



A Pipeline for Automated Nailfold Capillary Density Analysis

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Bachelor-Thesis, Medical Engineering

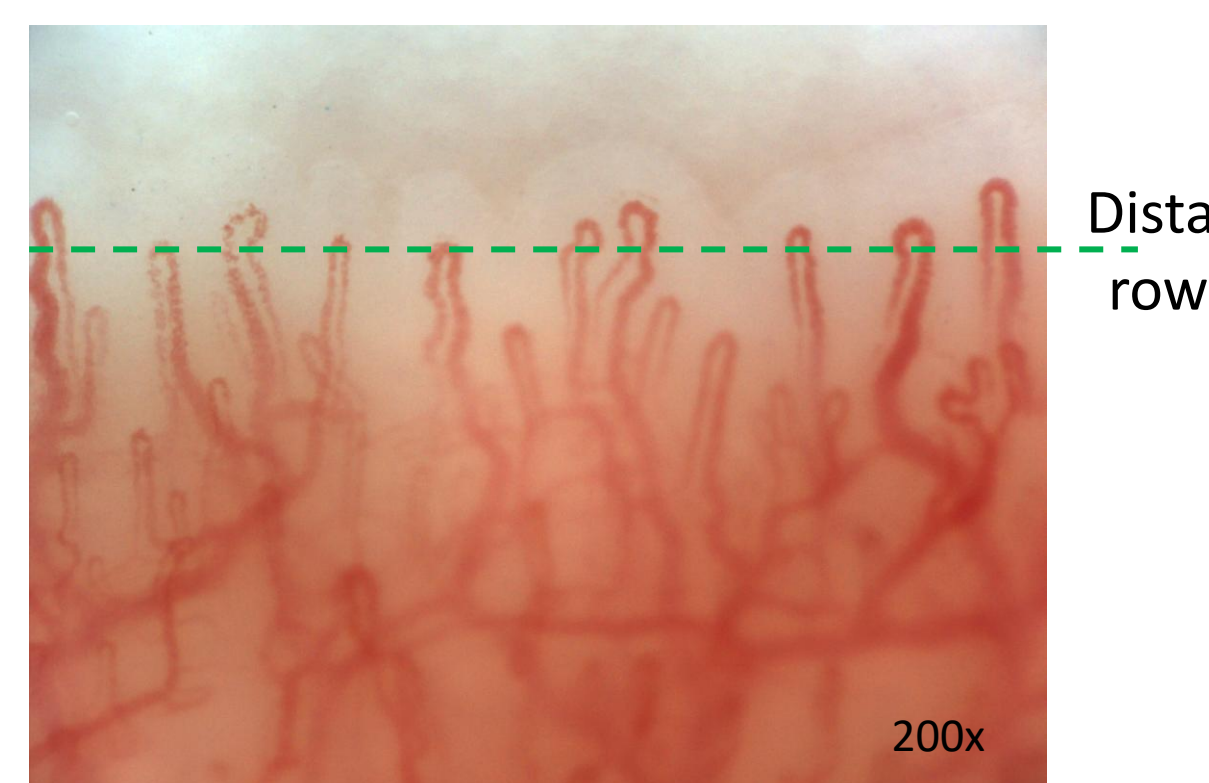
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► Introduction

- Microcirculation can be used as a marker in inflammatory illness such as sepsis [1]
- Nailfold Capillaroscopy (NFC); easy, non-invasive tool to assess microcirculation [2]
- **Problem:** Evaluation is time consuming, manual and subjective
- **Aim:** Create an automated processing pipeline to extract Capillary Density (CD)



NFC Image:

