Automatic Vessel Segmentation in Optos Images Using Deep Learning

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Introduction

Abnormalities in the retinal vasculature can provide a window to systemic disorders [1]. Ultra-widefield retinal imaging (UWF) captures 80% of the retina in a single acquisition providing a larger field of view to assess the retinal vasculature for disease. We are developing an automatic vessel segmentation system for UWF-SLO images, to enable automatic extraction of clinical vessel parameters for research and clinical assessment of retinal manifestations pertaining to systemic disorders. We aim to provide automatic, accurate, reliable segmentation of UWF-SLO images, to enable vessel analysis at the point of care.

Methods

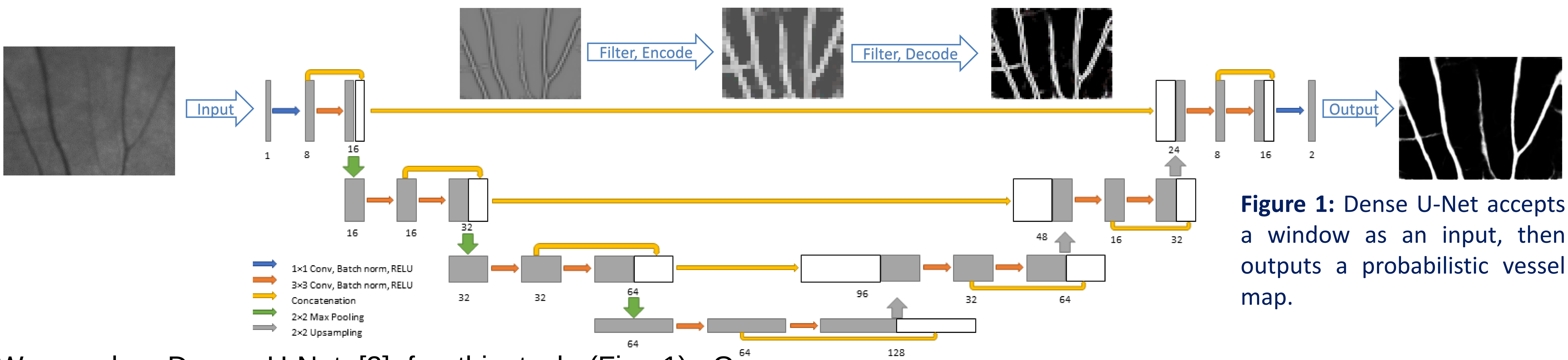

Figure 1: Dense U-Net accepts a window as an input, then outputs a probabilistic vessel map.

We used a Dense U-Net [2] for this task (Fig. 1). Our dataset contains 120 windows from 10 images taken with the P200C and 72 windows from 9 images with a California (Fig 2), each with vessels labelled (Fig. 3), split into training set (90 P200C windows, 48 California windows), validation set (15 P200C windows, 8 California windows) and test set (15 P200C windows, 16 California windows).

Predictions were marked as vessels if the probability was > 0.5. Predictions were quantitively compared to the hand-drawn annotations by 2 human observers using performance metrics: Dice similarity coefficient (DSC); sensitivity; specificity, and area under curve (AUC).

