Increased vessel length index in deep retinal layer angiography *en face* slabs via convolutional neural networks

Warren Lewis, MS[1]; Arindam Bhattacharya, PhD[2]; Luis de Sisternes, PhD[2]

[1] Bayside Photonics, Yellow Springs, OH, [2] Carl Zeiss Meditec, Inc. Dublin CA

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PURPOSE

Assessment of average vessel length in deep retinal layer projections is complicated by speckle and brightness variations, which can cause continuous vessels to appear broken in binarized skeleton traces. Hessian "vesselness" filters have been used to correct this[3], but they are limited in their ability to improve connectivity, and may even create spurious vessels from random background noise fluctuations. This is a study of the use of convolutional neural networks (CNN's) to improve vessel continuity without the use of Hessian filters.

METHODS

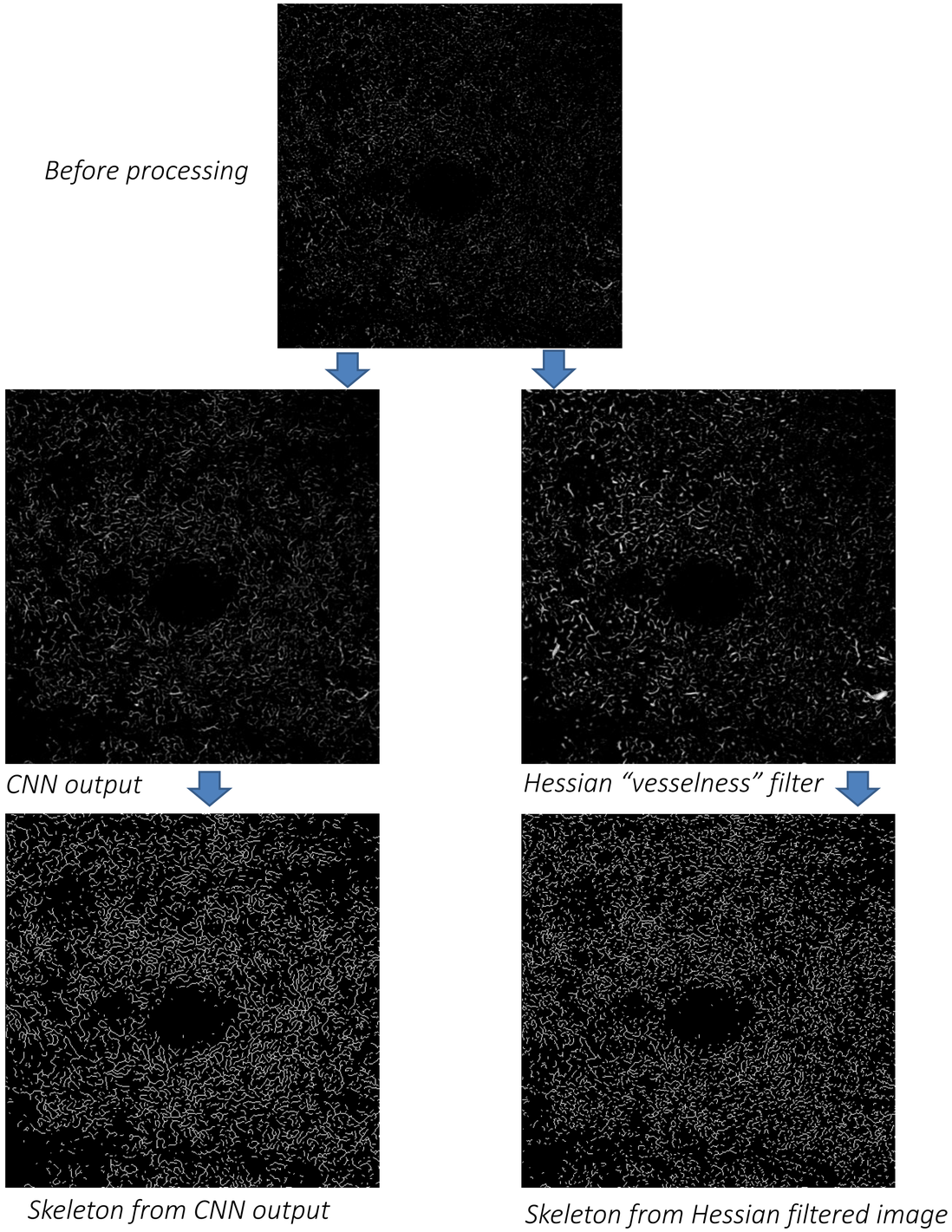
- A CNN having a 5-layer U-Net architecture with deep supervision was trained on OCTA images of the deep capillary plexus, using averages of repeated scans of the same subject as ground truth.
- Approximately 30,000 patches of individual images were trained against corresponding patches of the averaged image.
- A PLEX® Elite 9000 SS-OCT System (ZEISS, Dublin, CA) was used to acquire 3-4 repeated 6x6 mm OCTA scans of subjects having diabetic retinopathy, which can cause a decrease in retinal vascular density.
    - These repeated scans were registered and averaged, providing high quality averaged volumes, which were then segmented to produce en face projections of the deep retinal layer (DRL).
- The individual volumes were segmented to produce individual DRL projections, which were then processed by the CNN. Vessel traces were calculated from the CNN output images and compared with traces made using the traditional method using Hessian filters. The total length of vessels in each trace was divided by the number of connected components to obtain the vessel length index, which was compared between the two groups.

RESULTS

Average vessel length (mm) calculated using Hessian and CNN processing

	Hessian	CNN
set 1	0.0792	0.182
set 2	0.0698	0.147
set 3	0.0838	0.33

The CNN image has longer calculated average vessel length. Each vessel in the processed image has more uniform brightness and so has fewer discontinuities after binarization.



CONCLUSION

CNN-based vessel enhancement is a new, promising alternative to Hessian "vesselness" filters for improved vessel continuity with better verisimilitude.

Email: warren.h.lewis@gmail.com

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[3]Frangi, A. F., Niessen, W. J., Vincken, K. L., and Viergever, M. A., "Multiscale vessel enhancement filtering," in [Medical Image Computing and Computer-Assisted Intervention - Miccai'98], Wells, W. M., Colchester, A., and Delp, S., eds., 1496, 130–137, Springer-Verlag Berlin, Berlin (1998)