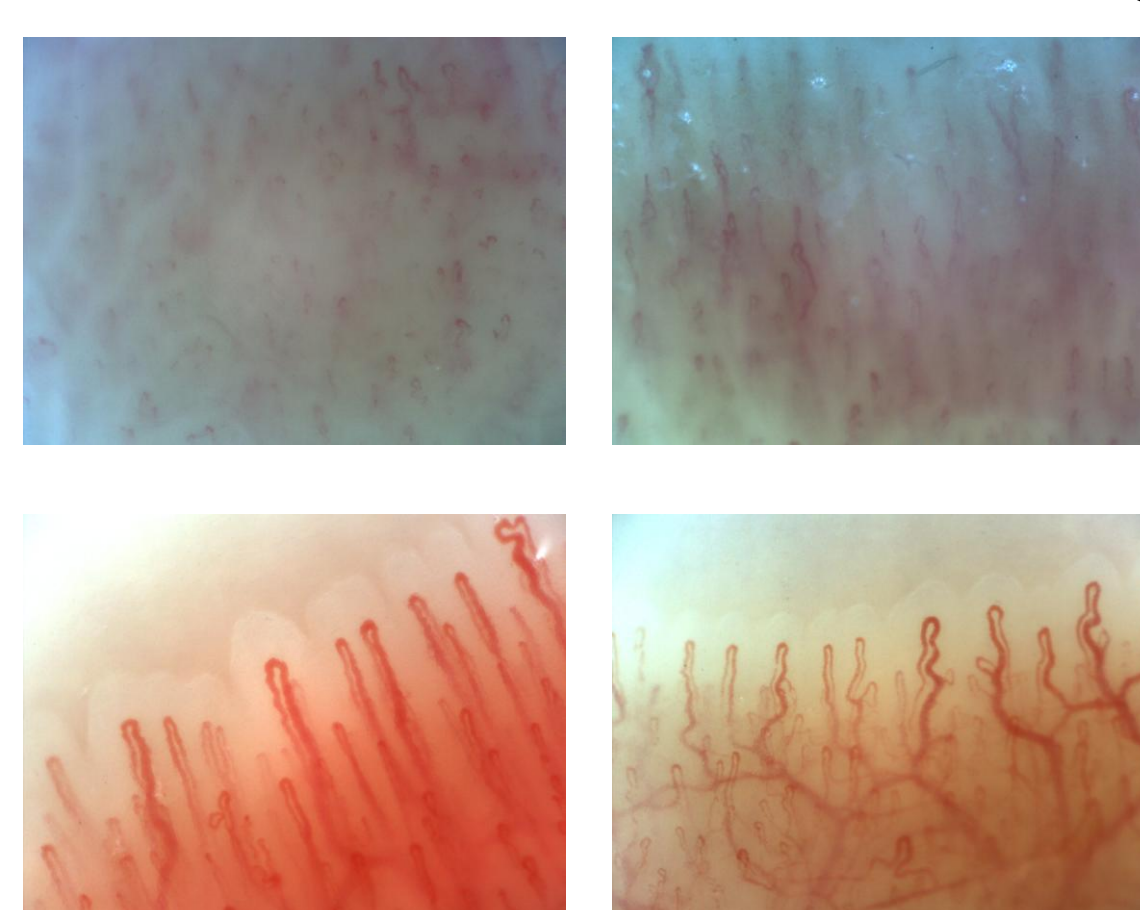
- Shows capillaries in the distal row with characteristic loop shapes

CD = Number of distal row capillaries per mm [2]