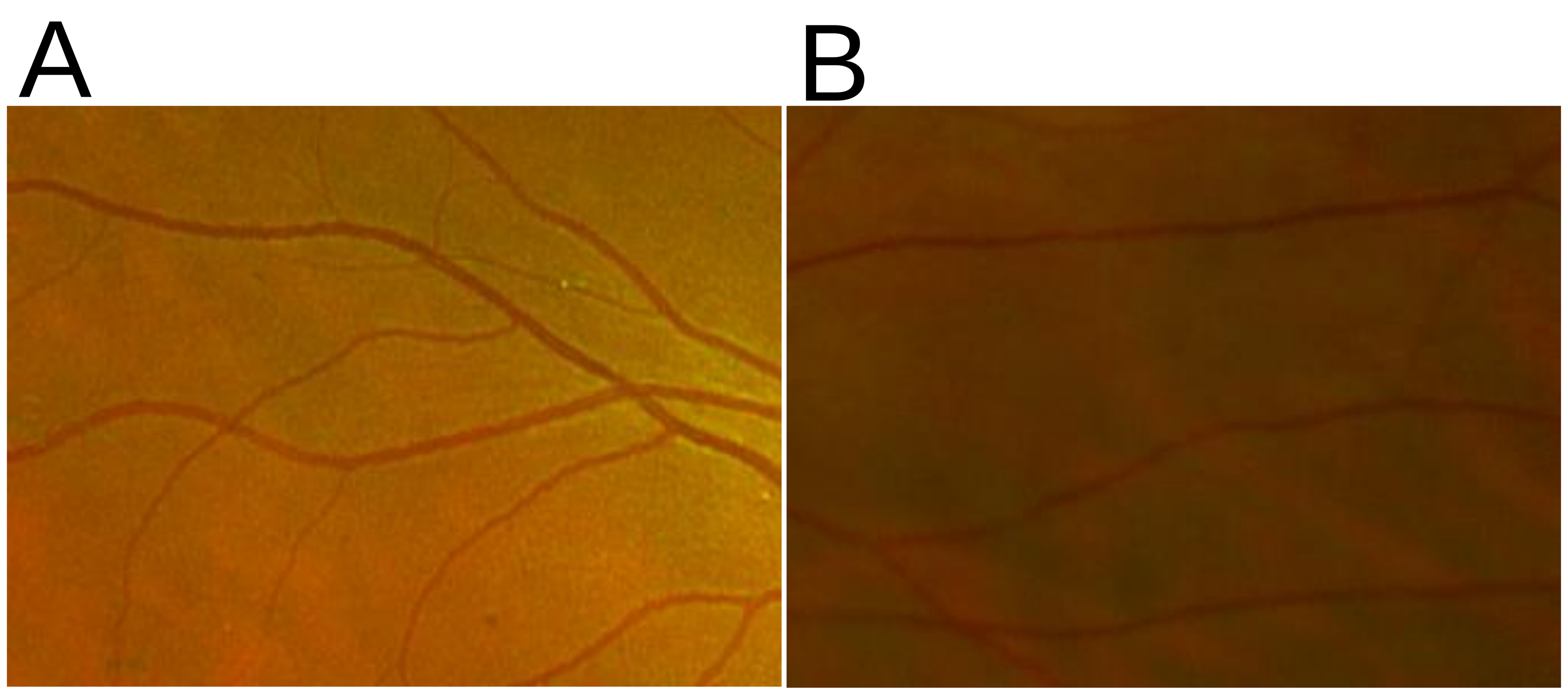

Figure 2: Examples of training images. A) Window from Optos California image. B) Window from Optos P200C image.

Results

Our results improve on the previous methods in [3] and [4], and are summarised in Table 1. Sources of false negatives included small discrete vessels that would be challenging for an automatic system to detect (magenta; Fig. 3). Sources of false positives include regions of noise and pixels close to the vessel boundary (green; Fig. 3).

	DSC	Sensitivity	Specificity	AUC
Proposed method	0.773 ± 0.025	0.746 ± 0.029	0.990 ± 0.001	0.98
Pellegrini et al. [3]	0.580 ± 0.039	0.702 ± 0.059	0.989 ± 0.006	0.97
Robertson et al. [4]	n/a	0.593 ± 0.073	0.991 ± 0.005	0.87

Table 1: Results of the proposed method, compared to [3] and [4]

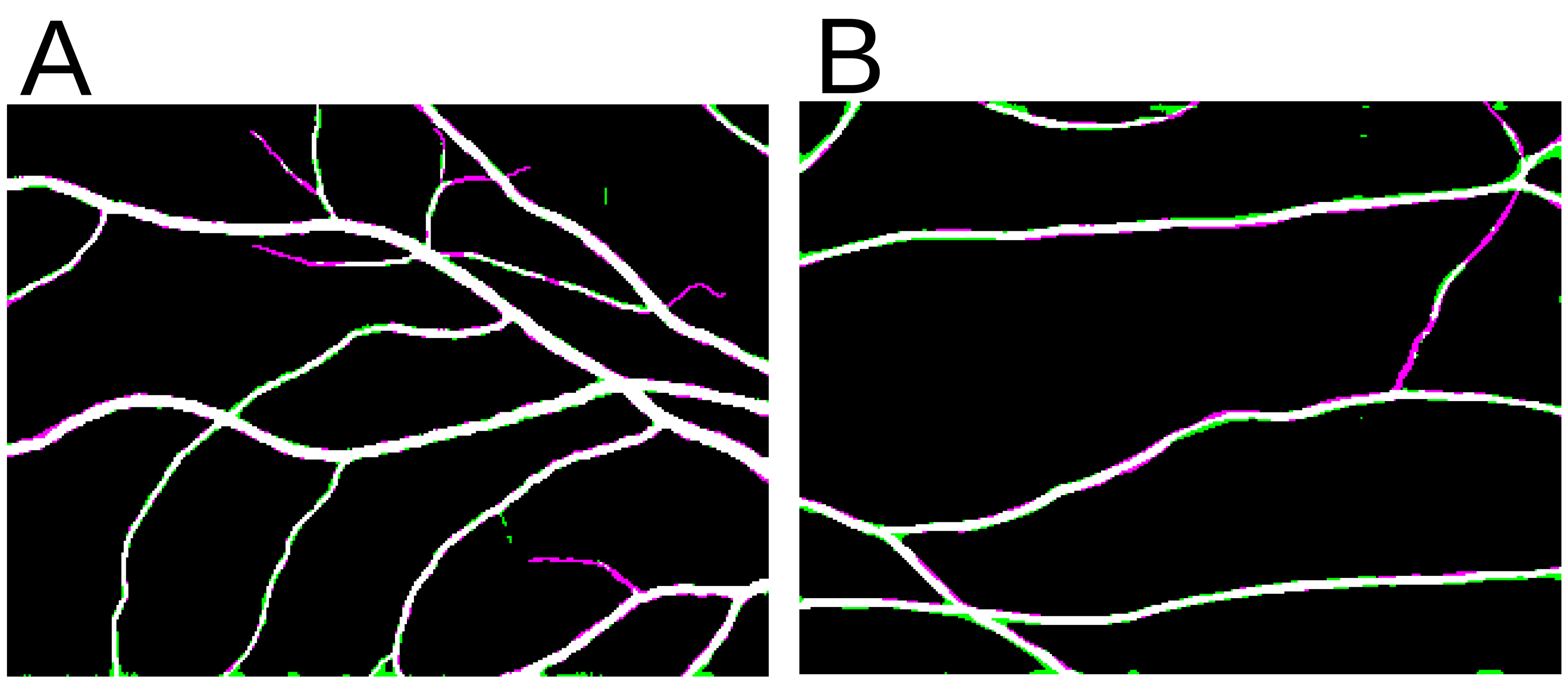

Figure 3: Vessel maps corresponding to images in Figure 1. Magenta: Ground truth. Green: proposed segmentation. White: Overlap.

Conclusions

Our automated method segments the vasculature quickly in full-sized UWF-SLO images and facilitates subsequent extraction of clinical vessel parameters (e.g. width calibres). Our system is likely to be improved with more training data.

References

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