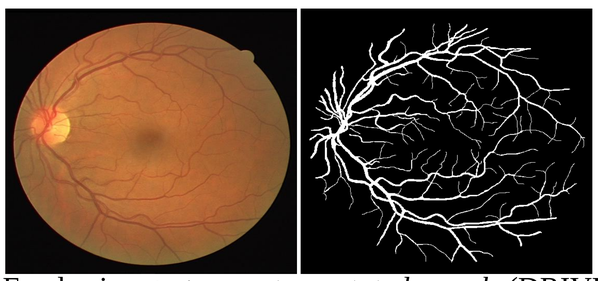
Fine-Scale Vessel Extraction in Fundus Images by Registration with Fluorescein Angiography

Kyoung Jin Noh[1], Sang Jun Park[1], and Soochahn Lee[2]
[1]Seoul National University Bundang Hospital, [2]Kookmin University

Overview

- Obtaining reliable and accurate vessel region in fundus images is extremely difficult
- Expert annotation (DRIVE, STARE. CHASE_DB1, HRF, etc) may have limited detail

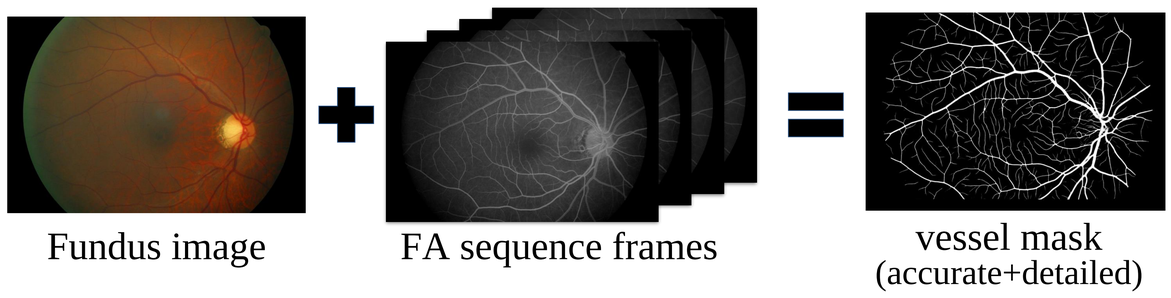


Fundus image + *expert annotated vessels* (DRIVE)

Increase detail of vessels

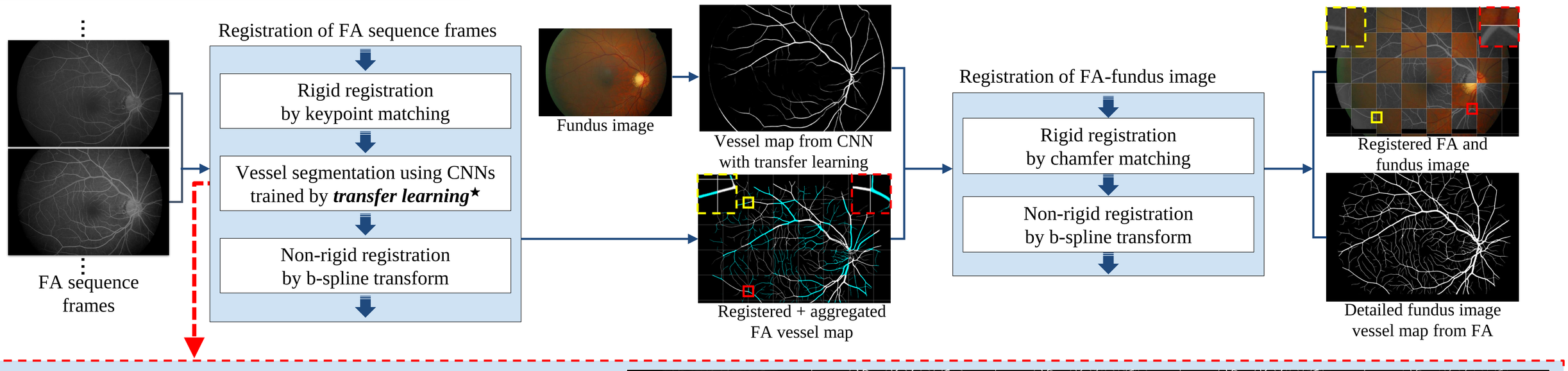
Decrease annotation effort

- Fluorescein angiography (FA) highlights vessels making segmentation easier & reliable
- We propose auto method using FA and fundus images to obtain accurate vessel masks
- Can be used to make DB for training next gen ML based retinal segmentation methods



