Holoscopic Microendoscopy towards Dynamic OCT with Flexible endoscopes

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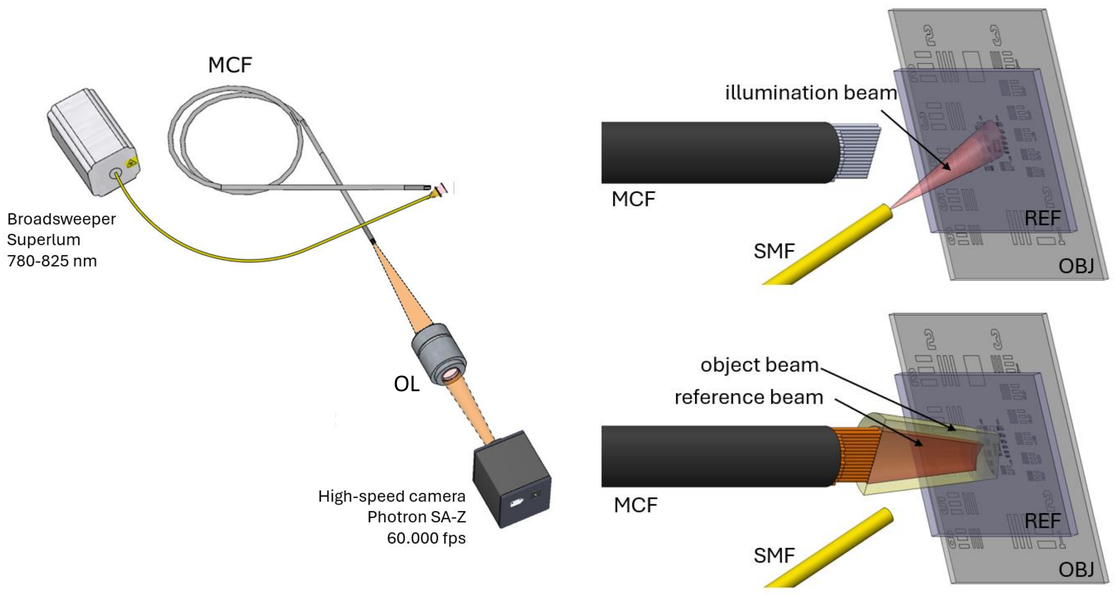
Introduction & Technical principle

- Optical coherence tomography (OCT) provides tomographic images with µm resolution
- Dynamic evaluation of time series data creates functional contrast
- In-vivo diagnostic requires endoscopic compatability
- Endoscopic implementations typically require stiff distal optics
- Holoscopy through multicore fibres avoids this
- Swept-source laser illuminates sample, switching wavelength
- Light is reflected at the reference plane and in the sample
- Multicore fibre guides the interferring light onto the camera
- Spatially resolved imaging is possible as each core corresponds to a different sample position
- Depth information can be acquired by the interference pattern over time

