# Editorial for the research topic: Artificial Intelligence in Point of Care Diagnostics

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Speeding up and improving the diagnosis process exactly where and when events occur is the goal of actual Point of Care (PoC) Diagnostics. Besides progress in sensing technologies that pertain to multidisciplinary domains, including nanotechnologies, microfluidics and advanced materials, it is envisaged that PoC Diagnostics can significantly benefit from a tighter interplay with Artificial Intelligence (AI). The interdisciplinary impact of AI is closely related with the general area of digital signal processing, forming an integrating platform for different applications and unifying their background based on computational intelligence and Machine Learning (ML). This approach follows ideas of Leibnitz presented in history, trying to interconnect researchers of different narrow areas who lost their ability to communicate Prochazka et al. (2021).

Indeed, AI and ML can lead to methods for integrating, analyzing and understanding multimedia data from a plethora of different devices. In addition, multivariate methods can correlate the current patient status with the previous history, adapting the findings to his personal history, in line with a more personalized and adaptive approach to care and favoring a more accurate prediction of future status.

To this end, there is the need to explore different research directions in AI and PoC Diagnostics. From one side, AI paradigms can be embedded into PoC testing devices, extending their capabilities and making possible analyses otherwise not viable, e.g. those including image analysis. This can lead to a convergence of pervasive computing and PoC Diagnostics. Similarly, networks of local devices can be devised taking advantage of distributed AI: wearable sensors and portable devices can communicate in an ecosystem, and their data can be cumulatively and coherently processed. Finally, AI can be decentralized, also considering a cloud-based approach, extending the capabilities of PoC Diagnostics all over the computational continuum. For instance, with a timely decentralized survey, PoC may allow the detection of anomalies that, once integrated with previously collected data and anamnesis, with the further purpose of a quality check to use reliable data, can be classified by AI methods. Immediately, the system can then alert the user and his caregivers. Moreover, specific assistance networks can guarantee control and rescue over the territory. Even if the cost of PoC devices is high, it reduces indirect costs and saves lives.

On the basis of such consideration, it has been our aim to collect in a Research Topic multidisciplinary contributions to ”Artificial Intelligence in Point of Care Diagnostics” and, eventually, after a careful revision, five papers were included and published.

Computer-aided diagnostic method, including the X-rays-based techniques, is one of the economical and safe options to diagnose disease, in particular pneumonia. A challenge to the currently existing diagnoses of the pneumonia models has been the feature extraction from the clinical pneumonia X-ray dataset. Four authors from China address this research problem by implementing techniques in AI. D. Yao and Z. Xu, from the State Key Laboratory of Reliability and Intelligence of Electrical Equipment at Hebei University of Technology, Tianjin, and Y. Lin and Y. Zhan, Department of Radiology, Hainan Women and Children's Medical Center, Haikou Yao et al. (2023), describe a two-step process, Accurate and intelligent diagnosis of pediatric pneumonia using X-ray images and blood testing data. They propose a two-stage training multimodal pneumonia classification method combining X-ray images and blood testing data, which improves the image feature extraction through a global-local attention module. They conclude that the two-stage strategy can reduce the misdiagnosis rate of the pneumonia model. They furthermore find that the data gap between bacterial pneumonia and viral pneumonia is very large when bacterial pneumonia and viral pneumonia are indistinguishable using their method.

Autonomous AI has the potential to reduce disparities, improve the quality of care, and reduce costs by improving access to specialty diagnoses at the PoC. Diabetes and related complications incorporate a significant source of health disparities. Vision loss may be a complication of diabetes, supporting annual eye exams for prevention. Prior to the use of autonomous AI, store-and-forward imaging approaches diabetes-related eye exams were not frequent. The US Federal Food and Drug Administration recently approved an AI-based system to diagnose diabetic retinopathy (including macular oedema) without a specialist physician overread at the point of care. J. Goldstein, D. Weitzman, M. Lemerond, and A. Jones, working at Digital Diagnostics, Coralville, Iowa, United States wrote a comprehensive review to identify common workflow themes leading to the successful adoption of the AI-based system Goldstein et al. (2023). They identify the determinants for scalable adoption of autonomous AI in the detection of diabetic eye disease in diverse practice types: key best practices learned through the collection of real-world data. They propose best practices upon the evaluation of four health centers, measured as the attainment number of exams per month using the autonomous AI system against targets set for each health centers. They believe that attainable best practices can be generalized to other autonomous AI systems in front-line care settings, thereby increasing patient access, improving the quality of care, and addressing health disparities.

