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**EPRO
BIOM - 001**

Content-Based Brain Tumor Retrieval for MR Images Using Transfer Learning

This paper presents an automatic content-based image retrieval (CBIR) system for brain tumors on T1-weighted contrast-enhanced magnetic resonance images (CE-MRI). The key challenge in CBIR systems for MR images is the semantic gap between the low-level visual information captured by the MRI machine and the high-level information perceived by the human evaluator. The traditional feature extraction methods focus only on low-level or high-level features and use some handcrafted features to reduce this gap. It is necessary to design a feature extraction framework to reduce this gap without using handcrafted features by encoding/combining low-level and high-level features. Deep learning is very powerful for feature representation that can depict low-level and high-level information completely and embed the phase of feature extraction in self-learning. Therefore, we propose a deep convolutional neural network VGG19-based novel feature extraction framework and apply closed-form metric learning to measure the similarity between the query image and database images. Furthermore, we adopt transfer learning and propose a block-wise fine-tuning strategy to enhance the retrieval performance. The extensive experiments are performed on a publicly available CE-MRI dataset that consists of three types of brain tumors (i.e., glioma, meningioma, and pituitary tumor) collected from 233 patients with a total of 3064 images across the axial, coronal, and sagittal views.

**EPRO
BIOM - 002**

WGAN-Based Synthetic Minority Over-Sampling Technique: Improving Semantic Fine-Grained Classification for Lung Nodules in CT Images

Data imbalance issue generally exists in most medical image analysis problems and maybe getting important with the popularization of data-hungry deep learning paradigms. We explore the cutting-edge Wasserstein generative adversarial networks (WGANs) to address the data imbalance problem with oversampling on the minority classes. The WGAN can estimate the underlying distribution of a minority class to synthesize more plausible and helpful samples for the classification model. In this paper, the WGAN-based over-sampling technique is applied to augment the data to balance for the fine-grained classification of seven semantic attributes of lung nodules in computed tomography images. The fine-grained classification is carried out with a normal convolutional neural network (CNN). To further illustrate the efficacy of the WGAN-based over-sampling technique, the conventional data augmentation method commonly used in many deep learning works, the generative adversarial networks (GANs), and the deep convolutional generative adversarial networks (DCGANs) are implemented for comparison. The whole schemes of the minority oversampling and fine-grained classification are tested with the public lung imaging database consortium dataset.

**EPRO
BIOM - 003**

Deep Belief Network Modeling for Automatic Liver Segmentation

The liver segmentation in CT scan images is a significant step toward the development of a quantitative biomarker for computer-aided diagnosis. In this paper, we propose an automatic feature learning algorithm based on the deep belief network (DBN) for liver segmentation. The proposed method was based on training by a DBN for unsupervised pretraining and supervised fine tuning. The whole method of pretraining and fine tuning is known as DBN-DNN. In traditional machine learning algorithms, the pixel-by-pixel learning is a time-consuming task; therefore, we use blocks as a basic unit for feature learning to identify the liver, which saves memory and computational time. An automatic active contour method is applied to refine the liver in post-processing. The experiments on test images show that the proposed algorithm obtained satisfactory results on healthy and pathological liver CT images. Our algorithm achieved 94.80% Dice similarity coefficient on mixed (healthy and pathological) images while 91.83% on pathological liver images, which is better than those of the state-of-the-art methods.

**EPRO
BIOM - 004**

Classification of Breast Cancer Histology Images Using Multi-Size and Discriminative Patches Based on Deep Learning

The diagnosis of breast cancer histology images with hematoxylin and eosin stained is non-trivial, labor-intensive and often leads to a disagreement between pathologists. Computer-assisted diagnosis systems contribute to help pathologists improve diagnostic consistency and efficiency. With the recent advances in deep learning, convolutional neural networks (CNNs) have been successfully used for histology images analysis. The classification of breast cancer histology images into normal, benign, and malignant sub-classes is related to cells' density, variability, and organization along with overall tissue structure and morphology. Based on this, we extract both smaller and larger size patches from histology images, including cell-level and tissue-level features, respectively. However, there are some sampled cell-level patches that do not contain enough information that matches the image tag. Therefore, we propose a patches' screening method based on the clustering algorithm and CNN to select more discriminative patches. The approach proposed in this paper is applied to the 4-class classification of breast cancer histology images and achieves 95% accuracy on the initial test set and 88.89% accuracy on the overall test set. The results are competitive compared to the results of other state-of-the-art methods.

