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Automated segmentation of nucleus, cytoplasm, and background of pap-smear images using a trainable pixel level classifier

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Background: Cervical cancer ranks as the fourth most prevalent cancer affecting women worldwide and its early detection provides the opportunity to help save a life. Automated diagnosis and classification of cervical cancer from pap-smear images has become a necessity as it enables accurate, reliable and timely analysis of the condition's progress. Segmentation is a fundamental aspect of enabling successful automated pap-smear image analysis. In this paper, a potent algorithm for segmentation of the pap-smear image into the nucleus, cytoplasm, and background using pixel level information is proposed.

Methods: First, a number of pixels from the nuclei, cytoplasm, and background are extracted from five hundred images. Second, the selected pixels are trained using noise reduction, edge detection, and texture filters to produce a pixel level classifier. Third, the pixel level classifier is validated using test set and 5- fold cross validation using Fast Random Forest, Naïve Bayes, and J48 classification techniques.

Results: An extensive evaluation of the algorithm and comparison with the benchmark ground truth measurements shows promising results. Comparison of the segmented images' nucleus and cytoplasm parameters (nucleus area, longest diameter, roundness, perimeter and cytoplasm area, longest diameter, roundness, perimeter) with the ground truth segmented image feature parameters (nucleus area, longest diameter, roundness, perimeter and cytoplasm area, longest diameter, roundness, perimeter) yielded average errors of 0.94, 0.93, 0.02, 0.63, 0.96, 0.37, 0.13 and 0.96mm respectively. Validation of the proposed pixel level classifier with 5-fold cross-validation yielded a classification accuracy of 98.48%, 94.25% and 98.45% using Fast Random Forest, Naïve Bayes, and J48 classification methods respectively. Finally, validation with a test dataset yielded a classification accuracy of 98.48% and 98.98% using Fast Random Forest and J48 Classification methods respectively.

Conclusion: This paper articulates a potent approach to the segmentation of cervical cells into the nucleus, cytoplasm, and background using pixel level information. The experimental results show that the approach gives good classification and achieves a pixel classification average accuracy of 98%. The method serves as a basis for first level segmentation of pap-smear images for diagnosis and classification of cervical cancer from pap-smear images using nucleus and cytoplasm pixel level information.

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