Guest Editorial
Artificial Intelligence-Driven Biomedical Imaging Systems for Precision Diagnostic Applications

RECENT advances in Artificial Intelligence (AI) have revolutionized the area of biomedical imaging, providing unprecedented prospects for precision diagnoses. This special issue offers an overview of the integration of AI into biomedical imaging systems and its tremendous impact on improving diagnostic accuracy and efficiency. The combination of AI and biomedical imaging has resulted in intelligent systems capable of deciphering complex medical pictures with amazing precision. Deep learning algorithms, particularly convolutional neural networks (CNNs), have shown exceptional capabilities in recognising patterns and extracting meaningful information from a variety of imaging modalities, including magnetic resonance imaging (MRI), computed tomography (CT), and positron emission tomography (PET) [1].

The capacity of AI-driven biomedical imaging systems to analyze large amounts of imaging data fast and accurately is one of its primary advantages. These tools can help doctors spot subtle irregularities, predict disease development, and provide personalized treatment options based on unique patient profiles. Furthermore, AI systems can help in early disease identification, perhaps leading to better patient outcomes [2]. The incorporation of AI in biomedical imaging also addresses data interpretation issues and improves reproducibility of outcomes. By automating the analysis process, these technologies limit the possibility of human mistake and variability in diagnostic interpretations. Furthermore, AI systems may continuously learn from the given data, adapting and growing over time to improve diagnostic performance.

Despite these advances, problems such as the requirement for huge, annotated datasets, ethical considerations, and regulatory frameworks must be addressed to assure the responsible and ethical deployment of AI-driven biomedical imaging systems [3]. Collaboration among researchers, healthcare professionals, and politicians is critical to navigating these hurdles and promoting wider acceptance of innovative technologies.

The guest editorial team (Vijay Kumar, Amit Kumar Singh, and Robertas Damasevicius) hopes that the articles included in this Special Issue contribute to the state-of-the-art AI and biomedical imaging systems for precision diagnosis. These technologies have the potential to revolutionize healthcare by giving quick and reliable diagnostic information, ultimately improving patient outcomes and contributing to the growth of personalized medicine as they develop. Our Call for Papers received an enthusiastic response with many high-quality submissions in this particular section. After a rigorous review process, we accepted 10 articles in the issue to form the Special Section. A brief summary of each paper is introduced below.

The first paper by Jiao et al. [4] introduces LYSTO, the Lymphocyte Assessment Hackathon dataset. This dataset is made up of multi-center and multi-organ pathological images that will serve as a reference for future computational pathology methods. LYSTO has supported a lot of studies on lymphocyte evaluation in oncology. LYSTO will serve as a long-term educational challenge in deep learning and digital pathology.

The second paper by Ahmed et al. [5] propose a rider-based Gaussian technique for tracking and estimating the diameter of retinal blood vessels. The blood vessel's diameter and curvature are assumed to be Gaussian processes. Using the Radon transform, the features are determined for training the Gaussian process. The Rider Optimization Algorithm is used to optimize the kernel hyperparameter of Gaussian processes in order to determine the vessel's orientation. The bifurcations are detected using multiple Gaussian processes, and the difference in prediction direction is assessed.

The third paper by Qayyum et al. [6] presents a novel 3D depth-wise Inception as encoder and residual network as decoder for quantitative assessment of head neck cancer diagnosis in multimodal PET and CT imaging. A 3D depth-wise convolution-inception encoder is developed that consists of an additional 3D squeeze, an excitation block, and a 3D depth-wise convolution-based residual learning decoder (3D-IncNet). This encoder not only helps to recalibrate the channel-wise features but also integrates the coarse and fine features, which results in accurate tumour segmentation. Random forest is used to predict survival using deep, clinical, and radiomics variables.

The fourth paper by Jeon et al. [7] proposes an innovative global context-aware DNN model that learns the complex Fourier coefficients of an object's masks to segment it. Integrating over the entire contour yields the Fourier coefficients. This model utilizes the object's global context to make a precise estimation of the coefficients, resulting in more accurate segmentation of the object's shape. The presented model is resistant to unobserved local perturbations during inference, such as additive noise or motion blur, which are common in medical images.

