Miniaturized Ubiquitous Scanning Laser Ophthalmoscope

Helene Strese[1], Oliver Gubler[1], Francois Corthay[1], Serge Amoos[1], Frederic Truffer[1], Nuria Pazos Escuerdo[2], Francois Tieche[2], Julien Senn[2], Martial Geiser[1]

University of Applied Sciences and Arts Western Switzerland
([1]HES-SO Valais-Wallis Sion Switzerland, [2]HE Arc Neuchâtel Berne Jura Switzerland)

Objective

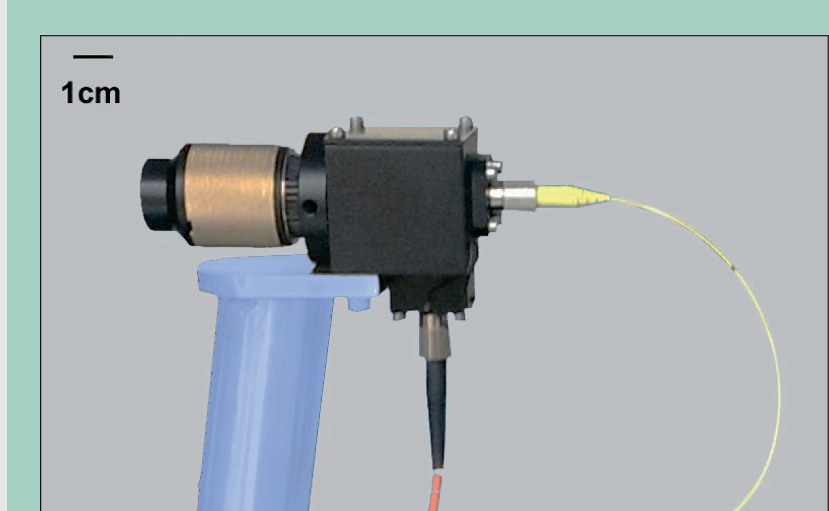
The aim of the project was to demonstrate the feasibility of a cheap miniaturized laser scanning ophthalmoscope (SLO) based on micro-electro-mechanical-system (MEMS) scanning mirrors, which is versatile, portable and capable of 3D measurements of different structures of the fundus, including the optic nerve head (ONH). Such a device could be used by ophthalmologists, but also in general medical practice by trained medical staff (optometrists, nurses and opticians) for glaucoma screenings.

Motivation

To reduce the prevalence of blindness, the detection of eye diseases, like glaucoma, is very important. Glaucoma screenings are held regularly in all European countries, in order to diagnose a disease in a curable stage. Screenings are performed by paramedical staff and captured images of the ONH can be interpreted remotely by medical doctors, to decide on further examinations. For that kind of imaging one of the main diagnostic imaging methods is the SLO. Current goals are also to make the use and handling of these systems as convenient and easy as possible, while maintaining lower costs of the device components.