► Methods

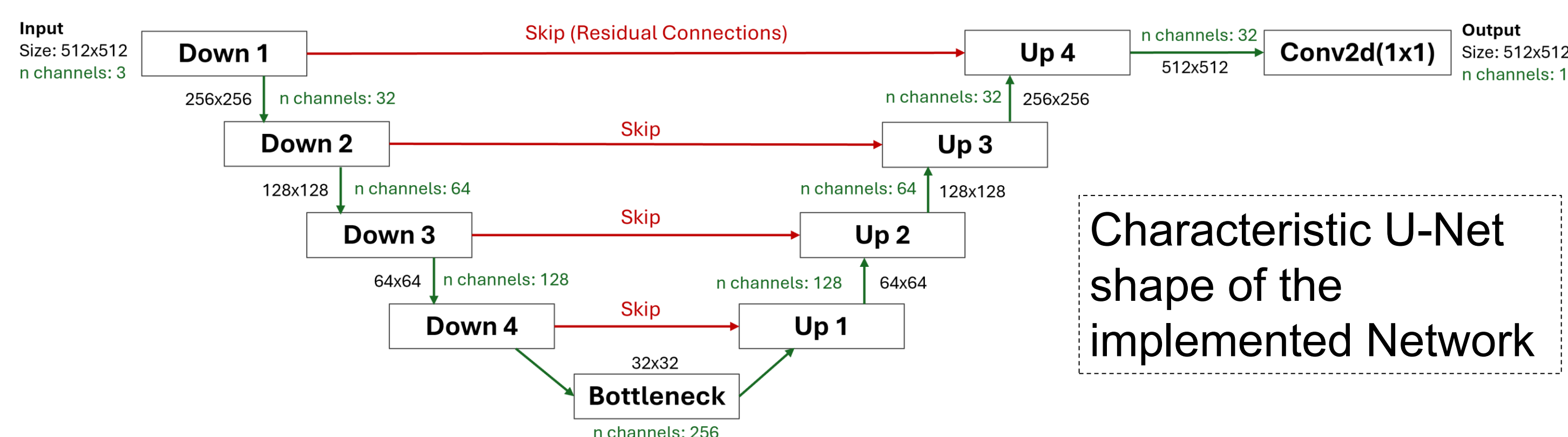
Image Capturing

- Initially supplied study data proved insufficient in quality
- Own dataset was captured
→ 192 images from 8 subjects

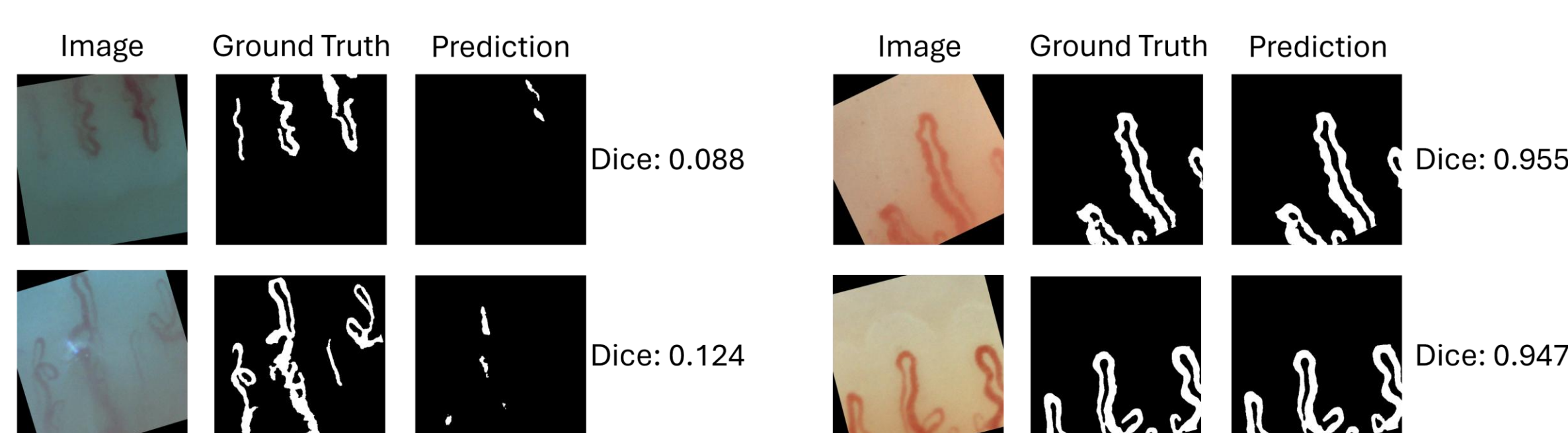


Segmentation

- Deep Learning approach: modified Res-U-Net, trained on a manually segmented subset of collected images



