**Retinal Optical Density Maps**

530  570  590  610

Superior temporal vein

**Arterial (red) regions of interest selected at the optic disc from all**

**improvement in the visual acuity to 6/24.**

This indicates an improved metabolic activity in the retina which corresponds with an improvement in the amount of oxygenated blood within the retinal arteries associated with a change in the oxygenation of the endmember. Linear spectral unmixing, performed in ENVI 4.1 (ITT Visual Information Solutions), incorporating these two endmembers was used to produce a qualitative abundance map of oxygenated blood in the retina.

**Oxygenated blood in the retinal arteries (pale red/white) and an increase in oxygenated blood in the superior retinal veins.**

**A***

**Figure 5. Oximetric maps of an 81 year old female with a right retinal vasculitic arteriopathy secondary to giant cell arteritis.**

**Inferior temporal artery Inferior temporal vein**

**Figure 7. A 64 year old female with a left supero-temporal Branch Retinal Vein Occlusion with localised retinal ischaemia.**

**Figure 6. A 76 year old male with advanced POAG.**

**CONCLUSIONS**

Hyperoxic imaging is capable of selecting oximetric changes in the retina and monitoring its response to treatment. However, the sequential technique of capturing retinal images described here is highly dependent on other factors such as the quality of the retinal digital camera and the retinal vasculature. This will change in the near future with the application of our co-registration algorithms and the development of a "robust" spectral retinal camera.

Linear spectral unmixing offers a powerful and visually useful method of producing semi-quantitative oximetric maps of the retina, but to increase the effectiveness in detecting changes caused by diabetic retinopathy and early glaucoma using hyperspectral imaging and spectral analysis techniques.

**METHODS**

A hyperspectral retinal imaging system consisting of a modified commercial fundus camera, a liquid crystal tuneable filter and a low noise CCD detector (figure 1) was used to capture sequential hyperspectral images of the retina. A hyperspectral data cube with a spectral bandwidth of 500nm to 700nm and a spectral resolution of 10nm at each wavelength was formed for each subject. Normal subjects (n = 11) were examined and compared to subjects with retinal retinal oximetry (n = 3), retinal vasculopathy (n = 6) and glaucoma using hyperspectral imaging and spectral analysis techniques.

Pre-processing algorithms were used to dark calibrate and co-register the raw retinal images. A further image processing algorithm produced a reflectance optical density map of the retina for each wavelength (figure 2).

Linear spectral unmixing is used in spectral imaging to determine the relative abundance of materials (endmembers) in each pixel of a scene through the analysis of their spectral characteristics. An example spectral profile of the arteries in the optic disc were calculated from all normal eyes (figure 2). This spectral profile was used to represent a pure endmember. Linear spectral unmixing, performed in ENVI 4.1 (ITT Visual Information Solutions), incorporating these two endmembers was used to produce a qualitative abundance map of oxygenated blood in the retina.

**Figure 1. Schematic arrangement of the Hyperspectral Retinal Camera.**

**Figure 2. Oximetric retinal maps from a selection of normal subjects.**

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**RESULTS**

Linear spectral unmixing produced consistent oximetric maps of the retina in normal subjects (figure 4) where oxygenated blood (red) has been identified within the arteries and arterioles. In subjects with retinal vasculopathy and advanced POAG, this technique was able to detect changes in the oximetric status of the retinal circulation (figure 5) using hyperspectral imaging and spectral analysis techniques.

**Figure 5. Linear spectral unmixing methods.**

**Figure 6. Schematic oximetric maps from ex-vivo samples of normal retina.**

**Oximetric retinal images.**

**Figure 7. Oximetric maps of the retina shows an increased oxygenation in the venous circulation of the right retina compared to the left.**

**Figure 4. Oximetric retinal maps from a selection of normal subjects.**

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