

Introduction

- Retinal vessels identification plays a critical role in **computer-aided diagnosis** and analysis of fundus images.
- Deep-Learning-based segmentation methods have shown remarkable performances in handling detailed and pathological fundus, but they produce **disconnected components** whereas retinal vessels are a **connected** structure.
- Linked to a project aiming to **detect the Alzheimer's disease from measurements extracted in the eye**, we developed a **post-processing** pipeline **to ensure a connected structure** for the retinal vessels networks.

Fundus

Segmentation



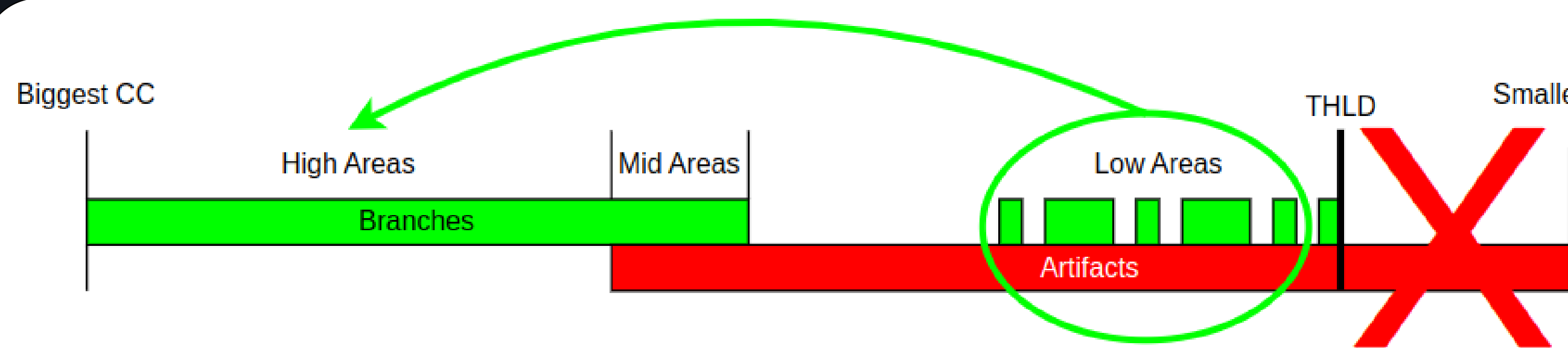
Retinal Vessel

Line-shaped pathology

Artifact

Choroidal Vessel

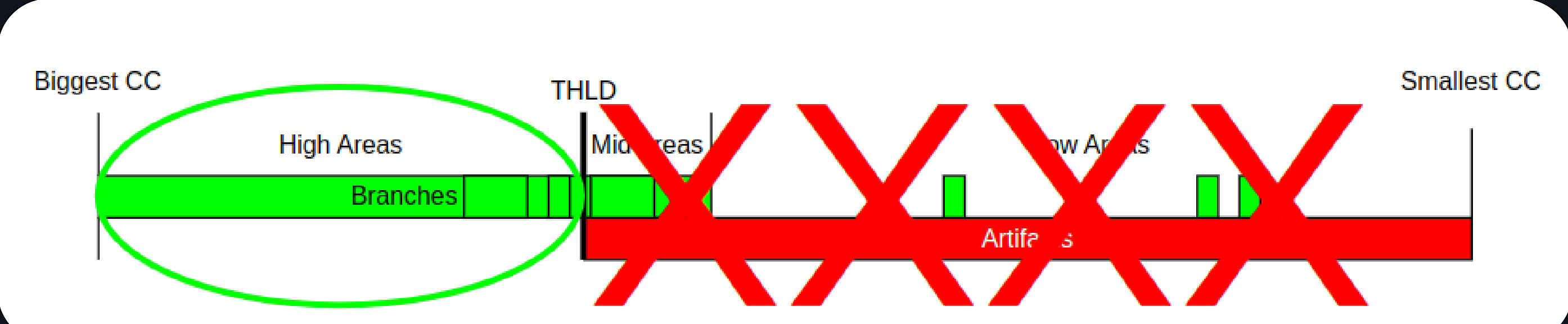
Step 1: Artifact Removal & Gap Filling



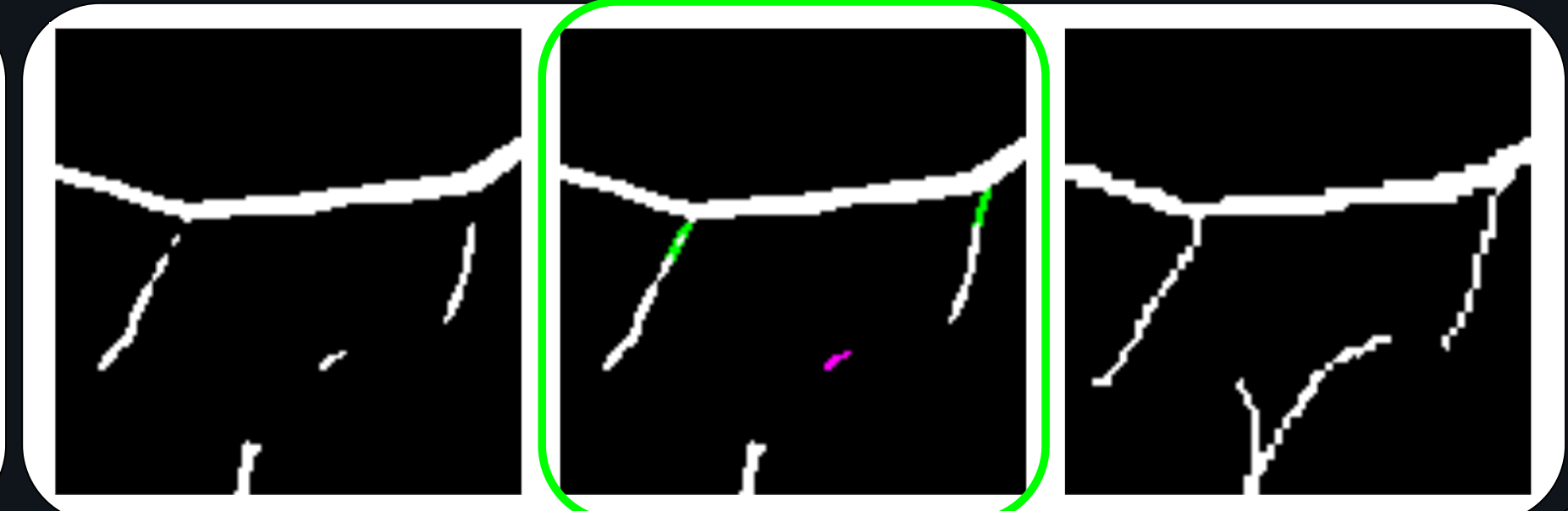
- Over 5 pixels area
- Skeleton
- Endpoints/Crosspoints
- Mutual Closest pairs
- Different CC
- Max 45 degrees deviation from a straight line



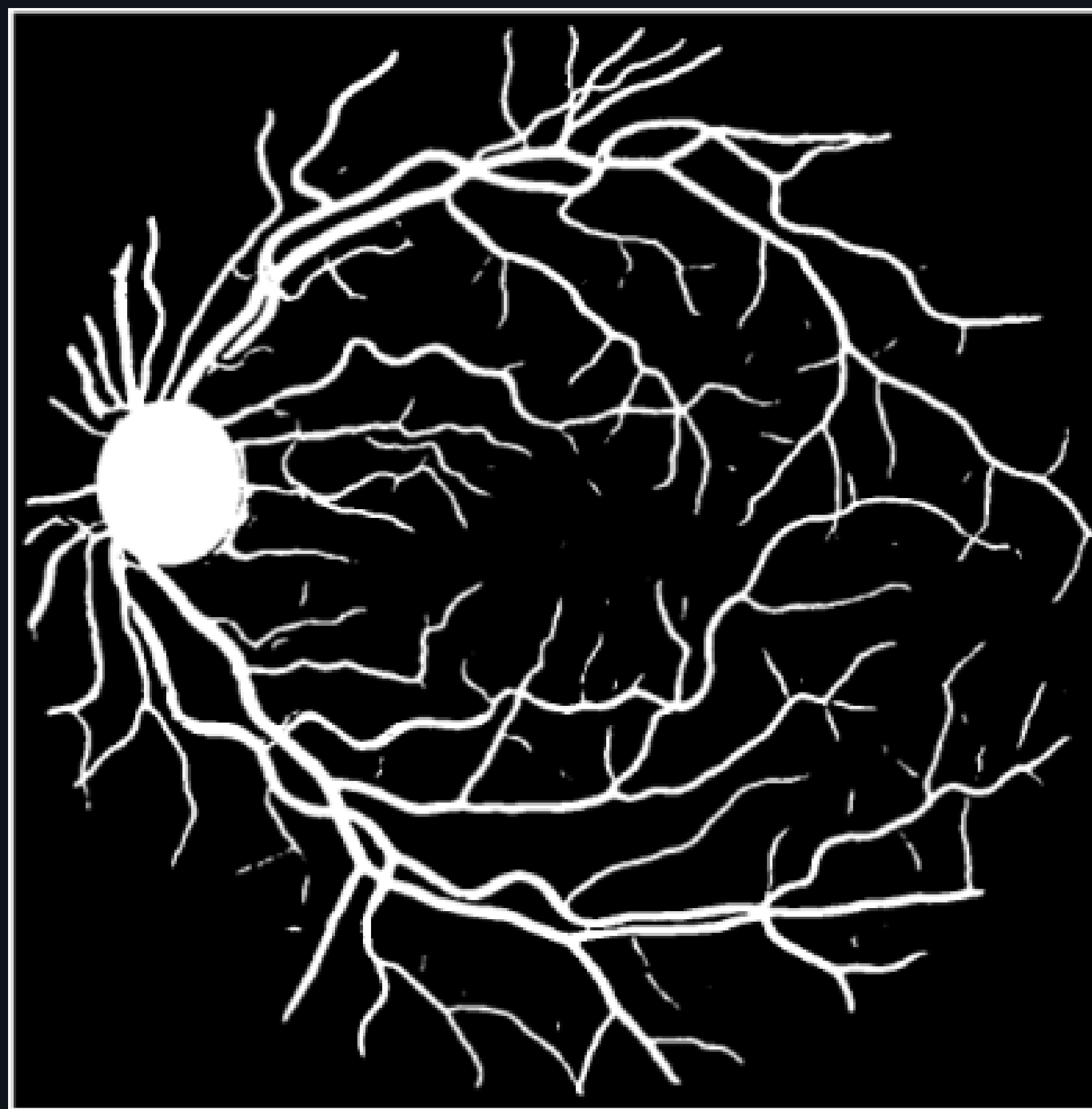
Step 2: Rebranch or Remove the remaining CCs



