Handheld device for early diagnosis of skin cancer

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Abstract. Prevention and early diagnosis of melanoma and non-melanoma skin cancers (NMSCs) are key to reducing the harm caused by exposure to the high levels and forms of UV radiation in New Zealand. This project aims to develop a handheld device with a unique design that utilizes detailed molecular fingerprinting, by combining sensitive Raman spectroscopy with a wide range of classification methods.

Introduction

Raman spectroscopy is unparalleled in the rich information it is able to provide on the molecular composition of even complex materials, in situ, rapidly and non-destructively (Bakker et al., 2002, Edwards et al., 1995). Rapid advancements in semiconductor materials and fabrication technologies continue to provide small high powered lasers, fibre optics and more compact yet sensitive instruments that can be used at point of care or collection to screen for adulteration of foods (Nieuwoudt et al, 2016), or to detect residual cancer cells using surface enhancement during brain surgery (Karabeber et al., 2011).

As a non-invasive surface technique, Raman spectroscopy lends itself to analysis of different skin conditions, such as malignant melanoma and non-melanoma skin cancers. The gold standard for confirming the presence of malignant melanoma is histology, which is both time consuming and expensive.

Much research has been invested in the feasibility of Raman spectroscopy for differentiating malignant melanomas and non-melanoma skin cancers. Differences were observed in spectra of non-melanoma pigmented lesions and malignant melanomas, particularly for lipids between 1310 and 1340 cm^{-1} selected amino acids between 830 and 850 cm^{-1} and for proteins between 1500 and 1800 cm^{-1} that allowed differentiation of these lesions (Lim et al., 2014). Three separate studies found that basal cell carcinomas (BCC) and malignant melanomas also displayed differences in their bands in these regions as well as the 3250 cm^{-1} band of the O-H stretching mode of water (Philipsen et al., 2013, Lim et al., 2014, Kourkoumelis et al., 2015). Further differences in the spectra of BCC and SCC (cutaneous squamous cell carcinomas) lesions were observed in the collagen bands between 920 and 940 cm^{-1}, phenylalanine and keratin bands between 1000 and 1010 cm^{-1}, and in the lipid and protein bands between 1060 and 1070 cm^{-1}, 1250 and 1330 cm^{-1} and 1445 cm^{-1} and 1650 cm^{-1} (Lieber et al., 2008).

These studies developed classification models using either band ratios (Philipsen et al., 2013) or multivariate statistical methods such as PCA-DA (principal component analysis discriminant analysis), PLS-DA (partial least squares discriminant analysis)(Silveira et al., 2015) or NN (neural networks)(Eijke et al., 2005).

These studies were performed using benchtop research grade spectrometers, and achieved sensitivity for distinguishing malignant melanoma from benign pigmented lesions ranged from 68 to 100%, and specificity from 45 – 100 %, however, the high sensitivities and specificities here were obtained on only 29 lesions (Lim et al., 2008).

We aim to develop a portable, handheld and self-contained Raman device that that can be used by doctors and clinicians to diagnose skin lesions accurately and rapidly with high sensitivity and high specificity. To achieve this we will build robust classification models by including benign naevi, melanoma, basal cell carcinoma, squamous cell carcinoma and inflammatory dermatoses that can mimic malignant lesions and by employing a diverse range of classification methods.

Initial results and Summary

Spectra of three similar benign naevi from three different participants are shown in Figure 1.
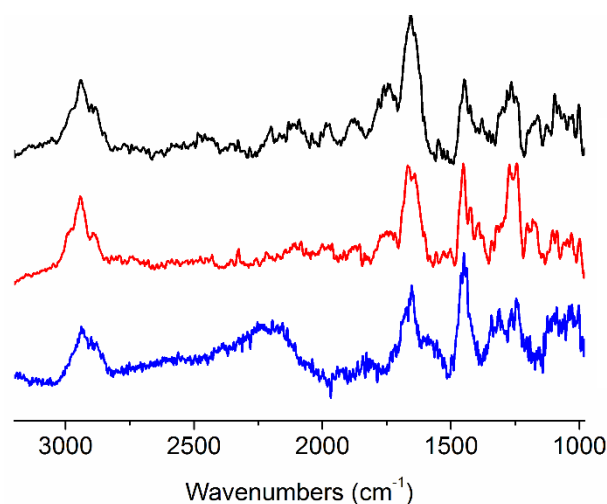
Figure 1. Raman spectra recorded in vivo of three different benign naevi.

While the spectra all show bands characteristic of the protein and lipid components of skin tissue, they also show significant differences. This shows the importance of

developing a spectral database that incorporates a large number and adequate range of benign samples.

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