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A Special Section on Emerging Techniques for Biomedical Imaging—Part 3

It is a pleasure as Guest Editors to introduce this special section on Emerging Techniques for Biomedical Imaging which pursues discussing the state-of-the art of research in the Biomedical Imaging Area, providing valuable insights on updated machine learning and image processing methods and their application to challenging biomedical problems. In general terms, this special section aims to account for outstanding research in biomedical imaging application in combination with Biological Mechanics [1–17] and relevant areas. However, although the practical biomedical interest is the main target of all papers selected, special attention has been devoted to theoretical and fundamentals of algorithms and methods discussed herein.

As Editors, it has not been an easy task to select the 27 papers due to the average high-level of most submitted manuscripts. It has been also our interest to cover a broad area of biomedical research, spanning from ultrasound and fMRI (Functional Magnetic Resonance Imaging) to PET (Positron Emission Tomography) systems; from deterministic to probabilistic/fuzzy methods and also paying special attention to the paradigm provided by DCNNs (Deep Convolutional Neural Networks).

Following our past Editorial guidelines, at least two reviewers—in occasions even 5 reviewers-assessed the quality of the papers, and those meeting the top standards were sent to a second round of reviews. Special care has been taken to plots, figures and algorithm descriptions included in this special section in order to provide a high-value visual impact to readers to ease its understanding.

The guest editors hope that the selected papers will provide the readers with useful examples of present research on some outstanding theoretical frameworks in the pattern recognition and machine learning context applied to Biomedical Imaging as well as in the challenging field of applications through practical and efficient algorithms.

The details of the accepted 27 papers are as follows:

Yuejun Liu et al. develop a thyroid extraction method for single photon emission computed tomography (SPECT) image based on artificial immune network which is optimized with firefly algorithm. The experimental results demonstrate that the method is efficient with less extraction error which is superior to other extraction methods. It is also robust for initial regions with varies radius.

Dayu Xiao et al. use the alternating direction method of multipliers (ADMM) to address the shearlet-based sparse regularization problem, which is subsequently referred to as ADMM-shearlet method, for reducing the (Computed Tomography) CT radiation dose in clinical diagnosis. Compared with the traditional reconstruction algorithms, the ADMM-shearlet algorithm performs well in suppressing the noise due to the low dose while maintaining the image details.

Ruihao Wang et al. evaluate the dosimetric variations of static intensity-modulated radiotherapy (sIMRT), dynamic intensity-modulated radiotherapy (dIMRT) and volumetric modulated arc therapy (VMAT) for thoracic esophageal cancer (EC). The Monaco 5.11 treatment planning system is used to design six radiotherapy plans. The results show that the 5 fixed-fields dynamic IMRT (D5) plan may be preferred for the treatment of thoracic esophageal cancer, significantly shortening the treatment time and simultaneously sparing the bilateral lungs and other organs at risk (OARs). In addition, VMAT plan also can significantly minimize the treatment time, but at the expense of increasing the exposure volume of lungs at lower radiation dose in patients with thoracic esophageal cancer.

Jingxian Liang et al. develop a non-invasive ballistocardiograms (BCG) monitoring system, and propose an effective and accurate algorithm for beat-to-beat detection. The results verify that the heartbeat modeling plays essential to the detection performance. And it is demonstrated that the robustness of the estimated heartbeat model can be enhanced by taking advantages of the morphological characteristics on BCG signals.

Lin Yang et al. propose a new method of pulse waveform analysis based on the traditional method of pulse wave analysis to have a better knowledge of the physiological and pathological state of the human beings. Results demonstrate that the method can fully reflect the characteristics of the pulse wave, and it is found to be an effective characteristic analysis method of pulse wave, thereby providing a scientific basis for the comprehensive analysis of the characteristics of the whole cardiac cycle pulse wave.

Shuchun Yu et al. aim to propose a stereo matching method based on the cost calculation of combination feature and reconstruction optimization of an unstable tree. The experimental results show that the performance of the proposed method is obviously better than that of the stereo matching method based

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on the minimum spanning tree, and is close to that of the two globally optimized stereo matching methods. Further, the method is applied to stereo matching of uterine images, and the depth information is rich in the disparity images, showing that this method can provide a basis for medical diagnosis.