**EPRO
BIOM - 005**

Convolutional Neural Network (CNN) Based Three Dimensional Tumor Localization Using Single X-Ray Projection

Accurate localization of lung tumor in real time based on a single X-ray projection is of great interest to the tumor-tracking radiotherapy but is very challenging. In this paper, a convolutional neural network (CNN)-based tumor localization method was proposed to address this problem with the aid of principal component analysis-based motion modeling. A CNN regression model was trained before treatment to recover the ill-conditioned nonlinear mapping from the single X-ray projection to the tumor motion. Novel intensity correction and data augmentation techniques were adopted to improve the model's robustness to the scatter and noise in the X-ray projection image. During treatment, the volumetric image and tumor position could be obtained by applying the CNN model on the acquired X-ray projection. This method was validated and compared with the other state-of-the-art methods on three real patient data. It was found that the proposed method could achieve real-time tumor localization with much higher accuracy (<1 mm) and robustness.

**EPRO
BIOM - 006**

Intrinsic Image Decomposition-Based Grey and Pseudo-Color Medical Image Fusion

It is difficult to extract both structural and functional information from the input grey magnetic resonance imaging (MRI) and pseudo-color positron emission tomography (PET) images using the same decomposition scheme in multi-scale transform fusion methods. To overcome this limitation, we propose two algorithms based on intrinsic image decomposition to decompose MRI and PET images into its two separate components in the spatial domain. Algorithm 1 could extract structural information while reducing the noise from the MRI image. Algorithm 2 is for averaging the color information from the PET image. As for the image fusion rule, the defined importance of image coefficients is used to combine the decomposed two-scale components to produce the final fused image, which could keep more spatial resolution with substitution strategies. It demonstrates that the proposed fusion methods could improve the values of mutual information by the metrics on the disease database. Furthermore, the proposed methods produce the competitive visual signal-to-noise ratio values on experiments for robustness database. In addition to the variance in metrics values, the non-parametric Friedman test and the post-hoc Bonferroni-Dunn test are used to analyze the significant difference between the proposed and the state-of-the-arts methods.

**EPRO
BIOM - 007**

Multi-Resolution CNN and Knowledge Transfer for Candidate Classification in Lung Nodule Detection

The automatic lung nodule detection system can facilitate the early screening of lung cancer and timely medical interventions. However, there still exist multiple nodule candidates produced by initial rough detection in this system, and how to determine authenticity is a key problem. As this work is often challenged by the radiological heterogeneity of the computed tomography scans and the variable sizes of lung nodules, we put forward a multi-resolution convolutional neural network (CNN) to extract features of various levels and resolutions from different depth layers in the network for classification of lung nodule candidates. Through the use of knowledge transfer, the method can be divided into three steps. First, we transfer knowledge from the source CNN model which has been applied to edge detection and improve the model to a new multi-resolution model which is suitable for the image classification task. Then, the knowledge is transformed from source training progress so that all of the side-output branches in the model will be considered in the calculation. Moreover, the loss function and objective equation are improved to be image-wise calculation rather than pixel-wise. Finally, samples production and data enhancement are performed to train and test a classifier tailored for classification of lung nodule candidates.

**EPRO
BIOM - 008**

Brain MRI Image Classification for Cancer Detection Using Deep Wavelet Auto encoder-Based Deep Neural Network

Technology and the rapid growth in the area of brain imaging technologies have forever made for a pivotal role in analyzing and focusing the new views of brain anatomy and functions. The mechanism of image processing has widespread usage in the area of medical science for improving the early detection and treatment phases. Deep neural networks (DNN), till date, have demonstrated wonderful performance in classification and segmentation task. Carrying this idea into consideration, in this paper, a technique for image compression using a deep wavelet autoencoder (DWA), which blends the basic feature reduction property of autoencoder along with the image decomposition property of wavelet transform is proposed. The combination of both has a tremendous effect on sinking the size of the feature set for enduring further classification task by using DNN. A brain image dataset was taken and the proposed DWA-DNN image classifier was considered. The performance criterion for the DWA-DNN classifier was compared with other existing classifiers such as autoencoder-DNN or DNN, and it was noted that the proposed method outshines the existing methods.

