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Breast Cancer Metastasis Detection and Localization through Transfer-Learning Convolutional Neural Network Classification Based on Convolutional Denoising Autoencoder Stack

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Abstract : Introduction: With the advent of personalized medicine, histopathological review of whole slide images (WSIs) for cancer diagnosis presents an exceedingly time-consuming, complex task. Specifically, detecting metastatic regions in WSIs of sentinel lymph node biopsies necessitates a full-scanned, holistic evaluation of the image. Thus, digital pathology, low-level image manipulation algorithms, and machine learning provide significant advancements in improving the efficiency and accuracy of WSI analysis. Using Camelyon16 data, this paper proposes a deep learning pipeline to automate and ameliorate breast cancer metastasis localization and WSI classification. Methodology: The model broadly follows five stages -region of interest detection, WSI partitioning into image tiles, convolutional neural network (CNN) image-segment classifications, probabilistic mapping of tumor localizations, and further processing for whole WSI classification. Transfer learning is applied to the task, with the implementation of Inception-ResNetV2 - an effective CNN classifier that uses residual connections to enhance feature representation, adding convolved outputs in the inception unit to the proceeding input data. Moreover, in order to augment the performance of the transfer learning CNN, a stack of convolutional denoising autoencoders (CDAE) is applied to produce embeddings that enrich image representation. Through a saliency-detection algorithm, visual training segments are generated, which are then processed through a denoising autoencoder -primarily consisting of convolutional, leaky rectified linear unit, and batch normalization layers- and subsequently a contrast-normalization function. A spatial pyramid pooling algorithm extracts the key features from the processed image, creating a viable feature map for the CNN that minimizes spatial resolution and noise. Results and Conclusion: The simplified and effective architecture of the fine-tuned transfer learning Inception-ResNetV2 network enhanced with the CDAE stack yields state of the art performance in WSI classification and tumor localization, achieving AUC scores of 0.947 and 0.753, respectively. The convolutional feature retention and compilation with the residual connections to inception units synergized with the input denoising algorithm enable the pipeline to serve as an effective, efficient tool in the histopathological review of WSIs.

Keywords : breast cancer, convolutional neural networks, metastasis mapping, whole slide images
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