Multispectral Fundus Analysis

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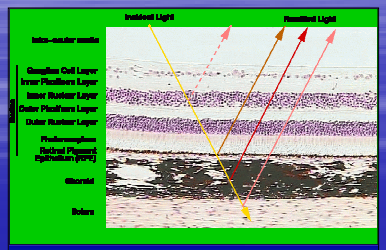
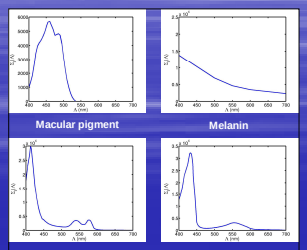
Purpose

To generate a reflectance model of the fundus that allows an accurate non-invasive quantification of blood and pigments.



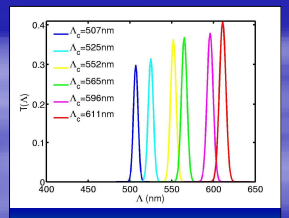
Cross-section of the ocular fundus showing the structure of the tissue and the reflectance from the various layers



Specific Absorption Coefficient Curves

Methods

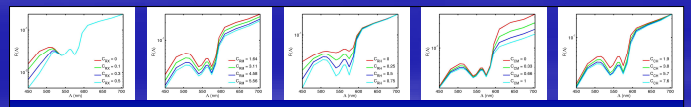
A Monte Carlo simulation was used to produce a mathematical model of light interaction with the fundus at different wavelengths. The model predictions were compared with fundus images from normal volunteers in several spectral bands (peaks at 507, 525, 552, 585, 596 and 611nm). The model was then used to calculate the concentration and distribution of the known absorbing components of the fundus.



Optimal filters for parameter recovery

Pigment	*Concentration (mmol/L)*
Macular Pigment	0.0, 0.1, 0.20, 0.3, 0.4, 0.5, 0.6
RPE Melanin	1.64, 3.11, 4.58, 5.56, 6.54, 8.00
Retinal Haemoglobin	0.0, 0.25, 0.50, 0.75, 1.00, 1.25
Choroidal Melanin	0.00, 0.33, 0.66, 1.00, 1.33, 1.66
Choroidal Haemoglobin	1.90, 3.80, 5.70, 7.60, 8.50

Parameter values used in the Monte Carlo Simulation

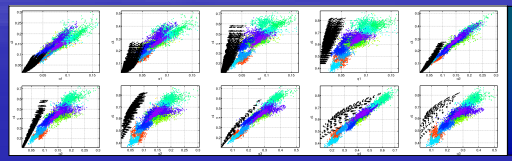


Calculated variation of fundus reflectance with changes in Macular Pigment, RPE Melanin, Retinal Haemoglobins, Choroidal Melanin, and Choroidal Haemoglobins respectively, maintaining other four parameters constant

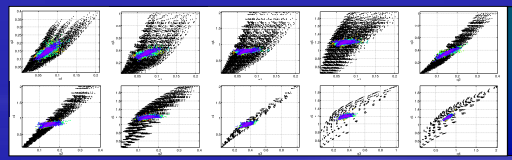
Results

The shape of the statistical distribution of the image data generally corresponded to that of the model data; the model however appears to overestimate the reflectance of the fundus in the longer wavelength region.

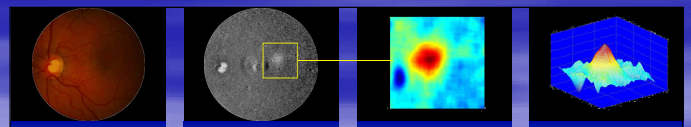
As the absorption by Macular Pigment has no significant effect on light transport above 534nm, its distribution in the fundus was quantified: the wavelengths where both shape and distribution of image and model data matched (<553nm) were used to train a neural network which was then applied to every point in the image data. The Macular Pigment distribution thus found was in agreement with published literature data in normal subjects.



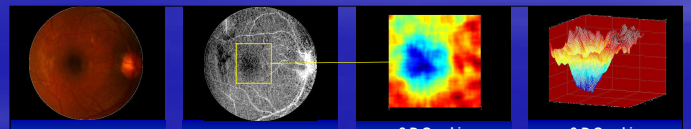
PROJECTIONS OF MODEL (BLACK) VERSUS NORMAL DATA (COLOUR)



MODIFIED PROJECTIONS OF MODEL (BLACK) VERSUS NORMAL DATA (COLOUR)



MACULAR PIGMENT RECOVERY



RETINAL BLOOD RECOVERY

Conclusions

We have developed a method for optimising multi-spectral imaging of the fundus and a computer image analysis capable of estimating information about the structure and properties of the fundus.

The technique successfully calculates the distribution of Macular Pigment in the fundus of healthy volunteers. Further improvement of the model is required to allow the deduction of other parameters from images; investigations in known pathology models are also necessary to establish if this method is of clinical use in detecting early chroido-retinopathies, hence providing a useful screening and diagnostic tool.

POTENTIAL CLINICAL IMPACT

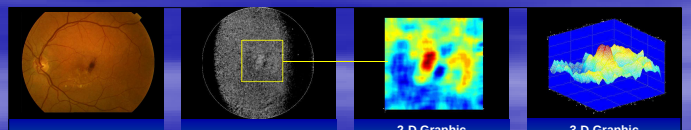
Macular Pigment Quantity and Distribution
- Age-Related Macular Degeneration Risk
- Diet Supplement Efficacy

▲Retinal Blood
- Haemorrhages (Diabetic Retinopathy, etc)

▼Retinal Blood
- Ischaemia (Diabetic Macular Ischaemia, Ischaemic CRVO)

▲Choroidal Blood
- Choroidal Neovascular Membrane

▼Choroidal Blood
- Choroidal Infarcts



MACULAR HAEMORRHAGE RECOVERY

FUTURE DEVELOPMENT

Equipment → Software → Model → Pathology → Diagnosis and Screening

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