EPRO
BIOM - 009

Lung Nodule Detection with Deep Learning in 3D Thoracic MR Images

Early detection of lung cancer is crucial in reducing mortality. Magnetic resonance imaging (MRI) may be a viable imaging technique for lung cancer detection. Numerous lung nodule detection methods have been studied for computed tomography (CT) images. However, to the best of our knowledge, no detection methods have been carried out for the MR images. In this paper, a lung nodule detection method based on deep learning is proposed for thoracic MR images. With parameter optimizing, spatial three-channel input construction, and transfer learning, a faster R-convolution neural network (CNN) is designed to locate the lung nodule region. Then, a false positive (FP) reduction scheme based on anatomical characteristics is designed to reduce FPs and preserve the true nodule. The proposed method is tested on 142 T2-weighted MR scans from the First Affiliated Hospital of Guangzhou Medical University. The sensitivity of the proposed method is 85.2% with 3.47 FPs per scan. The experimental results demonstrate that the designed faster R-CNN network and the FP reduction scheme are effective in the lung nodule detection and the FP reduction for MR images.

EPRO
BIOM - 010

Skin Lesion Classification Using Convolutional Neural Network with Novel Regularizer

One of the most common types of human malignancies is skin cancer, which is chiefly diagnosed visually, initiating with a clinical screening followed by dermoscopic analysis, histopathological assessment, and a biopsy. Due to the fine-grained differences in the appearance of skin lesions, automated classification is quite challenging through images. To attain highly segregated and potentially general tasks against the finely grained object categorized, deep convolutional neural networks (CNNs) are used. In this paper, we propose a new prediction model that classifies skin lesions into benign or malignant lesions based on a novel regularizer technique. Hence, this is a binary classifier that discriminates between benign or malignant lesions. The proposed model achieved an average accuracy of 97.49%, which in turns showed its superiority over other state-of-the-art methods. The performance of CNN in terms of AUC-ROC with an embedded novel regularizer is tested on multiple use cases. The area under the curve (AUC) achieved for nevus against melanoma lesion, seborrheic keratosis versus basal cell carcinoma lesion, seborrheic keratosis versus melanoma lesion, solar lentigo versus melanoma lesion is 0.77, 0.93, 0.85, and 0.86, respectively. Our results showed that the proposed learning model outperformed the existing algorithm and can be used to assist medical practitioners in classifying various skin lesions.

**EPRO
BIOM - 011**

A New Hybrid Algorithm for Retinal Vessels Segmentation on Fundus Images

Automatic retinal vessels segmentation is an important task in medical applications. However, most of the available retinal vessels segmentation methods are prone to poorer results when dealing with challenging situations such as detecting low-contrast micro-vessels, vessels with central reflex, and vessels in the presence of pathologies. This paper presents a new hybrid algorithm for retinal vessels segmentation on fundus images. The proposed algorithm overcomes the difficulty when dealing with the challenging situations by first applying a new directionally sensitive blood vessel enhancement method before sending fundus images to a convolutional neural network architecture derived from U-Net. To train and test the algorithm, fundus images from the DRIVE and STARE databases, as well as high-resolution fundus images from the HRF database, are utilized. In the experiment, the proposed algorithm outperforms the state-of-the-art methods in four major measures, i.e., sensitivity, F1-score, G-mean, and Mathews correlation coefficient both on the low- and high-resolution images. In addition, the proposed algorithm achieves the best connectivity-area-length score among the competing methods. Given such performance, the proposed algorithm can be adapted for vessel-like structures segmentation in other medical applications. In addition, since the new blood vessel enhancement method is independent of the U-Net model, it can be easily applied to other deep learning architectures.