- Segmentation performance on validation data. Mean Dice: 0.857 ± 0.099

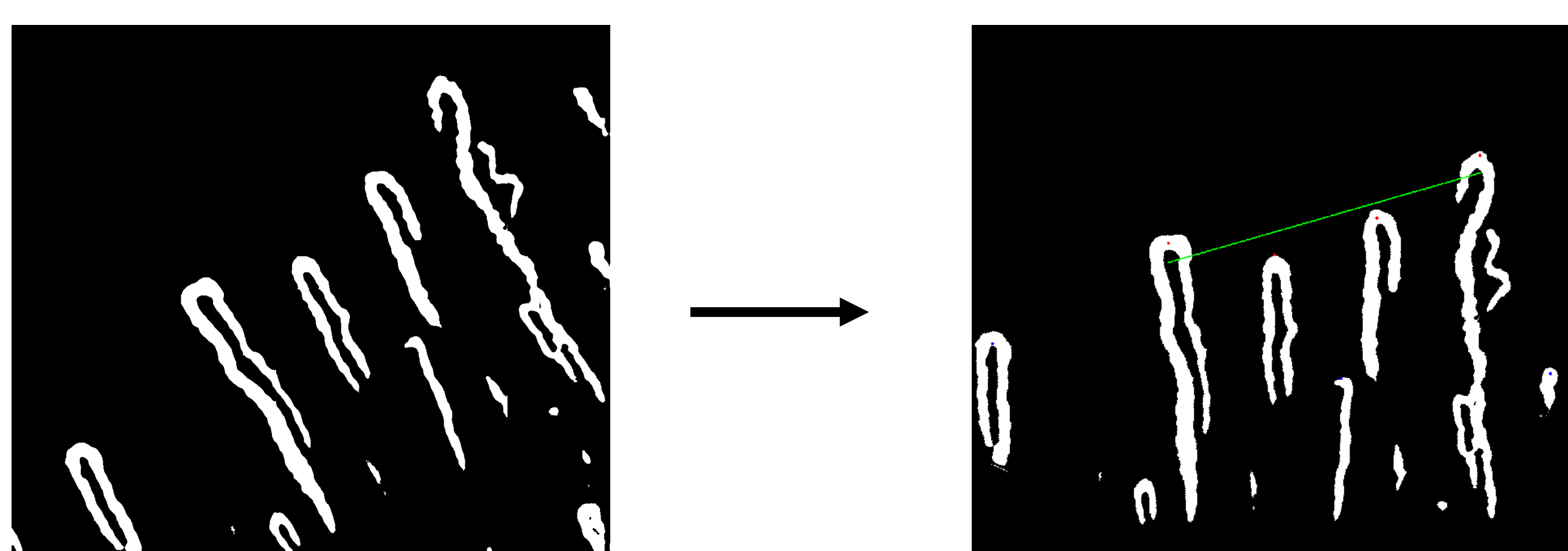


Worst Examples

Best Examples

Capillary Density Extraction

1. Rotation: PCA based rotation function to align capillaries vertically
2. Counting: Marks distal row points with filtering and the 90° method [2]
3. Density: Linear fit through points → length of distal row segment

