Guest Editorial Special Issue on Multi-Modal Biomedical Computing-Deep Transfer Learning

IN RECENT years, the development of biomedical imaging techniques, integrative sensors, and artificial intelligence has brought many benefits to the protection of health. We can collect, measure, and analyze vast volumes of health-related data using the technologies of computing and networking, leading to tremendous opportunities for the health and biomedical community. Biomedical intelligence, especially precision medicine, is considered one of the most promising directions for healthcare development. This special issue aims to prompt Deep Transfer Learning techniques in Multi-modal Biomedical Computing. After a rigorous review according to relevance, originality, technical novelties, and presentation quality, we selected 21 high-quality manuscripts. A summary is outlined below.

In [A1] by Wang et al., the authors propose an unsupervised LGE-CMR segmentation algorithm by using multiple style transfer networks for data augmentation. It adopts two different style transfer networks to perform style transfer of the easily available annotated balanced-Steady State Free Precession (bSSFP)-CMR images. Then, multiple sets of synthetic LGE-CMR images are generated by the style transfer networks and used as the training data for the improved U-Net.

In [A2] by Ni et al., the authors consider a collaborative vehicular network including the cloud, edge, and terminal. The authors further construct the virtual resource pool which can integrate the resource of multiple ESs since some regions may be covered by multiple RSUs. In this paper, the authors propose a Multi-Scenario offloading schedule for biomedical data processing and analysis in Cloud-Edge-Terminal collaborative vehicular networks called MSCET.

In [A3] by Zhang et al., the authors combine multi-kernel learning and transfer learning and propose a feature-level multi-modality fusion model with insufficient training samples. The authors first extend kernel Ridge regression to its multi-kernel version under the l_p-norm constraint. Then the authors use marginal probability distribution adaption to minimize the distribution differences between the source domain and the target domain.

In [A4] by Chen et al., the authors propose the message-passing-based nonlinear network fusion (MP-NNF) algorithm to estimate multimodal brain network connectivity. In the proposed method, the initial functional and structural networks were computed from fMRI and DTI separately. Then, the authors update every unimodal network iteratively, making it more similar to the others in every iteration, and finally converge to one unified network.

In [A5] by Yan et al., mixed domain images were generated from source and target image groups for improving the correlation between the mixed domain (training dataset) and the target domain (testing dataset). A subdomain alignment mechanism is employed to transfer knowledge from the mixed domain to the target domain. The proposed framework captures the fine-grained information more effectively.

In [A6] by Dharejo et al., the authors propose a generative adversarial network (GAN) with deep multi-attention modules to learn high-frequency information from low-frequency data. The integration of wavelet transform (WT) and GANs in our proposed SR model addresses the aforementioned limitation concerning textons. The authors train and perform on several modalities via transfer learning.

In [A7] by Bian et al., the authors introduce some rules into convolutional neural networks, which help present clinical knowledge to deep learning-based ECG analysis, to improve automated ECG diagnosis performance. The authors propose a Handcrafted-Rule-enhanced Neural Network for ECG classification with standard 12-lead ECG input.

In [A8] by Ahmed et al., the authors analyze the problem of lung cancer diagnosis by classification and detection of pulmonary nodules, i.e., benign and malignant, in CT images. To achieve this objective, an automated deep learning-based system is introduced for classifying and detecting lung nodules. In addition, the authors use novel state-of-the-art detection architectures.

In [A9] by Chen et al., the authors propose a semi-supervised dual-task consistent joint learning framework with task-level regularization for 3D medical image segmentation. Two branches are utilized to simultaneously predict the segmented and signed distance maps, and they can learn useful information from each other by constructing a consistency loss function between the two tasks.

In [A10] by Wang et al., the MRI image enhancement method based on metamaterial composite technology is proposed by analyzing the application status of DTs in medical direction and the principle of MRI imaging. Based on deep transfer learning, MRI super-resolution deep neural network structure is established. To address the problem that different medical imaging methods have advantages and disadvantages, a multi-mode

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medical image fusion algorithm based on adaptive decomposition is proposed and verified by experiments.

In [A11] by Xu et al., the authors propose Hygeia, a multilabel deep learning-based ECG classification method that can analyze and classify 55 types of ECG. First, a guidance model is constructed to transform the multilabel classification problem into multiple interrelated two-classification models. The proposed method ensures the good performance of each ECG analysis model, and the relationship between various types of ECG can be used in the analysis.

In [A12] by Ma et al., the authors propose an effective perceptual data augmentation method to improve the similarity between eye fundus images and coronary angiograms by synthesizing virtual samples. Auto Foreground Augment method is designed to search for geometric transformations that improve the similarity between foreground vessels of eye fundus images and coronary angiograms.

In [A13] by Li et al., the authors propose a hybrid model combined with a semi-supervised domain adaption model and extreme learning machine (ELM) classifier, and the application of a novel multi-kernel correntropy induced loss function in transfer learning is also presented.