**EPRO
BIOM -012**

Multi-Modal Medical Image Fusion with Adaptive Weighted Combination of NSST Bands Using Chaotic Grey Wolf Optimization

Recently, medical image fusion has emerged as an impressive technique in merging the medical images of different modalities. Certainly, the fused image assists the physician in disease diagnosis for effective treatment planning. The fusion process combines multi-modal images to incur a single image with excellent quality, retaining the information of original images. This paper proposes a multi-modal medical image fusion through a weighted blending of high-frequency subbands of nonsubsampled shearlet transform (NSST) domain via chaotic grey wolf optimization algorithm. As an initial step, the NSST is applied on source images to decompose into the multi-scale and multi-directional components. The low-frequency bands are fused based on a simple max rule to sustain the energy of an individual. The texture details of input images are preserved by an adaptively weighted combination of high-frequency images using a recent chaotic grey wolf optimization algorithm to minimize the distance between the fused image and source images. The entire process emphasizes on retaining the energy of the low-frequency band and the transferring of texture features from source images to the fused image. Finally, the fused image is formed using inverse NSST of merged low and high-frequency bands. The experiments are carried out on eight different disease datasets obtained from Brain Atlas, which consists of MR-T1 and MR-T2, MR and SPECT, MR and PET, and MR and CT.

**EPRO
BIOM - 013**

Diagnosis and Data Probability Decision Based on Non-Small Cell Lung Cancer in Medical System

There are many factors affecting the survival of people in developing countries, such as the tremendous number of population, nonuniform medical resources, and the threatening of malignant diseases. The improvements in medical information system in developing countries may lead to a bright future. By using effective medical resources and utilizing the information coming from the medical system, the doctors could come to a diagnosis with analysis. The probability of getting sick is very useful information which assists doctors to improve the accuracy of disease diagnosis, shortening treatment time, and reducing the incidence of misdiagnosis. This paper aims to build a model, considering not only probability analysis but also decision making, which can play a crucial role to figure out the probability of non-small lung cancer transitions in four different stages. In each process of the model, selecting effective parameters with big data are adopted for finding maximum effect with the top three high relevancy diagnose and decision data. With effective treatment methods that improve the relevancy diagnose data, the probability of malignant disease development will decrease. It is proved by the statistical analysis of clinical data that the model provides clinical data fast with enough accuracy.

**EPRO
BIOM - 014**

Robust Retinal Image Enhancement via Dual-Tree Complex Wavelet Transform and Morphology-Based Method

Retinal image processing is very important in the field of clinical medicine. As the first step in retinal image processing, image enhancement is essential. Because the details of a retinal image are complex and difficult to enhance, we present a robust retinal image enhancement algorithm via a dual-tree complex wavelet transform (DTCWT) and morphology-based method in this paper. To begin with, we utilize the pre-processing method to the captured retinal images. Then, the DTCWT is applied to decompose the gray retinal image to obtain high-pass subbands and low-pass subbands. Then, a Contourlet-based enhancement method is applied to the high-pass subbands. For the low-pass subbands, we improve the morphology top-hat transform by adding dynamic multi-scale parameters to achieve an equivalent percentage enhancement and at the same time achieve multi-scale transforms in multiple directions. Finally, we develop the inverse DTCWT method to obtain the enhanced retinal image after processing the low-frequency subimages and high-frequency subimages. We compare this approach with enhancement based on the adaptive unsharp masking, histogram equalization, and multi-scale retinex. We present the test results of our algorithm on 440 retinal images from the DRIVE and the STARE databases. The experimental results show that the proposed approach can achieve better results, and might be helpful for vessel segmentation.

