Optical Density Measurement of Macular Pigment

A. Budai[1A], J. Hornegger[1A], G. Michelson[1B], R.P. Tornow[B]

[1]Erlangen Graduate School in Advanced Optical Technologies (SAOT), [A]Pattern Recognition Lab, Department of Computer Science, [B]Department of Ophthalmology
University of Erlangen-Nuremberg, Erlangen, Germany
attila.budai@informatik.uni-erlangen.de

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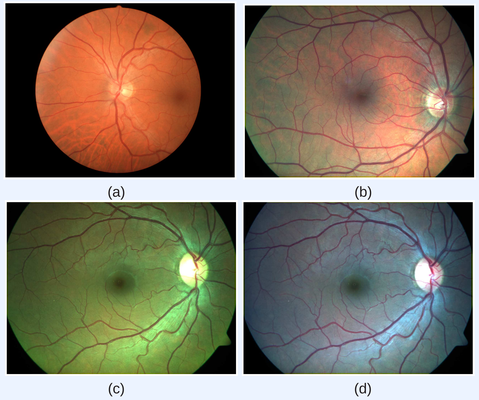
Purpose

Our purpose is to develop a new method to measure the optical density of macular pigments using fundus images to aid medical diagnosis.

Methods

1. Input Images

- Fundus images taken using a **spectral filtered illumination light**
- Ensure equally illuminated colour channels [1]



(a) (b) (c) (d)

Figure 1: Examples for common Fundus images (a) and images with different spectral filter settings (b)-(d)

2. Preprocessing

- Refraction differences of different wavelengths
- Blue channel of fundus images have a different scale Usually it is not visible, due to the under-illuminated channel.
- Compensated by a **rigid registration of the colour channels**.
- A region of interest (ROI) is selected manually.

3. Calculating an Optical Density Image

For each pixel in the ROI the optical density [1] [2] is calculated by the following formula:

$$ODMP(x,y) = -log\left(N * \frac{I_{blue}(x,y)}{I_{green}(x,y)}\right)$$

$$N = \frac{I_{green}(reference)}{I_{blue}(reference)}$$

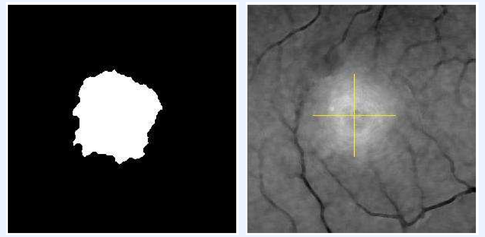
- N is a normalization factor
- I_{blue} and I_{green} are the intensities of the given channels of the given pixels
- Reference pixels are non-vessel pixels in 6 degree distance from the center of the selected macula region

(a) (b)

Figure 2: input image (a) with selected ROI(white) and the reference pixels (red), and the calculated density image (b)

4. Detection of Macula Center

- **Thresholding** is used to segment all the pixels above 25% of the global maximum
- Center of gravity of the segmented peak is calculated



(a) (b)

Figure 3: Segmented peak region (a) and the calculated center of the peak (b)

5. Generating Density Profile

- Mean density of the macular pigment is calculated in increasing distances from the calculated center
- The measures are visualized as a function of distance [3]
- If distance is less than 1.0 degree the absorbtion of photopigments change the measurements
- This effect can be avoided by a 1-2 minutes long preparation

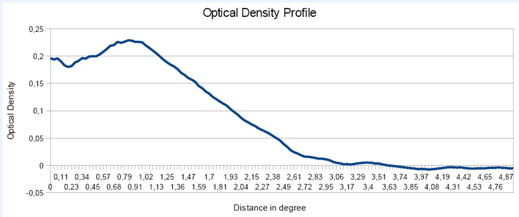
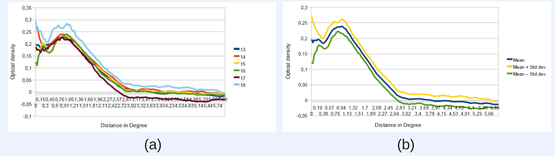


Figure 4: An example of density profiles

Results

Comparison of six different images of the same eye with varying illumination light intensity to test the reliability. Correlation between the curves was over 0.995 in each case.



(a) (b)

Figure 5: Six measures (a), and their mean with standard deviations (b)

Conclusion

A fast and reliable method is presented to measure the macular pigment density using fundus images as input. The proposed method is able to extract information from the fundus images, which was only available by using modified Heidelberg Retina Angiography (HRA) devides or multispectral image series.

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Commerical Relationship

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References

[1] R. P. Tornow *et al.*: Quantitativ Imaging Using a Fundus Camera in: ARVO Annual Meeting 2007, program No.: 1206 poster No. B110.

[2] Lo J. bour *et al.*: Fundus Photography Measurement of Macular Pigment Density Distribution in Children, in: Investigate Ophthalmology & Visual Science, May 2002, Vol 43, No. 5, pages 1450-1455.

[3] Tos T. J. M. Berendschot *et al.*: Macular Pigment Shows Ringlike Structures in: Investigate Ophthalmology & Visual Science, February 2006, Vol 47, No. 2, pages 709-714.