Automatic medical image detection utilizes AI techniques to accurately and efficiently detect lesions in medical images. It is a crucial task in computer-aided diagnosis (CAD) systems and can be integrated into portable imaging devices for intelligent Point of Care (PoC) Diagnostics. Feature Pyramid Networks (FPN) are commonly used deep-learning-based models for this purpose. However, FPN-based medical lesion detection models face two challenges: the object position offset problem and the degradation problem of IoU-based loss. To address these issues, in Xu et al. (2023), Z. Xu, T. Li, Y. Liu, Y. Zhan, J. Chen and T. Lukasiewicz –an international group of researchers from China and UK– propose a novel FPN-based backbone model, i.e., Multi-Pathway Feature Pyramid Networks with Position Attention Guided Connections and Vertex Distance IoU (abbreviated as PAC-Net and VDIoU respectively), to replace vanilla FPN for more accurate lesion detection. They conducted extensive experiments on the Deeplesion dataset, a public medical image detection dataset. The results demonstrated that PAC-Net outperforms all existing FPN-based depth models in terms of lesion detection evaluation metrics. Furthermore, the proposed PAC module and VDIoU loss proved to be effective and essential for achieving superior performance in automatic medical image detection tasks. Additionally, the VDIoU loss exhibits faster convergence compared to existing IoU-based losses, making PAC-Net an accurate and highly efficient 3D medical image detection model.

In Bai and Zhou (2023), another kind of lesion, namely skin lesion, is addressed, focusing on automated segmentation of dermatoscopy images, a task that plays a vital role in early skin cancer diagnosis. The complexity and indistinct boundaries of skin lesions make this task challenging. In this study, R. Bai and M. Zhou –affiliated to the University of Chinese Academy of Sciences and to the Department of Dermatology, China-Japan Union Hospital of Jilin University, Changchun, China– propose an innovative skin lesion segmentation network called SL-HarDNet. HarDNet serves as the backbone, enabling the network to learn more robust feature representations. Additionally, they introduce three powerful modules: the cascaded fusion module (CFM), the spatial channel attention module (SCAM), and the feature aggregation module (FAM). Briefly, the CFM combines features from different levels, effectively integrating semantic and location information of skin lesions. SCAM captures crucial spatial information, while FAM successfully fuses cross-level features. The high-level semantic position information features obtained from FAM are then reintegrated with CFM features to enhance the model's segmentation performance. The authors evaluated and compared SL-HarDNet with state-of-the-art skin lesion segmentation methods on the challenge datasets ISIC-2016&PH2 and ISIC-2018. The experimental results consistently demonstrate that SL-HarDNet outperforms other segmentation methods, achieving the best performance in skin lesion segmentation.

Microscopy is another important domain in which AI can provide systems and tools to ease and make more accurate the diagnostic process. An example is reported in the paper by X. Li, M. Chen, J. Xu, D. Wu, M. Ye, C. Wang et al. Li et al. (2023) from Sino-European School of Technology of Shanghai University and the School of Mechatronic Engineering and Automation of Shanghai University Li et al. (2023). They address the detection and analysis of circulating tumor cells (CTCs), which are crucial for precise cancer diagnosis and prognosis assessment. Traditional methods that rely on isolating CTCs based on physical or biological features are labor-intensive and unsuitable for rapid detection. Additionally, current intelligent methods lack interpretability, leading to diagnostic uncertainty. To address these challenges, the author propose an automated method that utilizes high-resolution bright-field microscopic images to gain insights into cell patterns. Their method achieves precise identification of CTCs by employing an optimized single-shot multi-box detector (SSD)-based neural network with integrated attention mechanism and feature fusion modules. Compared to conventional SSD systems, their method exhibits superior detection performance with a recall rate of 92.2% and a maximum average precision (AP) value of 97.9%. Notably, they combined the optimal SSD-based neural network with advanced visualization technologies, namely, gradient-weighted class activation mapping (Grad-CAM) for model interpretation and t-distributed stochastic neighbour embedding (T-SNE) for data visualization. The work thus demonstrates the outstanding performance of the SSD-based neural network for identifying CTCs in the human peripheral blood environment, offering great potential for early cancer detection and continuous monitoring of cancer progression.

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## CONFLICT OF INTEREST STATEMENT

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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