**EPRO
BIOM - 015**

Medical Image Retrieval Based on Convolutional Neural Network and Supervised Hashing

In recent years, with extensive application in image retrieval and other tasks, a convolutional neural network (CNN) has achieved outstanding performance. In this paper, a new content-based medical image retrieval (CBMIR) framework using CNN and hash coding is proposed. The new framework adopts a Siamese network in which pairs of images are used as inputs, and a model is learned to make images belonging to the same class have similar features by using weight sharing and a contrastive loss function. In each branch of the network, CNN is adapted to extract features, followed by hash mapping, which is used to reduce the dimensionality of feature vectors. In the training process, a new loss function is designed to make the feature vectors more distinguishable, and a regularization term is added to encourage the real value outputs to approximate the desired binary values. In the retrieval phase, the compact binary hash code of the query image is achieved from the trained network and is subsequently compared with the hash codes of the database images. We experimented on two medical image datasets: the cancer imaging archive-computed tomography (TCIA-CT) and the vision and image analysis group/international early lung cancer action program (VIA/I-ELCAP). The results indicate that our method is superior to existing hash methods and CNN methods. Compared with the

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BIOM - 016**

An Improved Confidence Connected Liver Segmentation Method Based on Three Views of CT Images

To enhance the accuracy of liver segmentation, we present an improved confidence connected liver segmentation method, which combines the liver segmentation results obtained from three views is proposed. First, to reduce noise, an improved curvature anisotropic diffusion filter is applied, which simultaneously stores edge information. Second, seed points located in the liver are selected automatically using statistics and analysis of the liver intensity. We extract the liver contours from three views of computed tomography (CT) images using the confidence connected method and improve the contours by the cavity filling method. Finally, we combine the liver contours extracted from the coronal, sagittal, and cross section. In our experiments, clinical validation is performed using ten abdominal CT datasets. The results show that our proposed method can extract liver contours quickly and accurately, achieving an overall true positive rate (TPR) of 0.97. In addition, this method is useful for clinical diagnosis of liver disorders and virtual surgical planning.

**EPRO
BIOM - 017**

Analyzing the Dynamics of Lung Cancer Imaging Data Using Refined Fuzzy Entropy Methods by Extracting Different Features

Lung cancer is the major cause of cancer-related deaths worldwide with poor survival due to the poor diagnostic system at the advanced cancer stage. In the past, researchers developed computer-aided diagnosis (CAD) systems, which were greatly used by the radiologist for identifying the abnormalities and applied few features extracting methods. The physiology and behavior of various physiological systems can be best investigated using nonlinear dynamical measures for capturing the intrinsic dynamics, which is influenced due to multiple pathologies by the degradation of structural and functional components. As cancer images contain hidden information, which can be best analyzed using these dynamical measures. In this paper, we proposed multiscale sample entropy (MSE) with a mean and KD-tree algorithmic approach, multiscale permutation entropy (MPE), multiscale fuzzy entropy (MFE), and refined composite multiscale fuzzy entropy (RCMFE) with mean, variance, and standard deviation. The statistically significant results were computed to distinguish non-small-cell lung cancer (NSCLC) from SCLC by extracting morphological, texture, and elliptic Fourier descriptors (EFDs). The highest significant results obtained based on texture features using MFE with standard deviation give the P-value of $1.95E-50$, morphological features using RCMFE with mean provide the

**EPRO
BIOM - 018**

Studies on Different CNN Algorithms for Face Skin Disease Classification Based on Clinical Images

Skin problems not only injure physical health but also induce psychological problems, especially for patients whose faces have been damaged or even disfigured. Using smart devices, most of the people are able to obtain convenient clinical images of their face skin condition. On the other hand, the convolutional neural networks (CNNs) have achieved near or even better performance than human beings in the imaging field. Therefore, this paper studied different CNN algorithms for face skin disease classification based on the clinical images. First, from Xiangya–Derm, which is, to the best of our knowledge, China’s largest clinical image dataset of skin diseases, we established a dataset that contains 2656 face images belonging to six common skin diseases [seborrheic keratosis (SK), actinic keratosis (AK), rosacea (ROS), lupus erythematosus (LE), basal cell carcinoma (BCC), and squamous cell carcinoma (SCC)]. We performed studies using five mainstream network algorithms to classify these diseases in the dataset and compared the results. Then, we performed studies using an independent dataset of the same disease types, but from other body parts, to perform transfer learning on our models. Comparing the performances, the models that used transfer learning achieved a higher average precision and recall for almost all structures. In the test dataset, which included 388 facial