Lulu Yang et al. design a hybrid convolutional neural network (HCNN) structure to classify electrocardiogram (ECG) beats based on the beat's morphology and relationship. The results show that the performance of the proposed HCNN method is higher than that of the traditional CNN on the test set. In particular, the atrial premature contraction beat (APC) improves most significantly from 57.67% to 76.92% in terms of sensitivity and from 58.80% to 78.46% in terms of the positive predictive value in lead V1.

Shaoguo Cui et al. propose a new end-to-end network model called Dense skip Unet (DsUnet), which consists of the Unet backbone, short skip connection and deep supervision to detect the breast ultrasound lesions. The UDIAT 212 dataset is adopted and the experimental results validate that the new approach achieves better performance than other existing methods in detecting and segmenting the ultrasound breast lesions.

Jing Sun et al. use the deep learning method DeepWalk to extract the structural features of the subjects based on brain function connection. The result demonstrate that structural features have a significant differentiation between Alzheimer's disease (AD) patients and normal controls (NCs). Those features may be a signal to track the progress of AD.

Shanshan Wang et al. apply six kinds of coherence factor-like beamforming methods, including coherence factor (CF), phase coherence factor (PCF), sign coherence factor (SCF), phasor dispersion based coherence factor (PDCF), spatial smoothed coherence factor (SSCF) and spatio-temporally smoothed coherence factor (STSCF) to improve the image quality for ultrasound computed tomography (USCT). Experimental results show that the reconstructed images of the breast phantom by the CF gets the highest contrast to noise ratio (CNR), but overall image brightness reduces significantly. PCF gets the lowest variance and provides a more homogenous background. STSCF beamforming method can improve the robustness of the PCF and having the ability to suppress clutter while significant removal of black region artifacts. For practical application, these coherence factor-like beamforming methods can be implemented with low computational complexity.

Xu Li et al. present combination of transcranial magnetic stimulation (TMS) and magnetic resonance image (MRI)-guided low-intensity focused ultrasound pulsation (LIFUP) for the treatment of depression. The data of the combined methods demonstrate significantly better clinical results in comparison to the control group, as measured by the Hamilton Rating Scale for Depression (HAM-D) scale, Geriatric Depression scale (GDS) and the Pittsburgh Sleep Quality Index (PSQI) with low adverse reaction.

Danyang Ma et al. make a new convolutional neural network (CNN) structure based on AlexNet to derive weight values as weight layer and classify the samples better. The results show that the modified CNN structure achieves better performance in terms of CPU time consumption and classification accuracy compared with the original classifier.

Hongbo Li et al. investigate the value of contrast-enhanced ultrasonography (CEUS) in the evaluation of neovascular density in plaques with different carotid atherosclerosis. CEUS clearly shows the continuity of plaque fibrous caps and finds plaque ulcers that are easily missed by conventional ultrasound. The lower the echo of the plaque, the more obvious contrast enhancement in the plaques.

Shiqing Wang et al. study related techniques for brain magnetic resonance image (MRI) skull-stripping. To evaluate the brain extraction results, considering that the existing segmentation evaluation indexes are greatly influenced by true positive (TP), which cannot reflect the segmentation of brain boundaries, a series of boundary-oriented segmentation evaluation indexes are proposed to differentiate the segmentation performance of brain boundary regions.

Haijing Sun et al. propose a new algorithm named cost sensitive and random forest α-weighted algorithm (αCSRF) as a diagnostic model for Alzheimer's disease (AD). The experimental results show that the algorithm is a dynamic model, and different performance classifiers are obtained by adjusting the parameter α. The value of α can be selected according to the actual demand to achieve the purpose of comprehensive optimization.

Shupeng Zheng et al. investigate a novel emotion recognition approach based on multimodal wearable biosensor network. The method narrows the classification range of samples with significant concentration and reduces the disturbance of noisy samples, so that the high accuracy (65.6%) and fast speed are achieved in wearable scenario.

Yong Xue et al. design a "quick acclimatization" method to make the volunteers adapt to rapid exposure at high altitude. The effects of mindful breathing on rapid hypoxia pre-acclimatization training is especially investigated. The experimental results demonstrate that the method can basically meet rapid growth in demand for entering high-altitude at a rapid pace.

