Hybrid OCT-OCTA Vessel Visualization for Projection-Free Display of the Intermediate and Deep Retinal Plexuses

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Purpose: In optical coherence tomography angiography (OCTA), projection artifacts (also shadowing artifacts or decorrelation tails) cause superficial retinal vasculature to appear in the segmented OCTA images of the intermediate and deep retinal plexuses. The projections of these larger superficial vessels obfuscate the unique vascular patterning of the deeper layers. Several algorithms have been proposed to remove these shadows. However, by removing the projected vessels these approaches also decrease the contrast of, or fully eliminate, the underlying vasculature, thereby introducing discontinuities. Thus, in effect, one artifact is replaced with another. The purpose of this study is to develop a projection artifact removal scheme that overcomes this limitation and fully preserves the intermediate/deep retinal vasculature.

Methods: Amplitude decorrelation based OCTA data was collected using a 1050nm swept source OCT system. A hybrid OCT-OCTA vessel visualization scheme (described in Figure 1) was developed. The key advantage of our proposed scheme is that the OCT signal is used to adaptively remove the OCTA signal only in the intercapillary regions.

Results: The hybrid OCT-OCTA approach reduces projection artifacts to a negligible level in the intermediate and deep plexuses without introducing vessel discontinuity artifacts (Figure 2).

Conclusions: Hybrid OCT-OCTA vessel visualization is a promising approach to visualize the unique patterning of the intermediate and deep plexuses, and is likely to be particularly important in diseases such as diabetic retinopathy where it is desirable to separately analyze the retinal plexuses.

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Purpose

- In optical coherence tomography angiography (OCTA), projection artifacts (i.e., “shadowing artifacts” or “decorrelation tails”) cause superficial retinal vasculature to appear in the intermediate and deep retinal plexuses.
- The projections of these larger superficial vessels obfuscate the unique vascular patterning of the deeper layers.
- Several algorithms have been proposed to remove these shadows (e.g. [1-3]).
- However, by removing the projected vessels it is sometimes the case that intermediate/deep vessels are also removed in that region (we term these “vessel discontinuity artifacts”).
- The purpose of this study is to develop a projection artifact removal scheme that overcomes these limitations, preserving the intermediate and deep retinal vasculature.

Methods

- Amplitude decorrelation based OCTA data was collected using a prototype 1050nm swept source OCT system developed at MIT.

