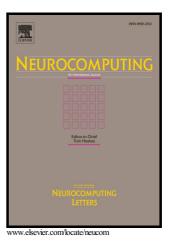
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## Automated grading of breast cancer histopathology using cascaded ensemble with combination of multi-level image features

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## Abstract

We present a novel image-analysis based method for automatically distinguishing low, intermediate, and high grades of breast cancer in digitized histopathology. A multiple level feature set, including pixel-, object-, and semantic-level features derived from convolutional neural networks (CNN), is extracted from 106 hematoxylin and eosin stained breast biopsy tissue studies from 106 women patients. These multi-level features allow not only characterization of cancer morphology, but also extraction of structural and interpretable information within the histopathological images. In this study, an improved hybrid active contour model based segmentation method was used to segment nuclei from the images. The semantic-level features were extracted by a CNN approach, which described the proportions of nuclei belonging to the different grades, in conjunction with pixel-level (texture) and object-level (architecture) features, to create an integrated set of image attributes that can potentially outperform either subtype of features individually. We utilized a cascaded approach to train multiple support vector machine (SVM) classifiers using combinations of feature subtypes to enable the possibility of maximizing the performance by leveraging different feature

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