Conclusion

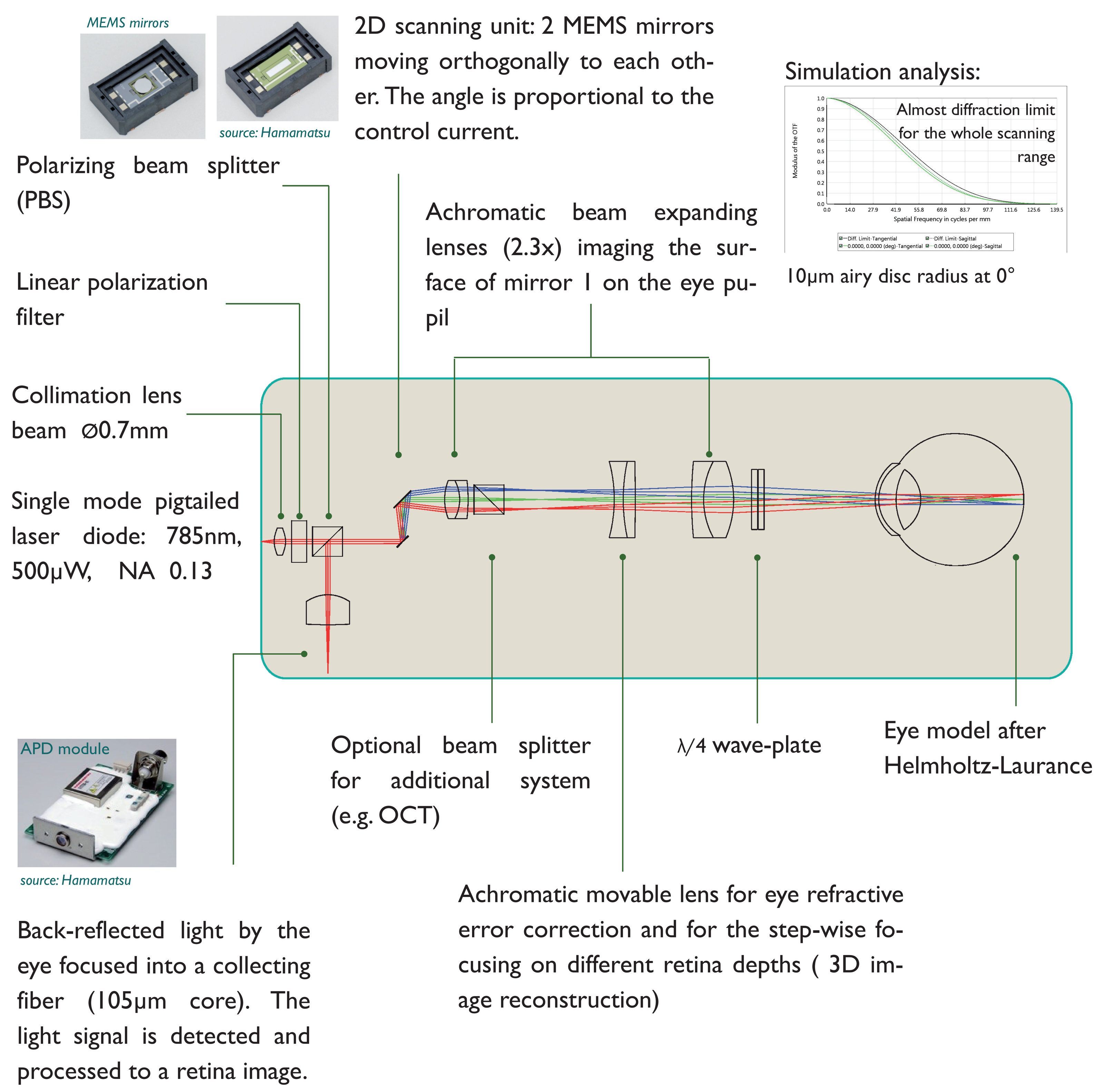
We designed a miniaturized SLO, based on two MEMS mirrors. The imaging device has dimensions of 88 x 48 x 35mm^3. According to the optical simulation, the system is capable to scan a retina excerpt of 1.8mm by 1.8mm by operating the MEMS mirrors at a scanning angle of ±3.5° (in air).



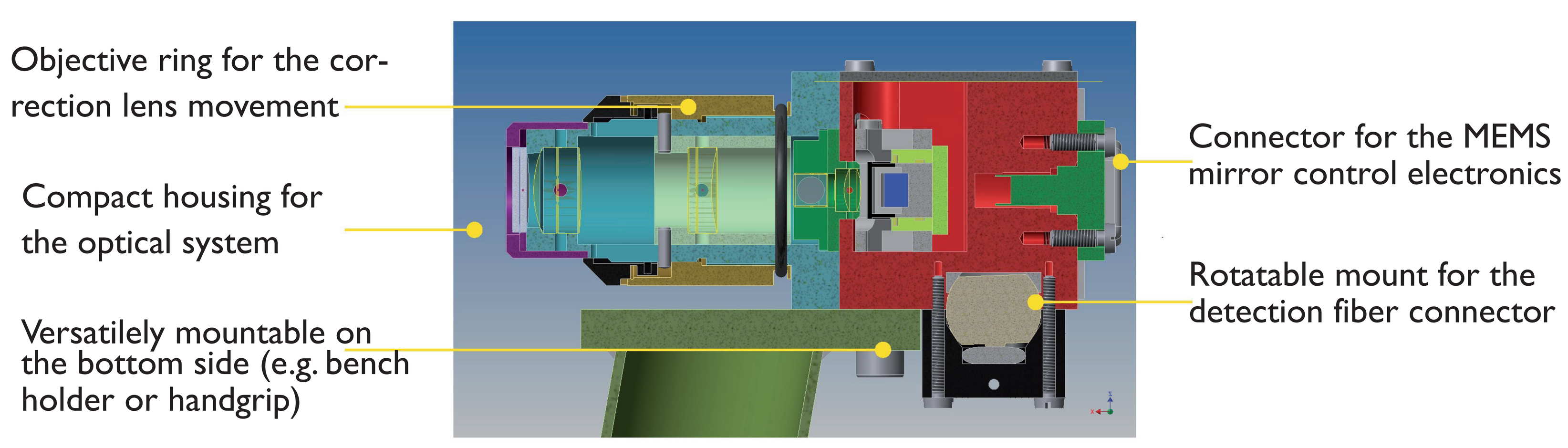
A frame rate of up to 4Hz and a sampling rate of 192kHz can be achieved. The feasibility was proven by imaging checkerboard resolution targets through a lens. Further, with an adjustable lens, possible refractive errors (-2.6 to +1.5dpt) of the subject can be corrected and retinal layers of different depths can be captured, to build a 3D image.

