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A Special Section on Approaches and Techniques for Biomedical Imaging—Part 2

It is a pleasure as Editors to introduce this special section on Approaches and 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 [1–14] 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 21 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 to PET (Positron emission tomography) systems; from deterministic to probabilistic/fuzzy methods and also pay special attention to the paradigm provided by CNNs (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 21 papers are as follows:

Hongxiang Gao et al. present an open-access electrocardiogram (ECG) database compose of challenging QRS detection and heart rate (HR) estimation for the 2nd China Physiological Signal Challenge (CPSC 2019). CPSC 2019 aims to promote the development of robust QRS detection and HR estimation algorithms. The database includes three kinds of challenging signals: pathological (atrial or ventricular) arrythmias, sinus tachycardia or bradycardia, and poor signal quality due to artifact and noise, collected with the wearable device in clinic. Furthermore, two specific evaluation methods are introduced for QRS detection and HR estimation. This paper acts as a guidance to CPSC 2019, aiming to improve the accuracy analysis for dynamic ECG signals.

Hong Li et al. propose a quantitative analysis method for the diagnosis of ankle injury, which could be applied to magnetic resonance images (MRIs) with different protocols. The calculated results are quite consistent with the manual segmentation of the radiologists. It provides a new method for measuring the ankle joint effusion and helps establish a quantitative reference between ankle joint effusion and ankle injury for doctors and relevant researchers.

Yizhang Jiang et al. develop a neural network model with a multitask learning mechanism, whose learning algorithm is based on the classical radial basis function neural network (RBF-NN) to diagnose epileptic electroencephalogram (EEG) signals. The experimental results demonstrate that the multitask RBF-NN (MT-RBF-NN) has better recognition performance than the previous single-task learning classification model and has better robustness and generalization performance.

Qi Mao et al. design a novel and robust model based on modified implicit functions for the simulation of pulmonary nodules on chest computed tomography (CT) images. The experimental results show that the approach outperforms the conventional method. It has potential application in areas such as nodule size measurement, tumor growth rate assessment, training and testing of machine learning algorithm in nodule detection, and other tasks.

Jiamin Zheng et al. propose a new semi-automatic synthetic computed tomography generation using transfer learning and semi-supervised classification (SA-SC-TS) method for generating synthetic CT images from modified Dixon (mDixon) magnetic resonance (MR) data of abdomens to address the challenges of positron emission tomography (PET)/MR attenuation correction. The experimental results indicate that the method can effectively generate synthetic CT images from challenging abdomen images using mDixon MR sequence data only.

Qian Wu et al. introduce a deformable image registration (DIR) method based on cone beam computed tomography (CBCT) intensity correction for accurate radiotherapy.

The results show that intensity correction based CT/CBCT DIR method is robust and efficient against severe CBCT artifacts and intensity uncertainty, and the registration accuracy and efficiency is improved compared to traditional Demons.

Jun Wu et al. adopt a method based on an improved Visual Geometry Group (VGG)-16 network for retinal arteriosclerosis detection. The results of arteriosclerosis detection agree with the actual situation of patients. The method is suitable for regular review of patients with arteriosclerosis and for long-term retinal arteriosclerosis surveys of community residents. It can also realize telemedicine, which allows patients in remote areas to acquire professional eye examinations, accelerate the automation of fundus examinations, and reduce considerable medical resources.

Yu Feng builds a generalized Takagi-Sugeno prediction model (GTS) for acute hyperglycemia actuation duration. The result shows that the prediction accuracy of GTS is the highest compared with the ones of three traditional models which are partial least squares (PLS), least squares support vector machine (LSSVM) and back propagation neural network (BPNN). The model is suitable for predicting the actuation duration of acute hyperglycemia.

Li Qian et al. construct an optimized 17-layer-deep convolutional neural network (CNN) using a genetic algorithm and grid search for automatic multiclassification of surface electrocardiogram signals. Cross-validation combined with various CNN evaluation indicators shows that the network classification performance is better than other studies, and the constructed CNN can be used for the multiclassification of complex arrhythmia in clinical practice.