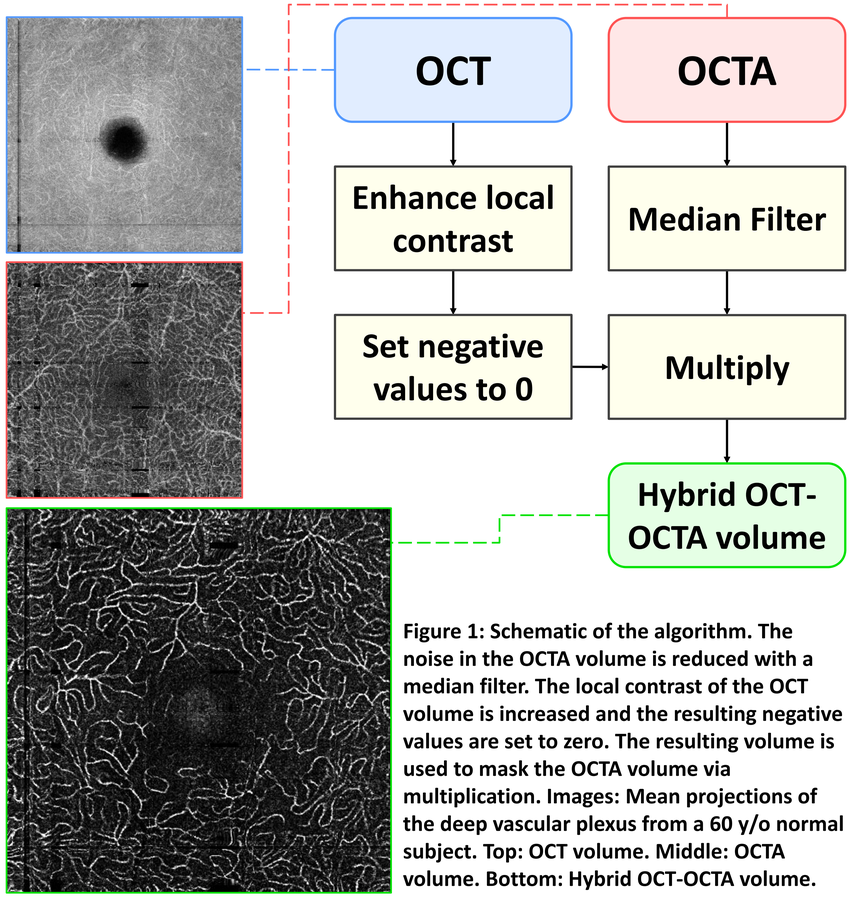

Figure 1: Schematic of the algorithm. The noise in the OCTA volume is reduced with a median filter. The local contrast of the OCT volume is increased and the resulting negative values are set to zero. The resulting volume is used to mask the OCTA volume via multiplication. Images: Mean projections of the deep vascular plexus from a 60 y/o normal subject. Top: OCT volume. Middle: OCTA volume. Bottom: Hybrid OCT-OCTA volume.

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Results and Discussion

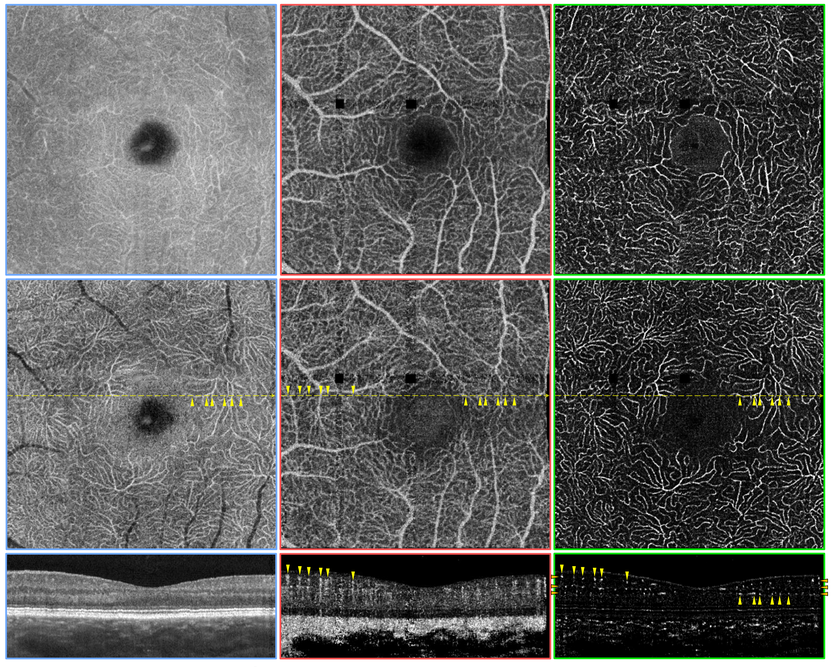

Figure 2: Images of a 43 y/o normal subject. Left column: OCT volume. Central column: OCTA volume. Right column: Hybrid OCT-OCTA visualization. Top row: en-face projections of the intermediate vascular plexus. Middle row: en-face projections of the deep vascular plexus. Bottom row: B-scans at the position of the dashed yellow line. Downward / upward facing yellow triangles point at vessels in the superficial / deep vascular plexus. Orange triangles from top to bottom: Superficial, intermediate and deep vascular plexus.

