Investigation of discriminant analysis methods for the diagnosis of basal cell carcinoma

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Abstract: The aim of this study was to compare two classification methods for analyzing Elastic Scattering Spectroscopy (ESS) data correlated with histopathology of skin tissues to see if these techniques could be used as an adjunct or alternative to histopathology in identifying basal cell carcinoma (BCC).
By using a linear discriminant analysis, a sensitivity of 88% and a specificity of 74% were obtained; using support vector machine also gave promising results especially when the training data set is relatively small. These results are encouraging and could suggest that BCC's can be distinguished from normal skin using ESS. Future work will assess whether the same technique can be used to distinguish between BCC's and other benign skin conditions or between malignant melanomas and benign pigmented lesions.
To prove the usefulness of the ESS in dysplasia detection in skin tissues conclusively, a larger body of data is needed. We aim to continue this study to obtain more data in an attempt to increase the accuracy of the technique.

Elastic Scattering Spectroscopy (ESS) is an emerging technique that generates an optical spectrum that depends on structural and morphological features within tissues. In ESS, white light enters from an optical fibre placed in contact with the tissue to be investigated, the incident light then undergoes single, or more commonly, multiple scattering events before being collected by an optical fibre that is close to the delivery fibre; the acquired data reflects both the scattering and absorptive properties of that tissue The structures that induce the scattering (collectively known as scattering centres) are the nucleus, and sub-cellular organelles; other scattering centres include structural proteins, lipids and erythrocytes. Absorption is determined by the chromatin concentrations present. The ESS system has been described in previous publications [1-[3].

Basal cell carcinoma is the most common malignancy in humans. It typically occurs in areas of chronic sun exposure. BCC is usually slow growing and rarely metastasizes, but it can cause clinically significant local destruction and disfigurement if neglected or treated inadequately. Our study is on fifty-nine skin sites from 21 patients, 20 males, 1 female, (mean age 54 years, range 30-75 years) who presented with suspected basal cell carcinoma (BCC). Surgical biopsies were acquired from each of the examination sites and histopathology showed that all 59 sites were positive for BCC; several spectra were collected at each site, 551 from normal skin sites, 570 from BCC sites. The acquired spectra were then correlated with histopathology.

Figure 1 shows the spectra collected from BCC's and regions of normal skin, the means of the two are different, but due to the large standard deviations, the two groups overlap, which makes it difficult to discriminate between the two groups under the original axes.

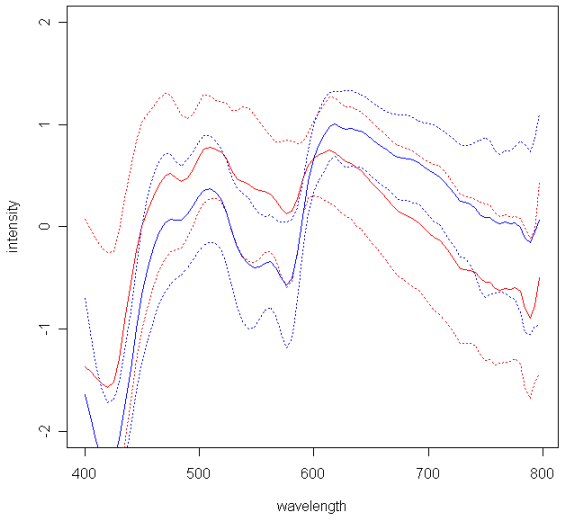

Figure 1 A representative plot of the mean BCC (blue solid line) and normal spectra (red solid line), with one standard deviation plotted either side of the mean (dashed lines)

We compared two methods of analysing this data to see which discriminated best between spectra from normal tissue and BCC's: linear discriminant analysis, which maximizes the ratio of the between-class distance to the within-class distance and support vector machine, which maximizes the margin between the two data sets. Figure 2 shows the ROC curve of the analysis results by using linear discriminant analysis.

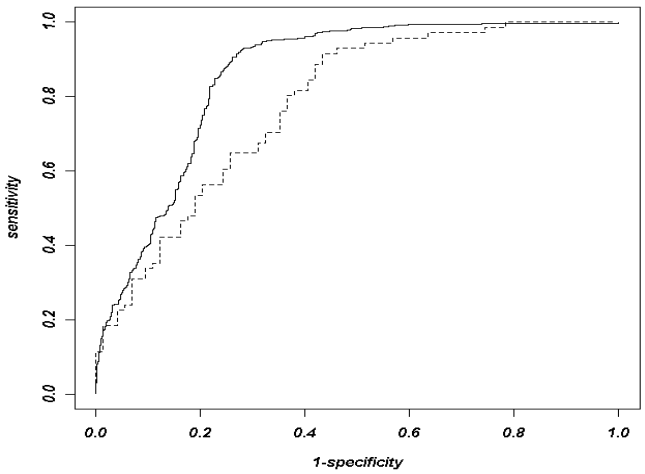

Figure 2 ROC curve of the analysis using linear discriminant analysis, results for each spectrum (solid lines), results for each site (dashed lines)

The result for the Support vector machine is also promising. The above optical diagnostic technique is a quick and accurate way of examining tissue. The accuracy found in many of our previous studies, suggests that it can provide cost effective, real-time and in situ diagnosis. The analysis can be varied to achieve higher specificity or higher sensitivity, depending on the clinical situation. If the aim is to identify high risk sites for taking a conventional biopsy to make a definitive diagnosis, then the analysis is tuned for maximum sensitivity. If treatment is to be based just on the optical diagnosis, then the analysis can be tuned for maximum specificity.

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