

## An automated machine vision system for the histological grading of cervical intraepithelial neoplasia (CIN)

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### Abstract

The histological grading of cervical intraepithelial neoplasia (CIN) remains subjective, resulting in inter- and intra-observer variation and poor reproducibility in the grading of cervical lesions. This study has attempted to develop an objective grading system using automated machine vision. The architectural features of cervical squamous epithelium are quantitatively analysed using a combination of computerized digital image processing and Delaunay triangulation analysis; 230 images digitally captured from cases previously classified by a gynaecological pathologist included normal cervical squamous epithelium (n=30), koilocytosis (n=46), CIN 1 (n=52), CIN 2 (n=56), and CIN 3 (n=46). Intra- and inter-observer variation had kappa values of 0.502 and 0.415, respectively. A machine vision system was developed in KS400 macro programming language to segment and mark the centres of all nuclei within the epithelium. By object-oriented analysis of image components, the positional information of nuclei was used to construct a Delaunay triangulation mesh. Each mesh was analysed to compute triangle dimensions including the mean triangle area, the mean triangle edge length, and the number of triangles per unit area, giving an individual quantitative profile of measurements for each case. Discriminant analysis of the geometric data revealed the significant discriminatory variables from which a classification score was derived. The scoring system distinguished between normal and CIN 3 in 98.7% of cases and between koilocytosis and CIN 1 in 76.5% of cases, but only 62.3% of the CIN cases were classified into the correct group, with the CIN 2 group showing the highest rate of misclassification. Graphical plots of triangulation data demonstrated the continuum of morphological change from normal squamous epithelium to the highest grade of CIN, with overlapping of the groups originally defined by the pathologists. This study shows that automated location of nuclei in cervical biopsies using computerized image analysis is possible. Analysis of positional information enables quantitative evaluation of architectural features in CIN using Delaunay triangulation meshes, which is effective in the objective classification of CIN. This demonstrates the future potential of automated machine vision systems in diagnostic histopathology.

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