Abstract: A Spatiotemporal Model for Precise and Efficient Fully-automatic 3D Motion Correction in OCT

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Optical coherence tomography (OCT) is a micrometer-scale, volumetric imaging modality that has become a clinical standard in ophthalmology. OCT instruments image by raster-scanning a focused light spot across the retina, acquiring sequential cross-sectional images to generate volumetric data. Patient eye motion during the acquisition poses unique challenges: Non-rigid, discontinuous distortions can occur, leading to gaps in data and distorted topographic measurements. We present a new distortion model and a corresponding fully-automatic, reference-free optimization strategy for computational motion correction in orthogonally raster-scanned, retinal OCT volumes. Using a novel, domain-specific spatiotemporal parametrization of forward-warping displacements, eye motion can be corrected continuously for the first time. Parameter estimation with temporal regularization improves robustness and accuracy over previous spatial approaches.We correct each A-scan individually in 3D in a single mapping, including repeated acquisitions used in OCT angiography protocols. Specialized 3D forward image warping reduces median runtime to < 9 s, fast enough for clinical use. We present a quantitative evaluation on 18 subjects with ocular pathology and demonstrate accurate correction during microsaccades. Transverse correction is limited only by ocular tremor, whereas submicron repeatability is achieved axially (0.51 µm median of medians), representing a dramatic improvement over previous work. This allows assessing longitudinal changes in focal retinal pathologies as a marker of disease progression or treatment response, and promises to enable multiple new capabilities such as supersampled/super-resolution volume reconstruction and analysis of pathological eye motion occuring in neurological diseases. This paper was accepted and presented at medical image computing and computer assisted intervention (MICCAI) 2022 [1].

References

1. Ploner S, Chen S, Won J, Husvogt L, Breininger K, Schottenhamml J et al. A spatiotemporal model for precise and efficient fully-automatic 3D motion correction in OCT. Medical Image Computing and Computer Assisted Intervention – MICCAI 2022:517–527.

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