3D OCT Motion Correction efficiently enhanced with OCT Angiography

Purpose:
Ophthalmic Optical Coherence Tomography (OCT) and Angiography (OCTA) suffer from motion artifacts caused by involuntary eye motion and the sequential OCT scanning process. Thus, motion correction (MoCo) can help to achieve more accurate and reproducible disease metrics. We propose to extend an existing MoCo approach by incorporating OCTA data and perform a quantitative evaluation to assess its reliability and accuracy.

Methods:
An existing 3D OCT MoCo algorithm that closely models the scanning process of a volume pair scan with orthogonal fast-scan directions is extended to not only use the structural, but also the angiographic OCT signal to guide the co-registration of both scans. Operating on the entire OCTA volume would increase computational cost significantly. Instead, a fast to compute vessel-contrast preserving en-face projection of the volume is used.

The evaluation was performed on 18 eyes from different subjects (10 healthy, 8 eyes with various pathologies) at both 3x3 mm and 6x6 mm field sizes. In each case, 3 repeated scan-pairs were acquired to assess reproducibility, adding up to 230 OCT volumes.

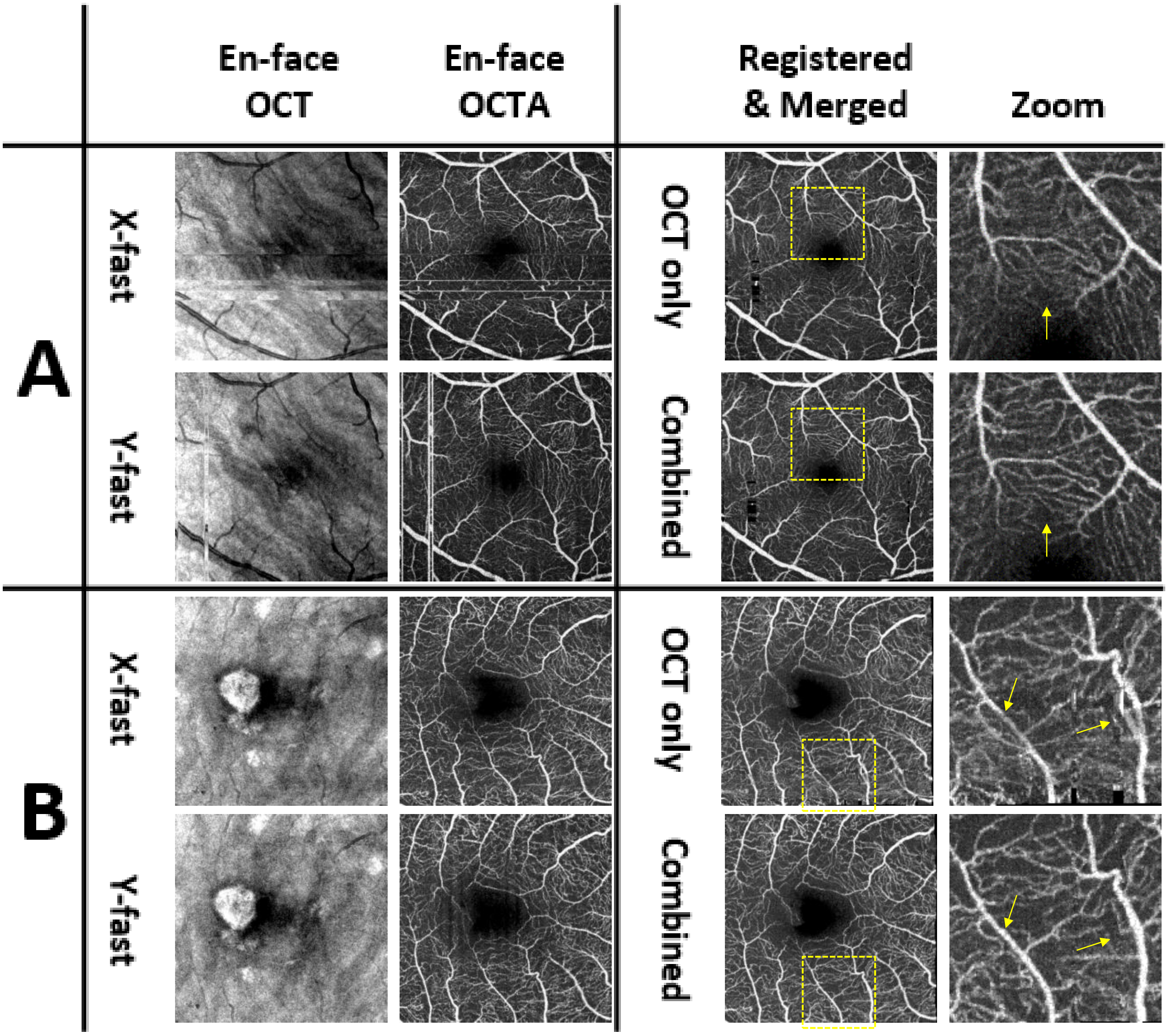
Results:
Figure 1 compares evaluation results for the OCT only registration and our combined approach. The proposed method improves both registration and reproducibility performance. The representative en-face images in Figure 2 visualize differences in the registered volumes.

Conclusions:
A novel approach of fully 3D OCT MoCo using a combination of OCT and OCTA data was introduced. The method showed an improvement over a registration using only OCT data with respect to transverse registration accuracy and success rate at a low additional computational cost.

Figure 1 (Quantitative Evaluation Result Table):
Quantitative evaluation results. Registration performance describes the agreement between the registered volumes of each volume pair, reproducibility performance compares independently acquired and merged volume pairs. The vessel probability was computed on the en-face OCTA projection of the superficial layer using a vesselness filter. The pixel spacing along depth is 4.5 µm.

Figure 2 (Visual comparison):
En-face images of the X/Y-fast OCT(A) and merged OCTA volumes. In A, the additional angiographic contrast helped to better align the scans, leading to less blurring in the merged image. In the OCT only registration in B, the vessels marked with arrows were badly aligned between both scans and thus appear twice in the merged volume. The combined registration result did not show this problem.

	Error Measure	OCT only (μ ± σ)	Combined (μ ± σ)	Two-sided Wilcoxon Signed-Rank Test
Registration	Vessel probability difference	0.251 ± 0.045	0.228 ± 0.033	p < 0.0001
Performance	Difference in auto-segmented ILM depth	5.01 μm ± 4.24 μm	4.47 μm ± 4.05 μm	p = 0.0223
Reproducibility	Vessel probability difference	0.241 ± 0.060	0.211 ± 0.045	p < 0.0001
Performance	Difference in auto-segmented ILM depth	8.37 μm ± 5.80 μm	7.68 μm ± 5.61 μm	p < 0.0005
	Success Rate	74.5 %	93.1 %	



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