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Editorial: Artificial Intelligence in Healthcare and Wellness — Emerging Frameworks, Intelligent Monitoring, and Precision Medicine

Sellappan Palaniappan[1]*
[1]Faculty of Computing and Digital Technology, HELP University, 15, Jalan Sri Semantan 1, Off, Jalan Semantan, Bukit Damansara, 50490 Kuala Lumpur, Malaysia.
corresponding author: (sellappan@help.edu.my; ORCiD: 0009-0009-1168-2864)

Abstract - AI is changing our understanding of health and health-care systems in ways that go beyond the traditional one-click-fits-all approach to care. It is also making care more personalised than ever before, with delivery occurring on an ongoing basis and at all times. The six papers in this special issue of the Journal of Informatics and Web Engineering will give you a clear view of where we are headed. They examine several different areas, including: monitoring chronic illness through wearable technology; using deep learning techniques for contactless heart monitoring via rPPG; developing new cancer risk models; identifying neuroplasticity therapeutic pathways using multi-agent systems; generating synthetic health data; and developing new tri-domain frameworks to examine the interrelationships among the heart, brain, and body. Each of these papers addresses some aspect of a true issue, such as lack of data, limited access, and clinical challenges that traditional methods cannot solve. Collectively, the studies presented in this issue do not just point toward new revolutionary computing; they also provide insight into the future of the health care system. A more intelligent health care system that can adapt to its environment; respond to its client, and ground itself in both ethical and clinical realities. This editorial will outline the common themes that are found throughout the contributions in this special issue. The editorial is an integrative perspective across multiple fields including real-time physiological sensing, explainability and trust, data scarcity solutions, and holistic AI wellness model development.

Keywords—Artificial Intelligence, Healthcare Informatics, Digital Health, Wearable Sensors, Telemedicine, Clinical System

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1. INTRODUCTION

The current era is defined by technologies to support healthcare driven by artificial intelligence through digital sensors and exchange of biomedical data. International healthcare systems now have increasing demands on them to implement innovative AI technologies that are beyond the limits of traditional diagnostic and surveillance paradigms; episodic clinical encounters; protocols based on averaged populations; and retrospective analyses. Thus, AI is creating a structural framework for establishing ongoing and multimodal physiological signals that are collected from all of

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the senses . With multisensory input to detect very small changes in physiological processes; to make individualized clinical predictions; to make timely decisions at scale [1], [2], [3].

The burden to communities around the world from non-communicable diseases (NCDs) such as CVDs, diabetes and cancer continues to grow, disproportionately impacting low- and middle-income countries [4]. In addition, mental health and neurological disorders continue to represent an expanding group of clinical conditions that have historically been neglected. This environment will continue to propel AI-enabled health technologies from aspirational ideas to functional necessities in real-world settings. Machine-learning models are providing clinically validated evidence of applicability to disease stratification; physiologic monitoring of patients at a distance, and identification of potential therapeutic targets [5], [6], [7].

The second structural change within increased use of AI to support the healthcare system is related to data. The healthcare information-as-data set is often small, imbalanced, privacy constrained and institutionally siloed. Synthetic data generation and federated learning are already starting to open some bottlenecks and model training at an affordable cost with no compromise of patient privacy [8]. These are complemented by the availability of affordable wearable biosensors and smartphone-based physiological sensing tools which is making continuous health monitoring accessible [9], [10].

A third dimension, less researched in AI, is based on an integrated wellness view. Recent frameworks are also increasingly aware of the interdependence of the cognitive-emotional and somatic model of health, an orientation currently empirically supported within psychoneuroimmunology and cardiac neuroscience. AI that can model this heart–brain–body coherence provides a frontier for clinical and preventive health significance [11], [12].