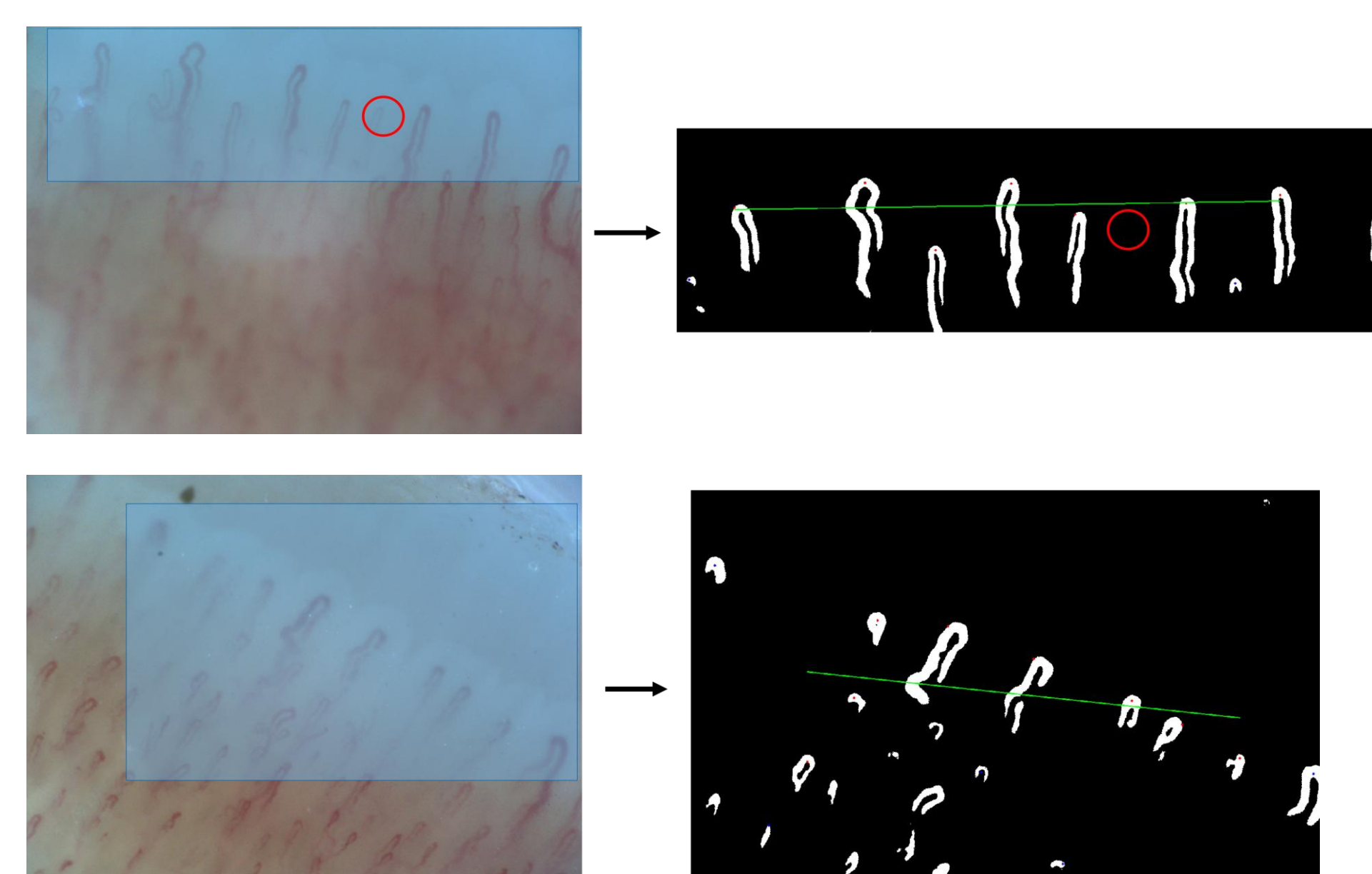


► Results

Pipeline Evaluation

- The developed pipeline is applied to all processable captured images:
→ Mean CD: 7.69 ± 1.29 capillaries/mm. This aligns well with literature [3]

- Real world examples (study images):