System Development

1) Principle and optical design

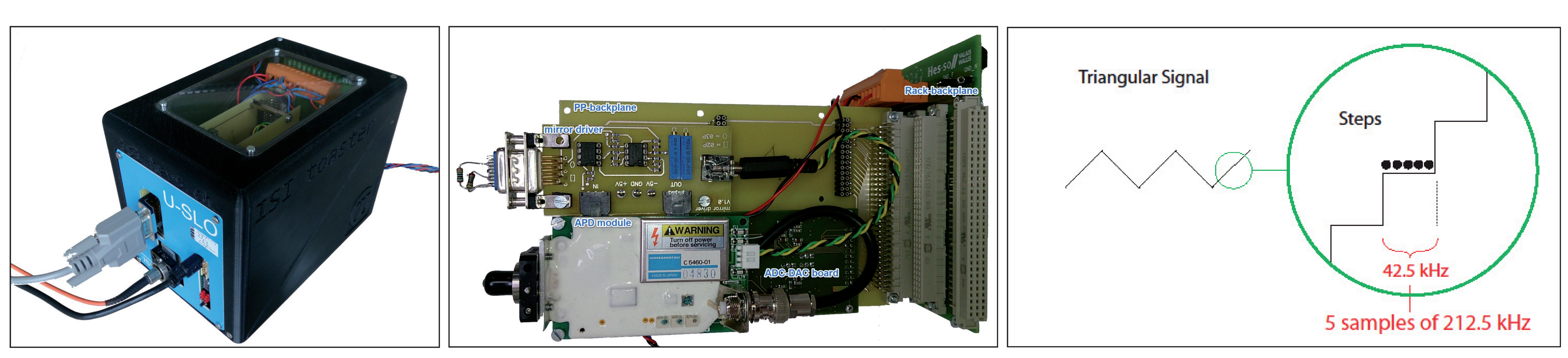


2) Optomechanical components



3) Electronics

The electronics components of the system, including MEMS control, APD module and ADC/DAC board, are in a separate box.



Electronics box, partial box interior and MEMS control signal (fast mirror)

MEMS control:

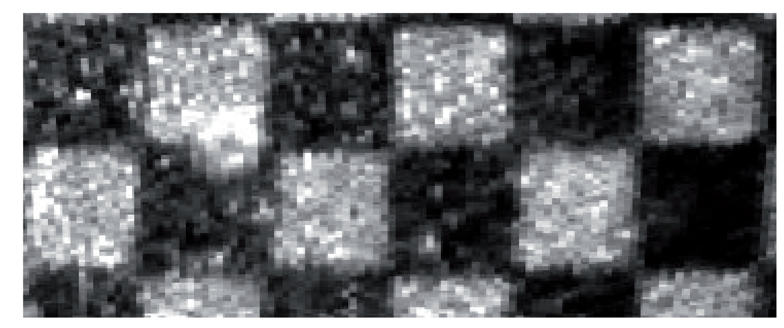
- drives one mirror at 212.5Hz and the other at 2.0Hz;
- the driving signal is triangular and built out of steps of 23.5ms duration each;
- drives a DAC at 192kHz, generating the current for the mirror control.

Signal processing:

- signal from detector is sampled at 192kHz (24bit audio ADC);
- one pixel corresponds to the mean value of five consecutive samples reduced to 16bit;
- the data are sent via USB to a dedicated image processing board for the image formation (at a speed of 1Mbit/s).

Results

First feasibility tests were made with a checkerboard image as resolution target. The preliminary MEMS control allows a horizontal scan of ±3.2° and ±1.3° vertical (in air), which results in an image size of 5 x 2mm^2, when focusing with a lens (f=50mm) on a target. The scans can be proceeded in fast (4Hz) and slow (1/20Hz) scanning mode.



checkerboard image (1 square = 800µm)

The displayed image was captured in a slow scanning mode (20s duration), because the control speed of the step signal is limited by the physical properties of the MEMS mirrors.

Future work

The following steps are planed for the second development phase:

- smaller detection fiber diameter to improve the image resolution (now at 242µm resulting from the core diameter and the system magnification);
- adapt the MEMS mirror control signal shape to their physical properties or observe their position at every time, to correct the signal position;
- motorize the movable lens and take over the focal plane positions in a software, which realizes the 3D image stacking;
- fixation target installation for the object position control.

Acknowledgements

This project was done thanks to a grant from the HES-SO, Ubiquitous SLO.

Contact

Tel. +41 27 606 87 32
helene.strese@hevs.ch
www.hevs.ch/isi

Hes·so VALAIS WALLIS School of Engineering

haute école arc ingénierie neuchâtel berne jura www.he-arc.ch