This diverse and rapidly evolving landscape has been reflected in the contributions gathered in this special issue of Journal of Informatics and Web Engineering. There are six pieces of research that drive forward both the technical and translational goals associated with the application of AI in healthcare, organized into two thematic clusters: (1) Intelligent Diagnostics, Remote Monitoring and Chronic Disease Management, (2) Synthetic Intelligence, Therapeutic Discovery & Integrative Wellness.

2. IN THIS THEMATIC ISSUE

2.1 Cluster 1 — Intelligent Diagnostics, Remote Monitoring, and Chronic Disease Management

The first cluster studies AI to intelligently diagnose or monitor patients with chronic diseases. The cluster is composed of 3 individual papers using the application of AI models to healthcare settings. The studies represented in the cluster are representative of four types of healthcare systems including telehealth platforms; chronic disease management systems' non-contact physiological sensing technologies; personalized oncology prediction systems. All four examples clearly relate to health services delivery and focus on addressing urgent clinical and social issues. Research conducted in this cluster has occurred in different settings; laboratory test research comparing AI tools across different clinical situations; providing patient care in developing countries where there is a shortage of healthcare resources. Each of these studies demonstrates how AI can be used in multiple and complex areas of healthcare services.

- AI-Powered Continuous Health Monitoring for Chronic Disease Management in Malaysia: Real-Time Risk Prediction Using Wearable Sensors and Digital Biomarkers: Mobile Wearable Sensors, Digital Biomarkers, and Real-Time Risk Prediction" focuses on the neglected topic of chronic disease tracking in a middle-income country. Real-time risk forecasting algorithms relying on multimodal wearable sensor data and digital biomarkers are developed, yet the research is contextualized in the epidemiology of Malaysia. Researchers also state that it is important to ensure that these algorithms can be validated on Malaysia specific populations, and it is not just desired but required for this to be done. It would be unreasonable to use a model calibrated with Western characteristics for this population [17],[18].
- Intelligent Telemedicine Systems for Contactless Heart Rate Estimation using Deep Learning-based rPPG: This research paper looked at heart rate estimates based on pictures of your face without needing to wear a strap, electrode, or finger sensor. The researchers were able to estimate your heart rate by looking at how your skin changed colour each time your heart beats and using deep learning to determine a person's heart rate by monitoring these colour changes over time. The researchers showed potential uses for Long-Term Monitoring of Patients at Home, Long-Term Monitoring of Infants, Population Health Monitoring, and other long-distance patient monitoring where wearing a sensor would be impractical or unnecessary [19].

These three contributions collectively demonstrate the emerging technology on the healthcare monitoring end with AI: from broadband telemedicine technologies to contactless fine-grained biosensing and clinically tractable cancer prediction.

2.2. Cluster 2 — Synthetic Intelligence, Therapeutic Discovery, and Integrative Wellness

This cluster offers us the following 3 papers in this cluster, discussing the key points of the integration, big picture, holistic and essential aspects of AI in healthcare: synthetic generation: data scarcity in health system settings; state-of the-art multi-agent systems to explore neuroplasticity; new coherence-based holistic wellness monitoring [20], [21], [22]. These additions raise questions of what AI in healthcare approaches may look or might look like or be in practice.