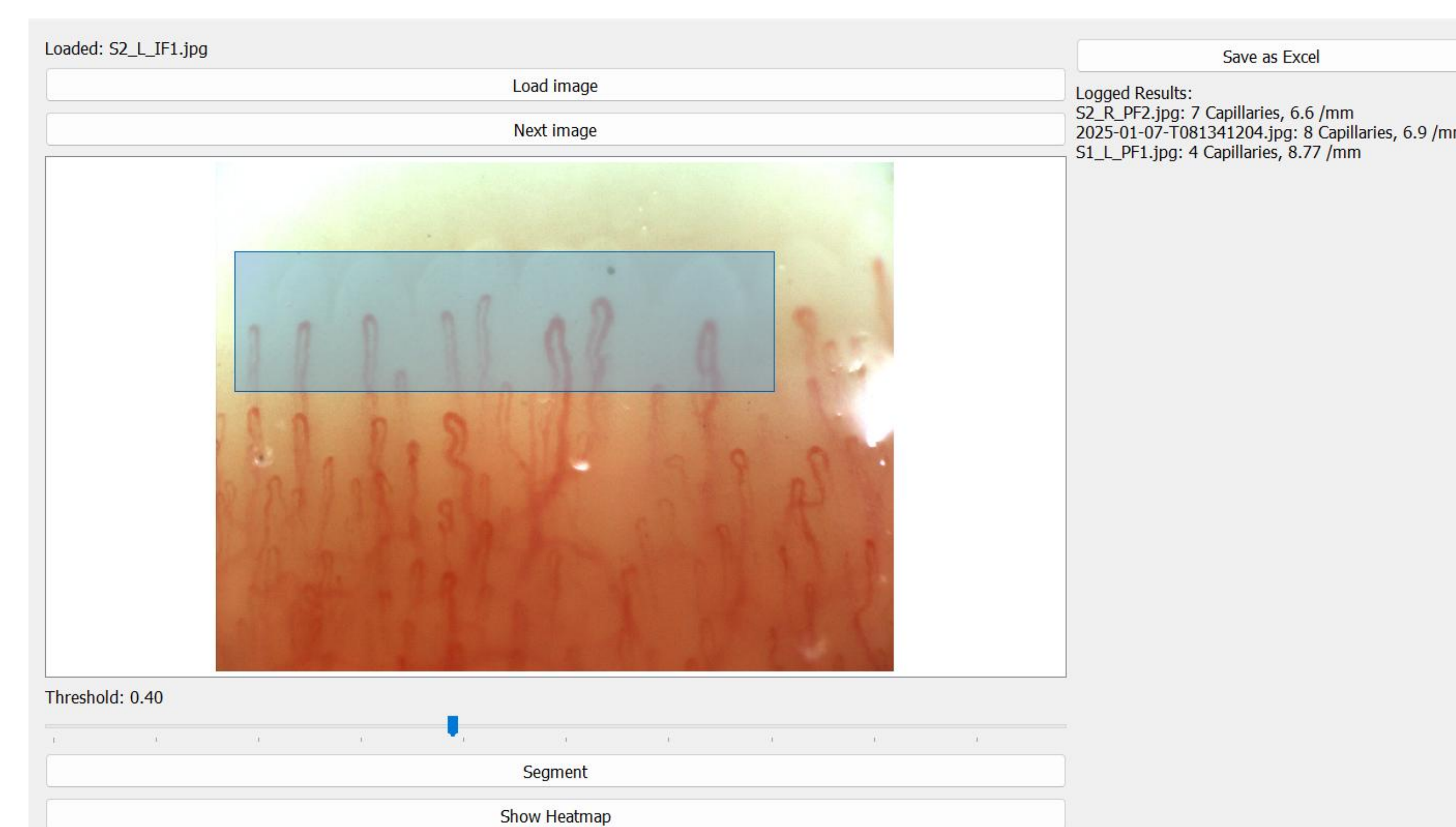


- Selected ROI is processed well
- Faint capillary is missed (red circle)

- Good segmentation of the distal row
- Rotation fails (edge case scenario)

Graphical User Interface

- A GUI was developed to embed the pipeline in a lightweight application



► Conclusion

The developed pipeline performs well under controlled circumstances but makes mistakes when presented with lesser quality images. Even though the yielding values seem plausible, no definitive statement about its accuracy can be made, as no expert-labeled data was present. After extensive validation and testing, this pipeline could contribute to capillaroscopy research by providing a fast and reproducible method for analysis.

► References:

- [1] Andrea Morelli and Maurizio Passariello. "Hemodynamic coherence in sepsis". issn:1521-6896. doi:10.1016/j.bpa.2016.10.009.
- [2] Zahra Emrani et al. "Capillary density: An important parameter in nailfold capillaroscopy". issn: 00262862. doi:10.1016/j.mvr.2016.09.001.
- [3] Deepak Jakhar, Chander Grover, and Archana Singal. "Nailfold capillaroscopy with USBdermatoscope: A cross-sectional study in healthy adults". issn:0378-6323. doi: 10.4103/ijdv.IJDVL_240_18.

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