In [A14] by Siniosoglou et al., the authors strive to apply a post-processing pipeline to models used by Federated Learning (FL). In particular, the proposed work ranks the model by finding how fair they are by discovering and inspecting micro-Manifolds that cluster each neural model's latent knowledge. The produced work applies a completely unsupervised both model and data agnostic methodology.

In [A15] by Cai et al., the authors study segment images through a novel Dual-path Feature Transfer design with only bounding box annotations. A Target-aware Reconstructor is proposed to extract target-related features by reconstructing the pixels within the bounding box through the channel and spatial attention module. Then, a sliding Feature Fusion and Transfer Module (FFTM) fuses the extracted features from Reconstructor.

In [A16] by Wang et al., the authors introduce the vision Transformer (ViT) architecture, which has recently achieved impressive results in natural image analysis, in the classification task of cervical OCT images. The proposed work aims to develop a computer-aided diagnosis (CADx) approach based on a self-supervised ViT-based model to classify cervical OCT images effectively.

In [A17] by Adhikari et al., the authors develop a novel edge-centric healthcare framework integrating with wearable sensors and advanced machine learning (ML) model for timely decisions with minimum delay. Due to limited resource capacity, analyzing the features in resource-constrained edge devices is challenging. Motivated by this, the authors introduce an advanced ML technique for data analysis at edge networks, namely Deep Transfer Learning (DTL).

In [A18] by Ding et al., the authors propose an image segmentation network based on reinforcement learning (RLSegNet). The proposed RLSegNet is a U-shaped network, which is composed of three components: the feature extraction network, the Mask Prediction Network (MPNet), and the upsampling network. The deep semantic feature in the image is extracted by adopting the feature extraction network. The MPNet is proposed to generate the prediction mask for the current frame.

In [A19] by Liang et al., the authors propose to formulate the BioNER task as a Textual Entailment problem and solve the task via Textual Entailment with Dynamic Contrastive learning (TEDC). TEDC not only alleviates the noisy labeling issue but also transfers the knowledge from pre-trained textual entailment models. The dynamic contrastive learning framework contrasts the entities and non-entities in the same sentence and improves the model's discrimination ability.

In [A20] by Qayyum et al., the authors present deep multimodal electroencephalography and speech signals-based framework for diagnosing mild depression. The authors have combined audio spectrograms and multiple frequencies of EEG signals to improve diagnostic performance. The authors have fused different levels of speech and EEG features and applied vision transformers and various pre-trained networks on the speech and EEG spectrum.

In [A21] by Ren et al., the authors propose a medical image super-resolution method based on semantic perception transfer learning. First, the authors propose a semantic perception super-resolution method. Second, the authors construct a semantic feature extraction network and an image description generation network and comprehensively utilized image and text modal data. Third, the authors train an end-to-end, semantic perception super-resolution model.

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Appendix: Related Articles

[A1] W. Wang, X. Yu, B. Fang, Y. Zhao, Y. Chen, W. Wei, and J. Chen, "Cross-modality LGE-CMR segmentation using image-to-image translation based data augmentation," *IEEE/ACM Trans. Comput. Biol. Bioinf.*, vol. 20, no. 4, pp. 2367–2375, Jul./Aug. 2023.

[A2] Z. Ni, H. Chen, Z. Li, X. Wang, N. Yan, W. Liu, and F. Xia, "MSCET: A multi-scenario offloading schedule for biomedical data processing and analysis in cloud-edge-terminal collaborative vehicular networks," *IEEE/ACM Trans. Comput. Biol. Bioinf.*, vol. 20, no. 4, pp. 2376–2386, Jul./Aug. 2023.

[A3] Y. Zhang, K. Xia, Y. Jiang, P. Qian, W. Cai, C. Qiu, K.W. Lai, and D. Wu, "Multi-modality fusion & inductive knowledge transfer underlying non-sparse multi-kernel learning and distribution adaption," *IEEE/ACM Trans. Comput. Biol. Bioinf.*, vol. 20, no. 4, pp. 2387–2397, Jul./Aug. 2023.

[A4] N. Chen, M. Guo, Y. Li, X. Hu, Z. Yao, and B. Hu, "Estimation of discriminative multimodal brain network connectivity using message-passing-based nonlinear network fusion," *IEEE/ACM Trans. Comput. Biol. Bioinf.*, vol. 20, no. 4, pp. 2398–2406, Jul./Aug. 2023.

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[A6] F. A. Dharejo, M. Zawish, F. Deeba, Y. Zhou, K. Dev, S. A. Khowaja, and N. M. F. Qureshi, "Multimodal-boost: multimodal medical image super-resolution using multi-attention network with wavelet transform," *IEEE/ACM Trans. Comput. Biol. Bioinf.*, vol. 20, no. 4, pp. 2420–2433, Jul./Aug. 2023.

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