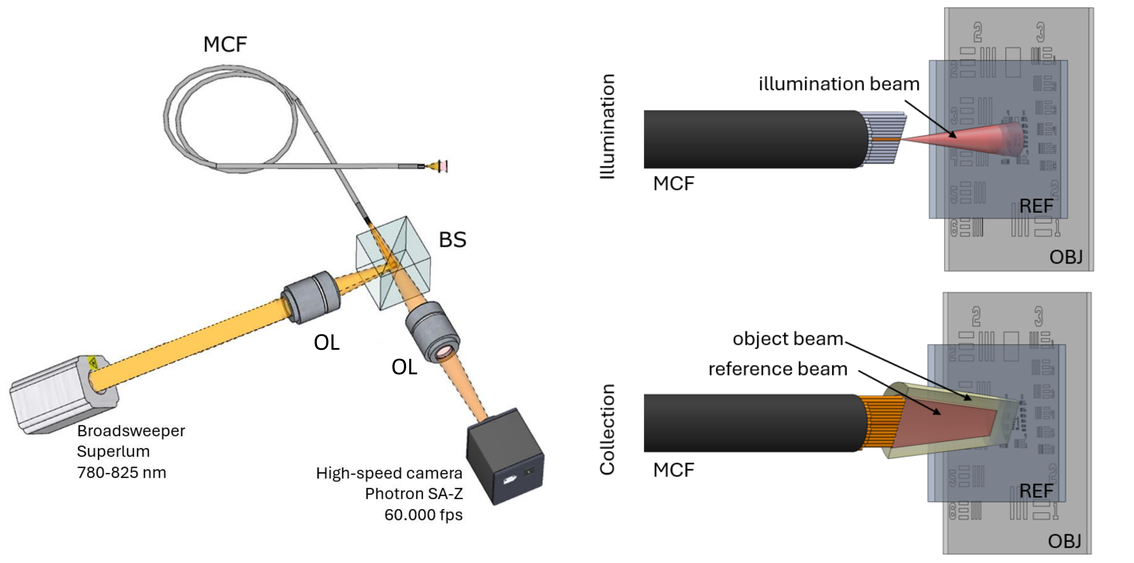
Experimental setup



Experimental holoscopic endoscope setup. The setup uses an external illumination onto the sample. The backscattered light is projected by a fibre onto a high-speed camera, capturing the interferogram over time. MCF: multicore fibre, OL: objective lens, SMF: single mode fibre, REF: reference glass, OBJ: sample object

- External illumination is used to minimize component alignment issues
- Sample and reference are angled to ensure the maximum amout of light can be collected
- Setup is not feasible for in-vivo use due to the external SMF

