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Editorial

Computational Physics and Imaging in Medicine

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The intersection of computational physics and medical imaging has become a cornerstone of modern healthcare, driving innovation in diagnosis, treatment, and patient management [1]. As the complexity of medical challenges increases, so does the need for sophisticated computational models and advanced imaging techniques that can offer precise, non-invasive insights into the human body. The synergy between these fields is not only enhancing our ability to detect and monitor diseases but also enabling personalized treatment approaches that were previously unimaginable [2].

This special issue, dedicated to "Computational Physics and Imaging in Medicine," arrives at a pivotal moment in the evolution of medical science. As researchers and clinicians continue to push the boundaries of what is possible, the integration of computational methods with imaging technologies is unlocking new possibilities in understanding and treating complex medical conditions. From high-resolution imaging that reveals intricate details of cellular processes to simulations that predict treatment outcomes, the contributions in this issue highlight the transformative impact of computational physics on the field of medical imaging.

This special issue showcases pioneering research at the intersection of computational physics and imaging in medicine. Andrews et al. [3] introduce a novel Ferumoxytol-enhanced, free-breathing 3D cine cardiovascular magnetic resonance (CMR) technique that addresses the limitations of traditional 2D cine CMR, which requires lengthy acquisition times and multiple breath holds. By integrating compressed sensing with a manifold-based denoising method, this new approach produces high-resolution, high-contrast images in shorter scan times without the need for breath holds. In pediatric patients, the 3D cine method demonstrated accuracy in measuring ventricular function comparable to conventional 2D breath-hold cine, offering a promising alternative for those unable to perform breath holds.

Ma et al. [4] introduce a novel technique for stitching panoramic half jaw images from intraoral endoscopic images, offering clearer and more comprehensive views of dental structures. Their approach addresses challenges posed by repetitive and low-texture features using an enhanced self-attention mechanism guided by Time-Weighting to improve feature point matching. The method combines the Sinkhorn algorithm with RANSAC to maximize matched feature pairs, remove outliers, and minimize errors. A wavelet transform and weighted fusion algorithm ensure precise alignment and seamless stitching along the dental arch. Experimental results demonstrate high accuracy, making this technique a promising solution for panoramic image stitching in dental applications.

Shen et al. [5] present a deep learning-based algorithm for medical image segmentation, addressing issues like blurred edges, uneven backgrounds, and noise. Using a U-Net backbone with an encoder-decoder structure, the algorithm incorporates residual and convolutional layers for feature extraction and an attention mechanism to enhance spatial perception of complex lesions. The decoder then produces accurate segmentation results. Tested on the DRIVE, ISIC2018, and COVID-19 CT datasets, the model demonstrates high effectiveness, significantly improving segmentation accuracy for complex medical images.

Gu et al. [6] introduce a novel model, LADTV, for deblurring and denoising magnetic resonance (MR) images, improving fidelity and reliability in clinical imaging. The model uses the least absolute deviations (LAD) term to suppress noise and adds an isotropic total variation constraint to maintain smoothness. An alternating optimization algorithm solves the resulting minimization problem. Comparative experiments show the model's effectiveness in enhancing image clarity and quality, highlighting the transformative potential of computational techniques in medical imaging.

Jia et al. [7] studied brain function in depressed patients using resting-state electroencephalogram (EEG). They analyzed 68 brain regions in 22 depressed patients and 22 healthy controls, focusing on information flow between regions using directional phase transfer entropy. The study found increased information flow between the hemispheres and reduced flow within hemispheres in depressed subjects, particularly in areas like the left supramarginal and paracentral gyri. With a 91% classification accuracy, these findings provide insights into altered brain dynamics in depression, helping in patient identification and understanding its pathology.

In conclusion, this special issue brings together groundbreaking research that demonstrates the significant advancements and potential of integrating computational methods with medical imaging. The studies featured here, ranging from innovative image stitching techniques and deep learning-based segmentation algorithms to advanced denoising models for MRI, highlight the diverse applications and transformative impact of computational physics on medical imaging. The work on altered EEG information flow in depression further expands the scope by applying computational analysis to neural activity, revealing critical insights into brain function and pathology. These contributions not only address current challenges in the field but also pave the way for future innovations that will continue to enhance diagnostic accuracy, improve patient outcomes, and expand the capabilities of medical imaging and neuroimaging technologies. We believe this special issue will serve as a valuable resource for researchers, clinicians, and industry professionals, inspiring continued exploration and collaboration in this rapidly evolving field.

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