Chunjiang Fan et al. use a novel paralleling structure based on conventional 3D U-net deep network for improving the performance of Computed Tomography (CT) image segmentation. The detailed evidence verifies that paralleling structure is effective for the convergence of loss curve. Results in the experiment also prove the huge potential of the method in detection injury parts of low-quality CT images.

Peng An et al. investigate the value of elastic strain rate ratio (SR) in the differential diagnosis of benign and malignant thyroid imaging reporting and data system (TI-RADS) 4 nodules under the influence of various factors. The results show that SR has a high accuracy identifying benign and malignant TI-RADS 4 nodules with a diameter of less than 0.8 cm (but $>$0.4 cm), no or granular calcification, nodules with blurred borders, and no thyroid gland with diffuse lesions. The diagnostic accuracy is improved by combining the two-dimensional ultrasound with SR determination in the differential diagnosis of benign or malignant TI-RADS 4 nodules.

Yu Jiao et al. develop a heart sound signal quality assessment method to get physiological and pathological information that can reflect the cardiovascular status. In view of the 3 common noises (deep breath, speaking and cough) in clinical data collection, a total of 72 features are extracted from 6 domains, i.e., time, frequency, entropy, energy, high-order statistics and cyclostationarity. The results indicate that the proposed method is effective for identifying different noise states.

Xia Yu et al. apply a target tracking method based on depth learning to ultrasonic speckle tracking. The proposed deep learning based method has better accuracy for myocardial motion

tracking, which indicates that the target tracking method based on convolutional neural network has potential advantages in the field of cardiovascular disease diagnosis.

Gang Xu et al. propose a novel automatic arrhythmia detection model utilizing a combination of 1D convolutional neural network (1D-CNN) and Gated Recurrent Unit (GRU) network for the diagnosis of five different arrhythmia on Electrocardiographic (ECG) signals taken from the MIT-BIT arrhythmia physio bank database. Combining 1D-CNN and GRU networks yields a higher degree of accuracy compared with other deep learning networks. The proposed arrhythmia detection method may be a powerful tool to aid clinicians in accurately detecting common arrhythmias on routine ECG screening.

Lingfeng Liu et al. design bidirectional Long Short-Term Memory (BiLSTM) networks to realize the semantic segmentation of QRS complex in single channel electrocardiogram (ECG) for the tasks of R peak detection and heart rate estimation. The cross-validation results show significant increase of the accuracy and decrease of discontinuous gaps in the QRS interval prediction by the ensembling over singular neural networks.

Xiaoyue Fang et al. propose a practical prior-information-based combination (PIBC) solution for picking the difference of time-of-flight between the reference data and the object data (DTOF) to enhance the reconstruction accuracy and uniformity of sound speed imaging. The PIBC solution can quantitatively decrease Root Mean Squared Error (RMSE) and Mean Squared Error (MSE) of DTOF picking and enhance the image quality of reconstructed sound speed images with higher accuracy and uniformity.

Shiliang Shao et al. suggest eight novel instantaneous indices of short-time heart rate variability (HRV) signals for prediction of cardiovascular and cerebrovascular events. The results reveal that seven novel indices are significantly different between the events and non-events groups, and the support vector machine (SVM) classifier has the highest classification Acc and Spe for prediction of cardiovascular and cerebrovascular events.

Mun Han et al. employ a novel manganese-enhanced magnetic resonance imaging (MEMRI) method to map the activity-dependent functional connectivity of the olfactory and non-olfactory pathways associated with various odorants. The functional MEMRI using anatomic standardization and statistical analyses can be a promising *in vivo* imaging method to map neural connectivity, enabling further understanding of the neural processing of different odorants.

Huijin Song et al. investigate how moderate and addictive exercise influence the executive function network of the brain using functional magnetic resonance imaging (fMRI). It is found that compared to no exercise, moderate and addictive exercise indicate a more focused organization of the executive function network during the Wisconsin Card Sorting Test (WCST). This functional reorganization through exercise may suggest improved neural efficiency for executive functions.

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