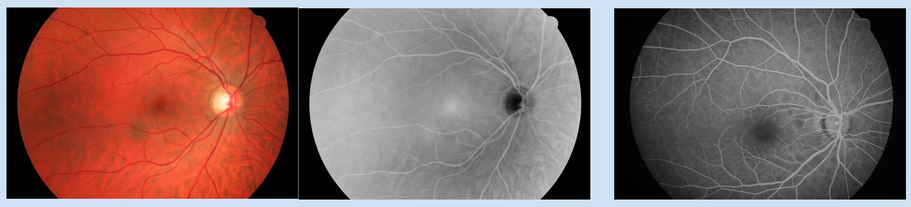
Fundus image + FA sequence frames = vessel mask (accurate+detailed)

Method

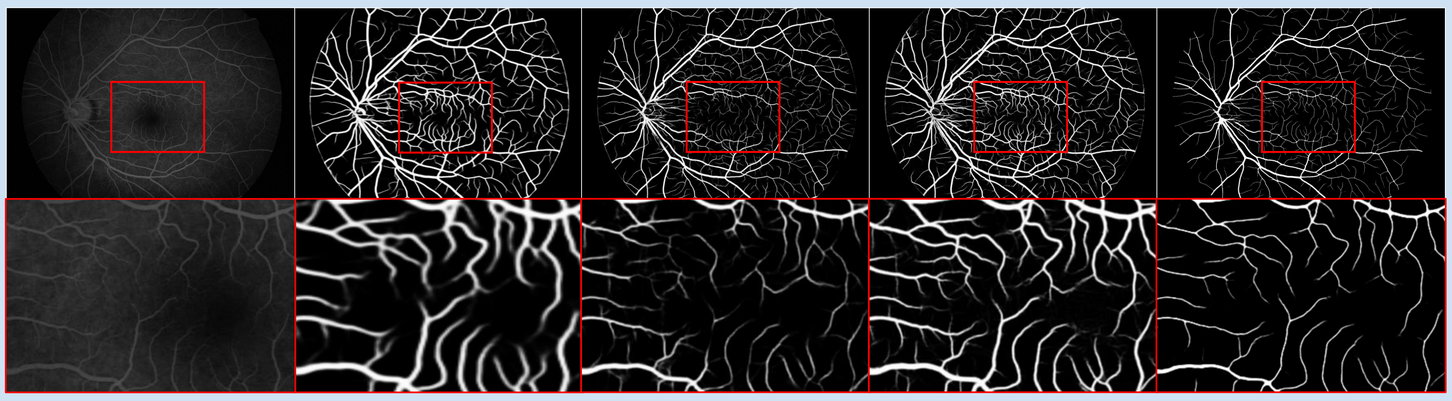


★Transfer learning

- No public FA database to learn ML based vessel segmentation
- Use public fundus image DB (DRIVE, HRF, etc) to train CNN
- Make fundus images look similar to FA by converting to greyscale and inverting



