Optimisation of a Fundus Imaging Module for Real-Time Retinal Tracking

Degree programme: BSc in Micro- and Medical Technology
Specialisation: Optics and Photonics
Thesis advisors: Prof. Christoph Meier, Jeremy Elia Lane Schori, Oskar Ambühl
Expert: Dr. Christian Burri (Meridian AG)
Industrial partner: Meridian Medical AG, Thun

This project presents a fundus imaging module that has been optimised for integration into a device for Selective Retina Therapy (SRT). The module is being developed for treatment planning and safety purposes. It is designed to accurately align the treatment laser with retinal structures by continuously monitoring and compensating for eye movements during therapy.

Introduction

Traditional retinal laser treatment as well as novel concepts such as SRT may benefit of tracking eye movements in real-time for safety purposes. Therefore, a new illumination set-up was developed and tested on several subjects, for high-contrast imaging of the fundus, with the aim of capturing cost-effective images sufficient for real-time monitoring. The tracking of retinal structure intends to allow for treatment planning and improve the overal safety by detecting eye movements.

Methods

An existing prototype was further developed to capture fundus images with a 30-35° field of view (FOV) and high image quality.the new illumination set-up uses ring-shaped infrared illumination (940 nm) with LEDs to evenly illuminate the retina. To minimise reflections from the cornea, the module is built to be polarization-sensitive. A cost-effective CMOS-based industrial camera is used for imaging. The ring-shaped illumination is tested and evaluated on an artificial eye. Optical simulations and adjustments were performed using OpticStudio (ZEMAX). In addition, various lens elements were integrated into the system and tested on a volunteer.

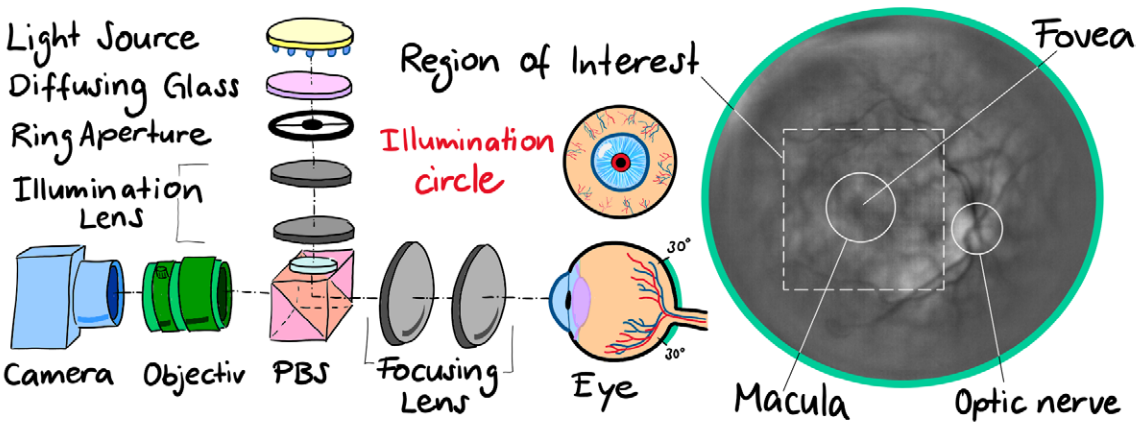
Results

The system provides a stable view of the retina with a field of view of approximately 55°. Tests show that the highest image quality was achieved with ring-shaped infrared illumination and an objective lens (focal length 25 mm) in front of the camera. Simulations in ZEMAX suggest that a lens with a focal length of 28 mm would improve the module even further.

Pascal Oberhänsli
pascal.oberhaensli@gawnet.ch

Conclusion and Outlook

This project demonstrates that fundus images can be captured using simple hardware and an inexpensive camera. The results show that the new lighting system delivers higher-contrast images. Simulations suggest that further adjustments to the prototype could improve imaging.
In future work, the captured images will be processed in MATLAB, Python or C++. Efficient filtering algorithms will be applied to enhance the contrast of blood vessels, providing optimal conditions for real-time tracking.



Sketch of the fundus imaging module. A polarising beam splitter (PBS) couples the illumination into the horizontal observation path. On the right is a fundus image with a FOV of approximately 60°.