. utilised various data analytics methods, including machine learning, to discern patterns, trends, and associations within health data.

Encouraging results have been reported, suggesting that AI has become so powerful that it outreasons human experts in areas such as radiology [9] and ophthalmology [10]. Although clinical specialties such as radiology might not disappear, they will certainly be heavily transformed, and clinicians will play a major new role in the time of AI [11]. Pham et al. illustrated a novel application by integrating fuzzy inference techniques based on knowledge graph pairs with clinicians' preferences in decision making. This integration has proven to be effective in the detection of preeclampsia signs, showcasing the potential of augmented AI in clinical diagnosis.

Advancements in sensor technology have been a catalyst for the widespread integration of AI into a plethora of everyday activities. Within the healthcare sector, smart Activities of Daily Living (ADL) monitoring systems and wearable sensor devices that are equipped with AI microchips can effectively assist patients with chronic conditions and disabilities in self-management. Ahmed et al. explored the feasibility of accessing depression severity and valence arousal with wearable sensors, revealing that machine learning combined with a multimodal analysis of signals from wearable devices can effectively identify and forecast individual patterns of depression.

We have also seen emerging applications of generative AI and multimodal models within the healthcare domain. A prime example is Med-PaLM M [12], a proof-of-concept multimodal generalist biomedical AI system conceptualised by Google Research and Google DeepMind. This system boasts remarkable flexibility in encoding and interpreting a wide range of biomedical data, encompassing clinical language, imaging, and genomics. To probe its capabilities and limitations, Med-PaLM M was benchmarked against radiologists in the creation of chest X-ray reports. When reviewing 246 retrospective chest X-rays, clinicians showed a preference for the reports generated by Med-PaLM M in approximately 40.50% of cases when compared directly with those produced by human radiologists, indicating significant progress towards its application in clinical settings.

The integration of AI into every facet of healthcare and medicine is poised to become commonplace. However, the path to embedding clinical AI into daily practice is complex and filled with unique challenges. There is growing recognition that translating clinical AI into routine practice is not straightforward. Common obstacles, such as little to no effort spent replicating trials or reporting harm to patients from AI trials, persist across applications. Furthermore, AI built using machine learning often struggle with generalisation, potentially underperforming in various clinical environments. These hurdles highlight a critical issue in the effective deployment of clinical AI, and they could introduce new types of patient risks and obstruct the translation of research and investment into tangible clinical benefits [13]. The successful implementation of healthcare AI tools hinges on recognising and overcoming these challenges to ensure their reliability and efficacy in enhancing patient care. The journey towards mitigating these issues is as much about understanding and adjusting to the complexities of healthcare systems as it is about advancing AI technology. Ultimately, by cutting through the hype and unravelling the mysteries and challenges of AI in healthcare, we anticipate that this field of research will grow increasingly dynamic.

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