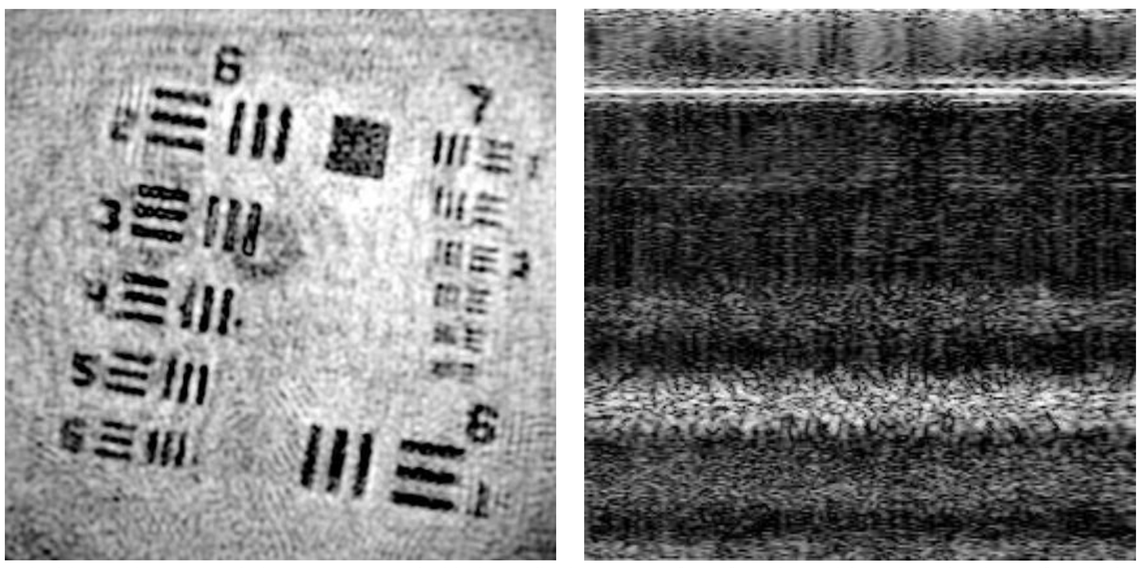
Application setup



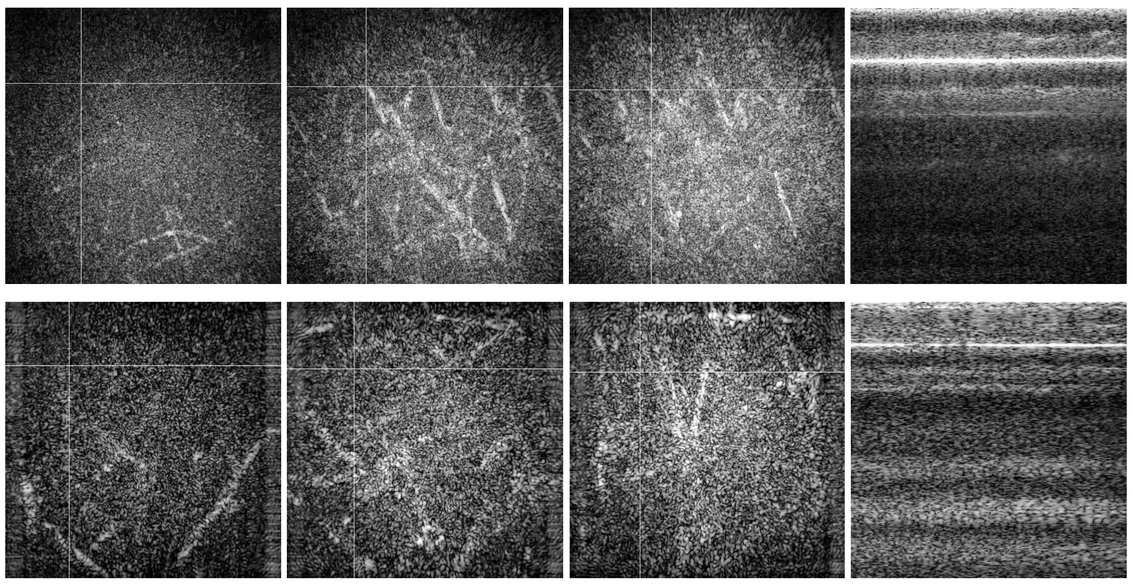
Application holoscopic endoscope setup. The illumination uses the central core of the MCF. The backscattered light is projected by the fibre onto a high-speed camera, capturing the interferogram over time. MCF: multicore fibre, OL: objective lens, BS: beam splitter, REF: reference mirror, OBJ: sample object

- Beamsplitter allows for simultaneous illumination and detection
- Illumination is performed through central core of the MCF
- Detection uses the surrounding cores

Results

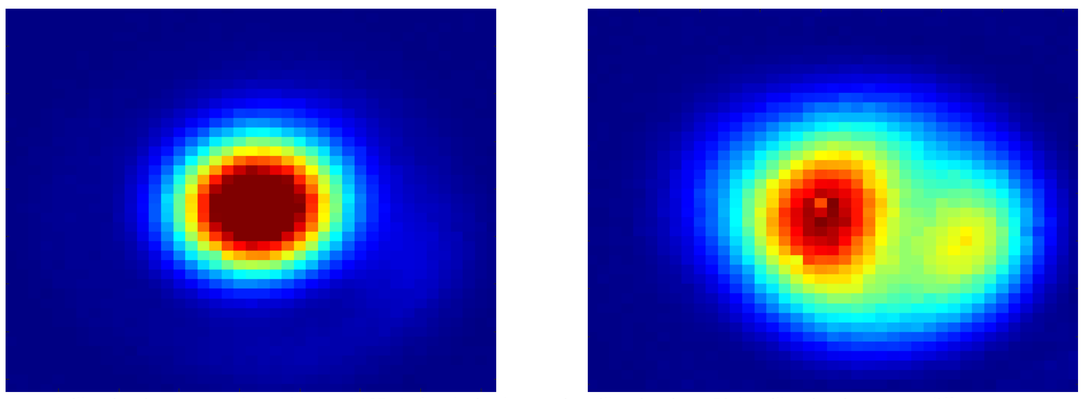


United States Air Force resolution target captured with the application setup. Left: En-face plane. Right: B-Scan showing artifacts in the lower imaging depths.



Scattering sample (lens cleaning tissue) captured with the experimental (top) and application (bottom) setup. Left: 3 en-face planes in different depths. Right: B-Scan. A volumetric reconstruction is possible in any case. The application setup however increases noise and introduces artifacts in large image depths.

- Volumetric imaging is possible
- Microscopic resolution
- Image quality highly dependant on alignment in expermental setup
- Non-gaussian beamprofiles due to chromatic abberations in application setup



Measured illumination spots through the MCF. Left: desired gaussian illumination. Right: illumination at a different wavelength. Chromatic aberrations deform the spot and result in an inhomogeneous illumination, reducing image quality.

Conclusion

The principal proof of concept has been established. Further research is ongoing to develop this promising technique into an in-vivo ready application to assist in the diagnostics of lung diseases.

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