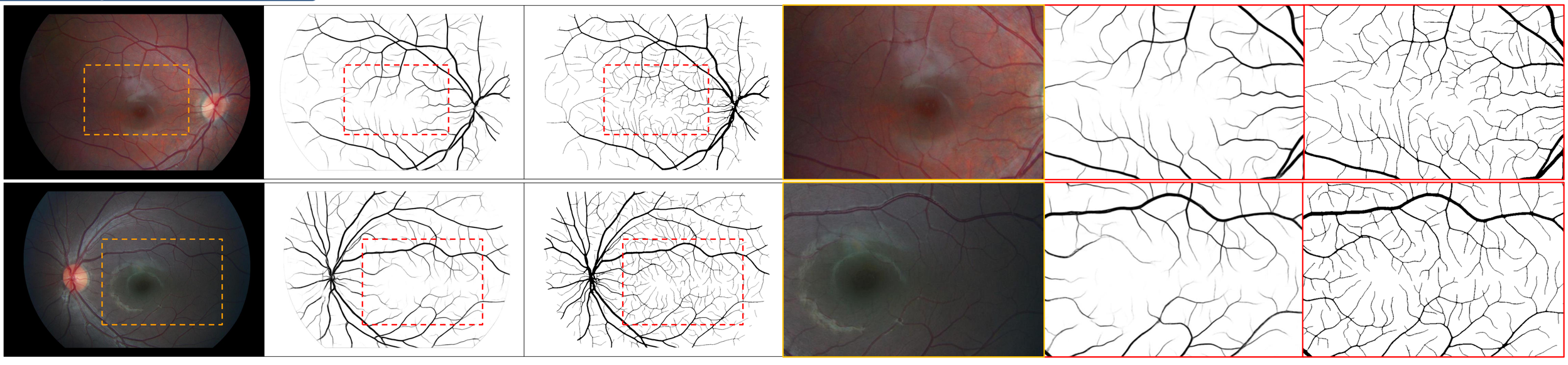
Fundus image from HRF | After conversion to greyscale and inversion | Sample FA frame



Input FA frame | Mask from CNN trained on DRIVE | Mask from CNN trained on HRF | Mask from CNN trained on DRIVE+HRF | Mask from CNN trained on results from proposed method

Results

Qualitative



Fundus image | SSANet trained on HRF | Proposed method | Zoomed fundus image | SSANet trained on HRF | Zoomed proposed method

Quantitative

Table 1: Quantitative results of the proposed method together with results obtained by SSANet (Noh et al., 2019b) trained on public fundus image datasets with expert annotated ground truth on our SNUBH F+FA dataset.

Method	Se	Sp	Acc	AUC ROC	F1	AUC PR
SSANet(DRIVE)	0.693	0.981	0.958	0.944	0.726	0.802
SSANet(STARE)	0.697	0.985	0.962	0.936	0.746	0.802
SSANet(CHASE_DB1)	0.723	0.984	0.963	0.949	0.758	0.822
SSANet(HRF)	0.720	0.985	0.964	0.950	0.760	0.827
SSANet(DRIVE+HRF)	0.739	0.985	0.965	0.956	0.771	0.841
Proposed	0.791	0.989	0.973	0.978	0.823	0.900
Proposed+ST	0.994	0.999	0.999	0.999	0.992	0.991

Table 2: Quantitative results obtained by a CNN (SSANet (Noh et al., 2019b)) trained on the SNUBH F+FA dataset with ground truth generated using the proposed method on public fundus image datasets.

Training set	Test set	Se	Sp	Acc	AUC ROC	F1	AUC PR
DRIVE	DRIVE	0.835	0.975	0.957	0.982	0.831	0.918
SNUBH F+FA	DRIVE	0.711	0.971	0.938	0.936	0.745	0.823
STARE	STARE	0.854	0.986	0.976	0.992	0.845	0.927
SNUBH F+FA	STARE	0.764	0.982	0.959	0.969	0.796	0.878
CHASE_DB1	CHASE_DB1	0.852	0.987	0.978	0.992	0.840	0.923
SNUBH F+FA	CHASE_DB1	0.740	0.970	0.949	0.962	0.722	0.782
HRF	HRF	0.833	0.979	0.966	0.987	0.819	0.907
SNUBH F+FA	HRF	0.797	0.978	0.961	0.978	0.791	0.874

Filamentary vessels

- Filamentary vessels are possibly missed in expert annotated ground truth.
- Evidenced in close inspection with histogram equalization.

HRF fundus image | Ground truth(GT) | SSANet trained on HRF | SSANet trained on SNUBH-F+FA

HRF fundus image | GT | SSANet trained on HRF | SSANet trained on SNUB-F+FA | Histogram equalized

Summary

- Currently accumulating DB
  - ✓ Only normal cases
  - ✓ 300 sets of FA seq+fundus img + vessel regions.
  - ✓ Will be adding 150 more soon.
- Artery/vein region labeling coming soon!
  - ➢ Leveraging FAs which contain information of blood flow to generate accurate A/V classification maps
- Pathological data coming soon!
  - ➢ Pathological fundus+FA sets are also being prepared.

Please visit our project page to find paper and code (coming soon)!