**EPRO
BIOM - 019**

Multi-Classification of Brain Tumor Images Using Deep Neural Network

Brain tumor classification is a crucial task to evaluate the tumors and make a treatment decision according to their classes. There are many imaging techniques used to detect brain tumors. However, MRI is commonly used due to its superior image quality and the fact of relying on no ionizing radiation. Deep learning (DL) is a subfield of machine learning and recently showed a remarkable performance, especially in classification and segmentation problems. In this paper, a DL model based on a convolutional neural network is proposed to classify different brain tumor types using two publicly available datasets. The former one classifies tumors into (meningioma, glioma, and pituitary tumor). The other one differentiates between the three glioma grades (Grade II, Grade III, and Grade IV). The datasets include 233 and 73 patients with a total of 3064 and 516 images on T1-weighted contrast-enhanced images for the first and second datasets, respectively. The proposed network structure achieves a significant performance with the best overall accuracy of 96.13% and 98.7%, respectively, for the two studies. The results indicate the ability of the model for brain tumor multi-classification purposes.

**EPRO
BIOM -020**

Fine-Grained Classification of Cervical Cells Using Morphological and Appearance Based Convolutional Neural Networks

Fine-grained classification of cervical cells into different abnormality levels is of great clinical importance but remains very challenging. Contrary to the traditional classification methods that rely on hand-crafted or engineered features, convolution neural network (CNN) can classify cervical cells based on automatically learned deep features. However, CNN in previous studies does not involve cell morphological information, and it is unknown whether morphological features can be directly modeled by CNN to classify cervical cells. This paper presents a CNN-based method that combines cell image appearance with cell morphology for classification of cervical cells in Pap smear. The training of cervical cell dataset consists of adaptively re-sampled image patches coarsely centered on the nuclei. Several CNN models (AlexNet, GoogLeNet, ResNet, and DenseNet) pre-trained on ImageNet dataset were fine-tuned on the cervical dataset for comparison. The proposed method is evaluated on the Herlev cervical dataset by five-fold cross-validation at patient-level splitting. The results show that by adding cytoplasm and nucleus masks as raw morphological information into appearance-based CNN learning, higher classification accuracies can be achieved in general. Among the four CNN models, GoogLeNet fed with both morphological and appearance information obtains the highest classification accuracies of 94.5%, 71.3%, and 64.5%, for two-class (abnormal versus normal), four-class (“The Bethesda System”), and seven-class (“World Health Organization classification system”) classification tasks, respectively.

**EPRO
BIOM - 021**

A Hierarchical Image Matting Model for Blood Vessel Segmentation in Fundus Images

In this paper, a hierarchical image matting model is proposed to extract blood vessels from fundus images. More specifically, a hierarchical strategy is integrated into the image matting model for blood vessel segmentation. Normally, the matting models require a user specified trimap, which separates the input image into three regions: the foreground, background, and unknown regions. However, creating a user specified trimap is laborious for vessel segmentation tasks. In this paper, we propose a method that first generates trimap automatically by utilizing region features of blood vessels, then applies a hierarchical image matting model to extract the vessel pixels from the unknown regions. The proposed method has low calculation time and outperforms many other state-of-art supervised and unsupervised methods. It achieves a vessel segmentation accuracy of 96.0%, 95.7%, and 95.1% in an average time of 10.72s, 15.74s, and 50.71s on images from three publicly available fundus image datasets DRIVE, STARE, and CHASE_DB1, respectively.