Shaoguo Cui et al. implement a deep generative adversarial network (DGAN) based on convolutional neural network to further improve the segmentation accuracy of multi-labels brain tumor images and an innovative loss function to mitigate the impact of label imbalance on the experiment to solve the major problem of label imbalances often encountered in medical magnetic resonance image (MRI) brain tumor image segmentation. The experimental results prove that the network structure and innovative loss function are effective in improving the segmentation accuracy of brain tumor MRI images.

Jin Qi et al. propose a long short-term memory (LSTM) based method to detect electrocardiography (ECG) characteristic waves, including the peak of P wave, the onset and offset of Q, R, and S Waves (QRS complex), and the peak of T wave. The method achieves good performance in terms of characteristic point detection accuracy in the public QT dataset.

Bin Liu et al. construct a color slice extraction framework for serialized virtual human project (VHP) slices based on spectral analysis and skeleton graffiti. The framework can process color slice images of VHP automatically and serially. It can also help design satisfactory reconstructed 3D models of the obtained organs and provide new insights for processing similar sequential image sets.

Gihyoun Lee et al. develop non-negative matrix factorization (NMF) based dynamic brain positron emission tomography (PET) analyzing software to separate original dynamic brain PET image into arbitrary components according to 3 dimensional features (m, n, t) of it. The results demonstrate that the NMF pattern-recognition method can separate the original PET image into regions with fine performance according to the activity level in each tissue.

Zhan Gao et al. aim to characterize brain regions which correlate with both normal ageing and Alzheimer's disease (AD), where an accelerated decline in cerebral glucose metabolism is observed when compared to healthy controls. The results show that specific neuroimaging markers of AD may aid in early diagnosis and identifying candidates for future therapies.

Fangfang Jiang et al. apply a transfer learning method to detect the occurrence of paroxysmal atrial fibrillation (PAF) automatically with ballistocardiogram (BCG) signal, which non-invasive records the micro-movements produce by the recoil forces to maintain the overall momentum. Compared with the convolution neural networks (CNN) directly, support vector machine (SVM), random forests (RF) methods respectively, the transfer learning method is indicated to own the precision and the speed superiority, which is suitable for home non-invasive monitoring of cardiac disease.

Seung-Hyeok Shin et al. present a new ultrasound 3D image formation technique which used an advanced matrix pattern in Fourier transform using 1D ultrasound transducer array to reduce the ultrasound system complexity. Experimental results show that the performance of adaptive support weight is affected by the window size. The obtained results are a dense disparity map of stereo matching and a performance evaluation of the disparity map.

Yanxing Qi et al. propose an improved short-lag spatial coherence (SLSC) algorithm which utilizes the eigenspace-based minimum variance (ESBMV) method to adaptively synthesize the transmit aperture for enhancing the imaging quality of the SLSC method. *In vivo* experiments indicate that the method can offer a satisfactory anatomical performance, which will benefit the diagnosis of doctors.

Xufeng Yao et al. aim to propose an optimized strategy of Relief scoring to evaluate the brain features by comparing their weights in the classification of brain aging. The results show that Relief scoring demonstrate robust capability in feature selection for brain aging. The optimized brain features after Relief scoring have better performance than that without Relief scoring in the classification of brain aging. The brain features optimized by Relief scoring can be used to extract significant brain features for evaluating brain aging.

Yanfei Wang et al. use a fast, stable and automatic gradient pre-emphasis adjustment method for permanent magnetic resonance imaging (MRI) scanner. The results indicate that the gradient pre-emphasis adjustment method provides an automatic, simple, rapid and robust method to compensate eddy currents.

Haibin Wu et al. present a method of head orientation tracking based on combination of Kinect depth image and color image to realize accurate, high-resolution and real-time location of doctor's head in three-dimensional space. Experimental results show that face detection rate of this algorithm is 98.2%, and false detection rate is 0 under complex illumination conditions. Accuracy of head orientation tracking is 97.2%, and spatial resolution of tracking process is five times higher than that of existing methods.

Juanjuan Jiang et al. develop an automatic, non-invasive mild cognitive impairment (MCI) detection approach with multimodal measurements and deep belief network (DBN) framework to perform first-line cognitive assessment for clinical practices. The experimental results show that the combined model has an

excellent identification ability and is a good model for MCI detection.

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