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The fifth work by Haq et al. [8] focuses on deep learning techniques for breast cancer diagnosis. For diagnosing early-stage breast cancer, a convolutional neural network (CNN) is used. The proposed technique, which includes the CNN model for invasive ductal carcinoma (IDC) classification, is built using breast histopathology imaging data. To improve the predicted outputs of the CNN model, transfer learning (TL) and data augmentation (DA) approaches are used. For fine-tuning, the CNN model is trained on breast histopathology imaging data. Furthermore, the held-out cross-validation method is employed for optimal model selection.

The sixth paper by Behera, Tanmay Kumar et al. [9] offer an ensemble transfer learning deep architecture that leverages the simple linear iterative clustering-based superpixel technique in conjunction with CNN to categorize MR images as normal or abnormal. The Superpixel technique is applied over the input MR images to segment them into clusters of regions specified by similarity measures in perceptual feature space. These superpixel images are advantageous because they can offer a compact and meaningful image, which is important in computationally intensive applications. The superpixel pictures are subsequently sent into the deep convolutional neural network (CNN) for classification. The experiments are performed over three brain MR imaging datasets namely, NITR-DHH, DS-75, and DS-160.

The seventh paper by Wang, Miao et al. [10] proposes an efficient multi-task synergetic network (EMTS-Net) for concurrent polyp segmentation and classification. An expanded multi-scale network (EMS-Net) is introduced for coarse-grained polyp segmentation. EMS-Net is used to obtain coarse segmentation masks. Thereafter, these rough masks are concatenated with colonoscopic images to aid EMTS-Net in precisely finding and classifying polyps. A random multiscale (RMS) training technique is used to eliminate interference caused by redundant information, resulting in improved polyp segmentation performance. EMTS-Net includes an offline dynamic class activation mapping to improve the performance even further. A comprehensive polyp classification benchmark is designed to investigate the potential benefit of classification results in the polyp segmentation task.

The eighth paper by Bharti, Vandana et al. [11] focuses on issues associated with image-to-image translation using generative adversarial network (GAN). A novel Quantized Evolutionary gradient aware multi-objective Cyclic GAN (QEMCGAN) is designed to overcome the limitations of GAN. To maintain convergence and diversity, Pareto-based ranking and simulated annealing-based concepts are utilized as selection techniques. Evolutionary training with these selection schemes is employed to alleviate the mode collapse limitation. Cyclic, heuristic, identity, and diversity sensitivity losses are incorporated into QEMCGAN for solving the vanishing gradient problem. QEMCGAN is applied on three medical image datasets for cross-domain conversion.

The ninth paper by Berzoini, Raffaele et al. [12] proposes NERONE, a framework to deploy the deep learning models on field programmable gate arrays (FPGAs). This is an open-source framework that, given a trained network and a dataset, transparently deploys the inference phase on FPGA, maintaining the resulting accuracy but improving the energy efficiency compared to GPU-based solutions. The end users will get benefit from FPGA-based inference without coding overhead. NERONE can be applied on different image modalities and platforms. NERONE outperforms the GPU-based solutions in terms of energy efficiency. Nonetheless, it achieves lower FPS rates.

The tenth paper by Hossain, Shahriar et al. [13] focuses on detection of brain tumors from MRI images. The authors investigate the performance of several deep learning architectures namely VGG16, VGG19, ResNet50, InceptionV3, InceptionResNetV2, and Xception. A novel transfer learning model is developed for the classification of multiclass in MRI brain imaging. Thereafter, explainable artificial intelligence technique is used to validate the performance of transfer learning models.

All ten papers tackle different but extremely relevant domain vectors of AI and biomedical systems for precision diagnostics. We believe this Special Issue will raise awareness in the scientific community, through presenting and highlighting the advances and latest novel and emergent technologies, implementations, applications concerning the brain tumour, breast cancer and medical image translation.

In closing, we would like to thank all the authors who submitted their research work to this special issue. We would also like to acknowledge the contribution of many experts in the field who have participated in the review process and provided helpful suggestions to the authors to improve the contents and presentations of the articles. We would in particular like to thank *Professor Dimitrios I. Fotiadis*, the Editor-in-Chief, and the publishing team for their support and very helpful suggestions and comments during the delicate stages of concluding the special issue.

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