

Graduation Project

Eye Accommodation Analysis in Presbyopia from MR Imaging

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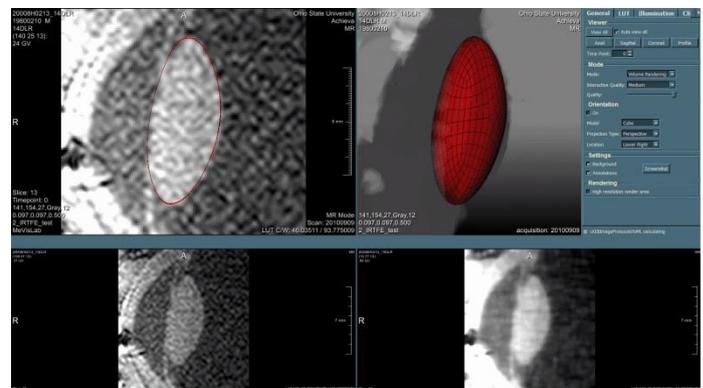
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Background: Presbyopia is a common condition in which the eye lens cannot accommodate anymore and is generally associated with age. Conventional imaging techniques in ophthalmology use light to visualise the internal structures of the eye, but fail to give adequate data for this condition as the iris blocks the view of most of the eye lens and of the ciliary body, the muscle which is responsible for the accommodation.

Magnetic Resonance Imaging (MRI) is not limited by the opaqueness of tissues and can therefore image the complete eye. MRI is, however, susceptible to eye-motion which makes the acquisition of high resolution images challenging. Eye blinks, for example, naturally occur every 5 to 8 seconds. One of the approaches is to acquire a full 3D image within these 5 seconds. These images, however, have a very low signal-to-noise (SNR). One of the potential solutions would be to acquire these scans multiple times and average them to increase the SNR. This is, however, not a trivial task because of the rotational degrees of freedom of the eye.

In a 2013 studyⁱ, Richdale *et al.*, used this method to measure the lens thickness as a function of accommodation in a group of 26 subjects of different age. She acquired 3D MR-images of while the subject was asked to look at a fixation targets at different distances, to let the subject accommodate. Each measurement was performed at least 8 times because of the low SNR of the individual measurements. The subjects furthermore received an extensive ophthalmic evaluation during which their ability to accommodate was measured.

As they did not have the means to register or segment the MR-data, only the lens thickness was manually measured on the images. These measurements showed a correlation between the subjects' ability to accommodate and the measured increase in lens thickness.



Pilot segmentation of the eye-lens on of the low SNR MR-images

Purpose: Within this project we aim to get more and quantitative data from these MR-images, to get a better understanding on the origin of the lack of accommodative response from the older subject.

Proposed methodology:

1. Register the different acquisitions onto each other to produce images with sufficient SNR for subsequent segmentation and analysis. For a successful completion of this step, a method to correct for eye-rotations needs to be designed.
2. (Semi-)automatic segmentation of the key anatomical elements of the eye: lens, ciliary body and retina.
3. A mathematical description of the shape of the ciliary body and lens

Envisioned results: Next to the image processing methods, which already are novel on its own, the final description of the ciliary body and lens, as a function of the different refractive states, will be the main results of this project. These measurements will be compared to the ophthalmic measures to get a better understanding of the origin of presbyopia. One of the key outcomes would be to know whether the ciliary bodies still contracts when the lens fails to accommodate, as this would open up different possibilities for treatment, such as accommodating intra-ocular lenses. Depending on the speed of the project, it would furthermore be very interesting to put the descriptions of the lens shape into our optical models, to assess whether the shape change alone is sufficient to explain the measured change in refractive power.

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ⁱ Richdale et al. "Quantification of Age-Related and per Diopter Accommodative Changes of the Lens and Ciliary Muscle in the Emmetropic Human Eye" *Invest Ophthalmol Vis Sci*. 2013 Feb; 54(2): 1095–1105.