- Multi-Agent AI Systems for Detecting Emerging Therapeutic Targets and Intervention Patterns in Neuroplasticity Research: to achieve remarkable accomplishments in computational neuroscience and AI-based drug discovery. Multi-agent architectures are also used to retrieve the existing research literature on neuroplasticity and experimental datasets to determine new targets for therapy and intervention signatures. The collaborative, distributed reasoning of artificial intelligence has demonstrated its value in accelerating research into many areas of complex and voluminous data, in addition to the integration of diverse areas of knowledge from multiple knowledge domains [23], [24].
- Synthetic Data Generation for Healthcare and Wellness: Methods, Applications, and Future Directions for synthetic data generation describes how to generate synthetic data by mapping the current state of all known methods and potential future methods from deployment to health informatics. This literature review describes the methodological areas and discusses issues relating to clinical validation of synthetic data, such as through the use of generative adversarial networks (GANs), variational autoencoders (VAEs), and privacy-protected federated synthesis [25]. The limited accessibility of large, labeled, and ethically usable datasets limits the research in the area of artificial intelligence in healthcare. Therefore, this literature review presents synthetic data generation as a viable alternative to use as a complement to the clinical datasets [25].
- An AI-Based Framework for Heart–Brain–Body Coherence in Wellness Monitoring: A Longitudinal Simulation Study: The study of this framework introduces the concept of a new tri-domain model that unites cardiovascular rhythm, neurologic function, and physiological function. This study uses knowledge from cardiac neuroscience, psychoneuroimmunology, and affective computing to propose coherence (the simultaneous regulation of physiologic sub-systems) as a variable that can be measured for wellness and potentially be monitored by artificial intelligence. Potential applications of the heart-brain-body model and the use of artificial intelligence in healthcare may include preventive medicine, mental wellness, and job wellness [26], [27].

The three contributions mentioned here take AI technology in healthcare beyond the traditional limitations placed on AI: synthetic data generation alleviates the data scarcity problem, distributed intelligence will enable therapeutic discovery, and AI will be used to track and support integrated wellness models.

3. CONCLUSION

Collectively, the six papers that make up this special issue are comprehensive in terms of how they provide important and multi-dimensional advances in the use of artificial intelligence within the healthcare and wellness industries. As the field evolves, the following key themes have emerged that need to be highlighted.

The first major trend is a shift away from episodic monitoring, and towards continuous, or always-on, patient monitoring. The contributions within this special issue demonstrate that it is not only possible, but also beneficial, to use real-time AI data analysis applied to physiological data (such as those that can be derived from both wearable devices, as well as from cameras and/or video streams). The key challenge facing the implementation of real-time AI applications will be the successful integration of these technologies into existing clinical pathways and healthcare delivery systems that are equitable, understandable, and interoperable [28], [29].

Second, a lack of available data remains the single most significant barrier to advancing artificial intelligence research within the healthcare industry. The development of techniques to create synthetic data sets makes it feasible for artificial intelligence systems to learn both from responsibly generated, statistically valid, synthetic data as well as

from clinical data generated from existing, real-world healthcare systems. In particular, the aforementioned challenges associated with the creation of annotated datasets are also especially critical for low- and middle-income countries (LMICs), which will likely lack the large scale annotated datasets necessary to train/instruct artificial intelligence systems within their respective healthcare systems [30], [31].

Thirdly, contextualisation is paramount. The Malaysian example of monitoring chronic disease demonstrates the need for validating models of AI health within each of its own local contexts. Since different epidemiological characteristics and health system structures and demographics of populations will exist dependent on their geographical areas; it is crucial to have very robust local prospectivist assessments [32]. Fourthly, through this issue, a new agenda of research is introduced, which is the development of integrative wellness frameworks. AI will allow for not just the use of single biomarkers but also to examine how cardiac, neural and somatic systems interact with each other in order to represent health as a dynamic, systems-based construct. Emerging from these papers, we observe a definitive shift in designing healthcare systems that are adaptable, individualized, and holistic. We appreciate many aspects of all of the papers included here, and thank all of the authors for their commitment to building a scholarly community, along with producing an amalgamation of scholarly effort and innovative foresight.

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AUTHOR CONTRIBUTIONS

Sellappan Palaniappan — Completed the entire editorial article.

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ETHICS STATEMENTS

Our publication ethics follow The Committee of Publication Ethics (COPE) guideline. https://publicationethics.org/

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analysed in this study.

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BIOGRAPHIES OF AUTHORS

Sellappan Palaniappan is a Professor at HELP University. His research focuses on the application of artificial intelligence, machine learning, data science, and cybersecurity in diverse domains. His research interests also include quantum physics, neuroscience, energy frequency vibration, healing and wholeness, and sustainable development goals. He can be contacted at email: sellappan.p@help.edu.my.