**EPRO
BIOM - 022**

Robust retinal blood vessel segmentation using hybrid active contour model

In the present scenario, retinal image processing is toiling hard to get an efficient algorithm for de-noising and segmenting the blood vessel confined inside the closed curvature boundary. On this ground, this study presents a hybrid active contour model with a novel preprocessing technique to segment the retinal blood vessel in different fundus images. Contour driven black top-hat transformation and phase-based binarisation method have been implemented to preserve the edge and corner details of the vessels. In the proposed work, gradient vector flow (GVF)-based snake and balloon method are combined to achieve better accuracy over different existing active contour models. In the earlier active contour models, the snake cannot enter inside the closed curvature resulting loss of tiny blood vessels. To circumvent this problem, an inflation term $F_{\text{inf(balloon)}}$ with GVF-based snake is incorporated together to achieve the new internal energy of snake for effective vessel segmentation. The evaluation parameters are calculated over four publically available databases: STARE, DRIVE, CHASE, and VAMPIRE. The proposed model outperforms its competitors by calculating a wide range of proven parameters to prove its robustness. The proposed method achieves an accuracy of 0.97 for DRIVE & CHASE and 0.96 for STARE & VAMPIRE datasets.

**EPRO
BIOM - 023**

Multi-objective based radiomic feature selection for lesion malignancy classification

Objective: Accurately classifying the malignancy of lesions detected in a screening scan is critical for reducing false positives. Radiomics holds great potential to differentiate malignant from benign tumors by extracting and analyzing a large number of quantitative image features. Since not all radiomic features contribute to an effective classifying model, selecting an optimal feature subset is critical. **Methods:** This work proposes a new multi-objective based feature selection (MO-FS) algorithm that considers sensitivity and specificity simultaneously as the objective functions during feature selection. For MO-FS, we developed a modified entropy based termination criterion (METC) that stops the algorithm automatically rather than relying on a preset number of generations. We also designed a solution selection methodology for multi-objective learning that uses the evidential reasoning approach (SMOLER) to automatically select the optimal solution from the Pareto-optimal set. Furthermore, we developed an adaptive mutation operation to generate the mutation probability in MO-FS automatically. **Results:** We evaluated the MO-FS for classifying lung nodule malignancy in low-dose CT and breast lesion malignancy in digital breast tomosynthesis. **Conclusion:** The experimental results demonstrated that the feature set selected by MO-FS achieved better classification performance than features selected by other commonly used methods. **Significance:** The proposed method is general and more effective radiomic feature selection strategy.

**EPRO
BIOM - 024**

Discriminative Feature Learning with Foreground Attention for Person Re-identification

The performance of person re-identification (Re-ID) has been seriously effected by the large cross-view appearance variations caused by mutual occlusions and background clutters. Hence learning a feature representation that can adaptively emphasize the foreground persons becomes very critical to solve the person Re-ID problem. In this paper, we propose a simple yet effective foreground attentive neural network (FANN) to learn a discriminative feature representation for person Re-ID, which can adaptively enhance the positive side of foreground and weaken the negative side of background. Specifically, a novel foreground attentive subnetwork is designed to drive the network's attention, in which a decoder network is used to reconstruct the binary mask by using a novel local regression loss function, and an encoder network is regularized by the decoder network to focus its attention on the foreground persons. The resulting feature maps of encoder network are further fed into the body part subnetwork and feature fusion subnetwork to learn discriminative features. Besides, a novel symmetric triplet loss function is introduced to supervise feature learning, in which the intra-class distance is minimized and the inter-class distance is maximized in each triplet unit, simultaneously. Training our FANN in a multi-task learning framework, a discriminative feature representation can be learned to find out the matched reference to each probe among various candidates in the gallery.

Cell classification especially that of white blood cells (WBCs), plays a very important role in the field of diagnosis and control of major diseases. Compared to traditional optical microscopic imaging, hyperspectral imagery, combined with both spatial and spectral information, provides more wealthy information for recognizing cells. In this paper, a novel blood-cell classification framework, which combines a modulated Gabor wavelet and deep convolutional neural network (CNN) kernels, named as MGCNN, is proposed based on medical hyperspectral imaging (MHSI). For each convolutional layer, multi-scale and orientation Gabor operators are taken dot product with initial CNN kernels. The essence is to transform the convolutional kernels into the frequency domain to learn features. By combining characteristics of Gabor wavelets, the features learned by modulated kernels at different frequencies and orientations are more representative and discriminative. Experimental results demonstrate that the proposed model can achieve better classification performance than traditional CNNs and widely-used support vector machine (SVM) approaches, especially as training small-sample-size situations.



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