Optical Density Measurement of Macular Pigment

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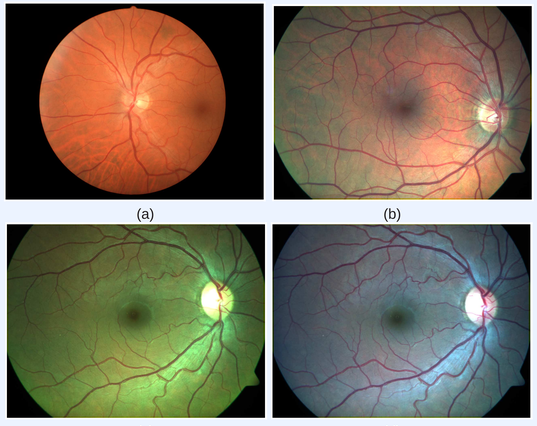
Purpose

To develop an automatic method to measure the optical density of macular pigments using filtered fundus images for clinical application

Methods

1. Input Images

- Fundus images acquired by a Zeiss fundus camera (FF450) and a **special 3-band-filter**
- The filter ensures equally illuminated colour channels [1][2]



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

Figure 1: Examples for common fundus image (a) and images with different camera settings (b)-(d).

2. Preprocessing

- **Registration of colour channels** to compensate scaling due to refraction differences
- Vessel segmentation is used to exclude the vessels from the analysis
- The macula is marked manually to determine the region of interest (ROI)

3. Calculation of Optical Density of Macular Pigment (ODMP)

For each pixel in the ROI the optical density [1, 3] is calculated by the following formula:

$$ODMP(x,y) = -log\left(N * \frac{I_{blue}(x,y)}{I_{green}(x,y)}\right) \quad (1)$$

$$N = \frac{I_{green}(reference)}{I_{blue}(reference)} \quad (2)$$

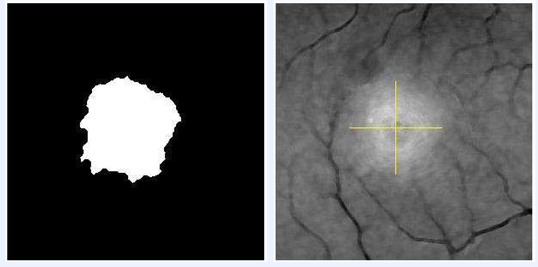
- N is a normalization factor
- I_{blue} and I_{green} are the intensities of the blue and green colour channels
- Reference pixels are non-vessel pixels in 6° (visual angle) distance from the center of the selected macula region

(a) (b)

Figure 2: Input image (a) with selected ROI (white), 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 [4]
- In images taken for the development of this algorithm the photopigment was not fully bleached

Results

Comparison of 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.

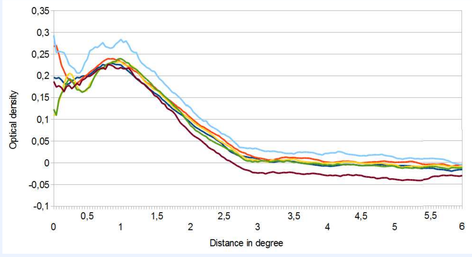


Figure 4: Optical density profiles measurements of the same macula with varying illumination light intensity. The pigment density decreases with the increasing distance from the center of the macula

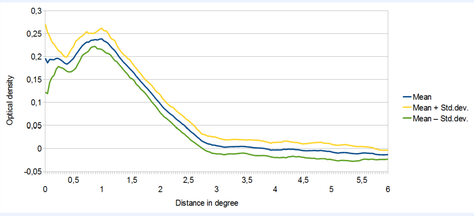


Figure 5: Mean value and standard deviation of the previous measurements

Conclusion

A fast and reliable automatic method is presented to **measure the macular pigment density using fundus images** as input. The proposed method is able to extract information from fundus images, which was only available by using modified Heidelberg Retina Angiography (HRA) devices or multispectral image series [5]

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Commercial Relationship

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