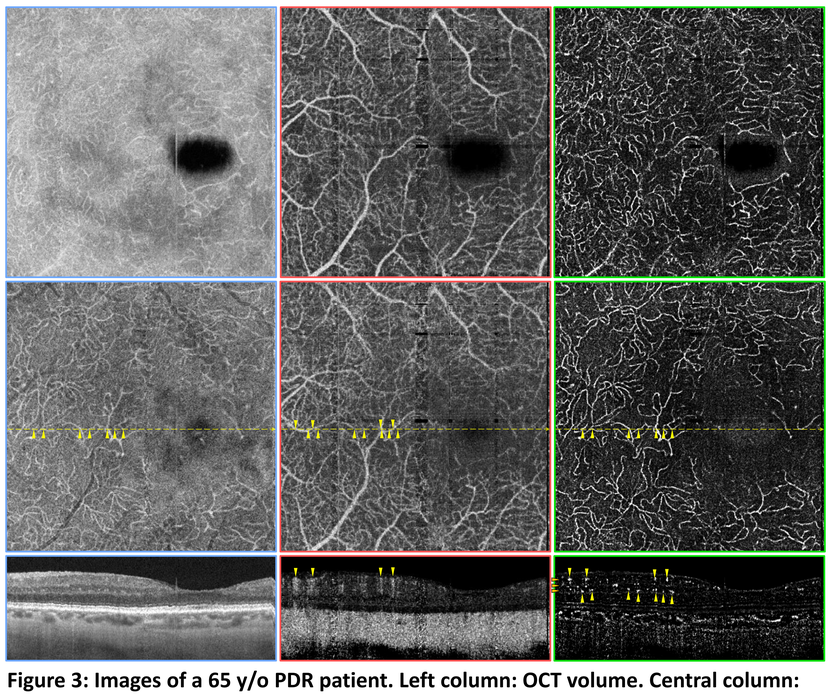

Figure 3: Images of a 65 y/o PDR patient. Left column: OCT volume. Central column: OCTA volume. Right column: Hybrid OCT-OCTA visualization. Top row: en-face projections of the intermediate vascular plexus. Middle row: en-face projections of the deep vascular plexus. Bottom row: B-scans at the position of the dashed yellow line. Downward / upward facing yellow triangles point at vessels in the superficial / deep vascular plexus. Orange triangles from top to bottom: Superficial, intermediate and deep vascular plexus.

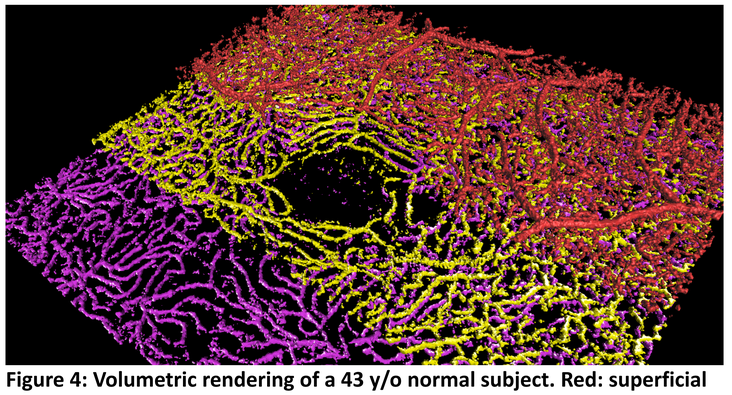

Figure 4: Volumetric rendering of a 43 y/o normal subject. Red: superficial vascular plexus. Yellow: intermediate vascular plexus. Purple: deep vascular plexus.

Conclusions

- The hybrid OCT-OCTA approach reduces projection artifacts to a negligible level in the intermediate and deep plexuses while minimizing vessel discontinuity artifacts (Fig. 2, Fig. 3).
- Hybrid OCT-OCTA improves 3-D visualization of vascular plexuses (Fig. 4).
- Further work is needed to evaluate the algorithm in different pathologies.
- Hybrid OCT-OCTA may be useful for quantitative analysis of vascular patterns (e.g., [4]), particularly in diseases such as diabetic retinopathy where the deep plexus is known to be altered (Fig. 3) (e.g., [5]).

References

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