- Biggest CC / Smaller CCs
- Skeleton
- Endpoints/Crosspoints
- Linear path: closests smaller CCs endpoint/biggest CC
- Path has to be smaller than the length of the smaller CC.



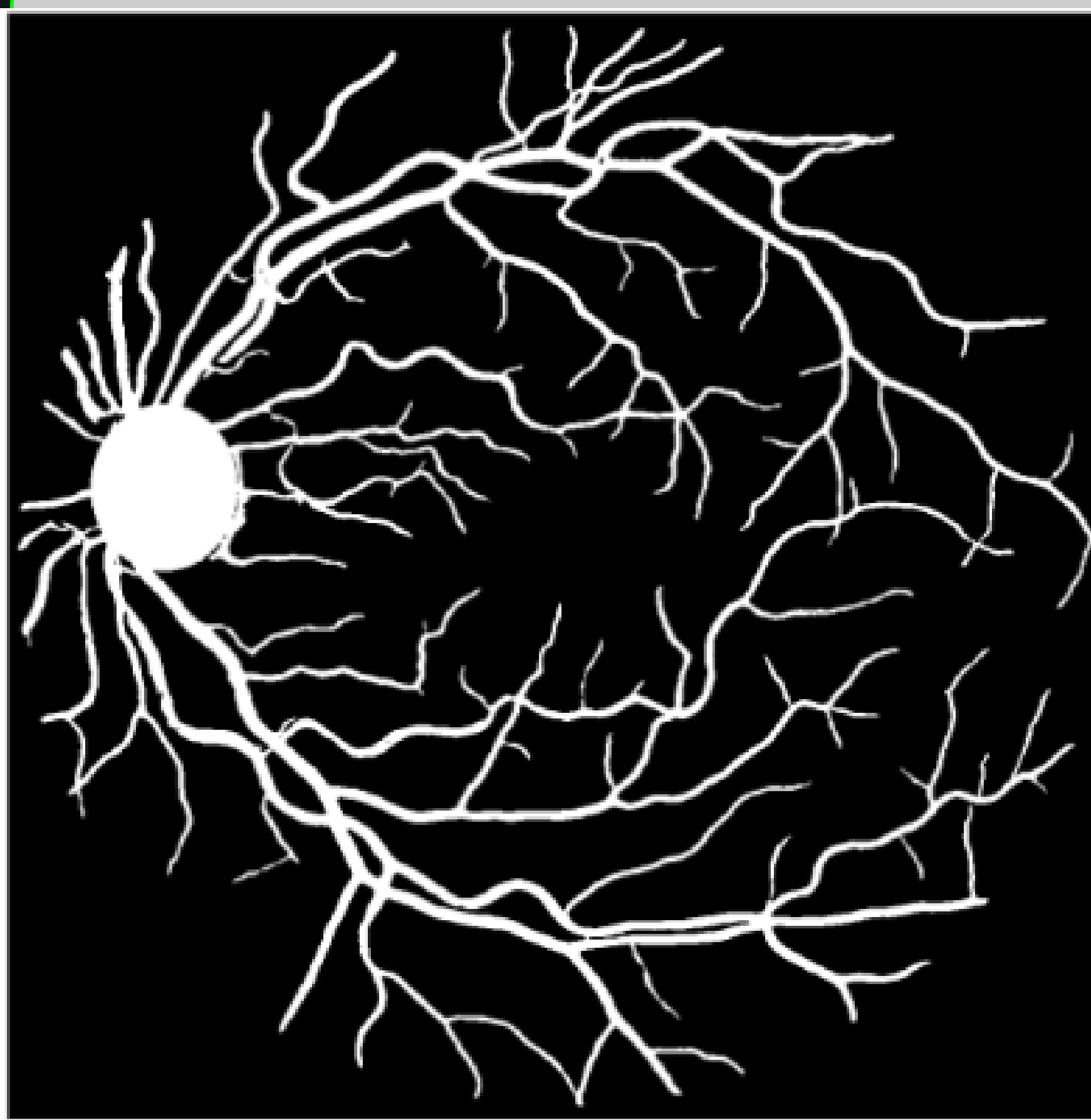
Deep-Learning Predicted segmentation



Dice: 0.847

CC: 77

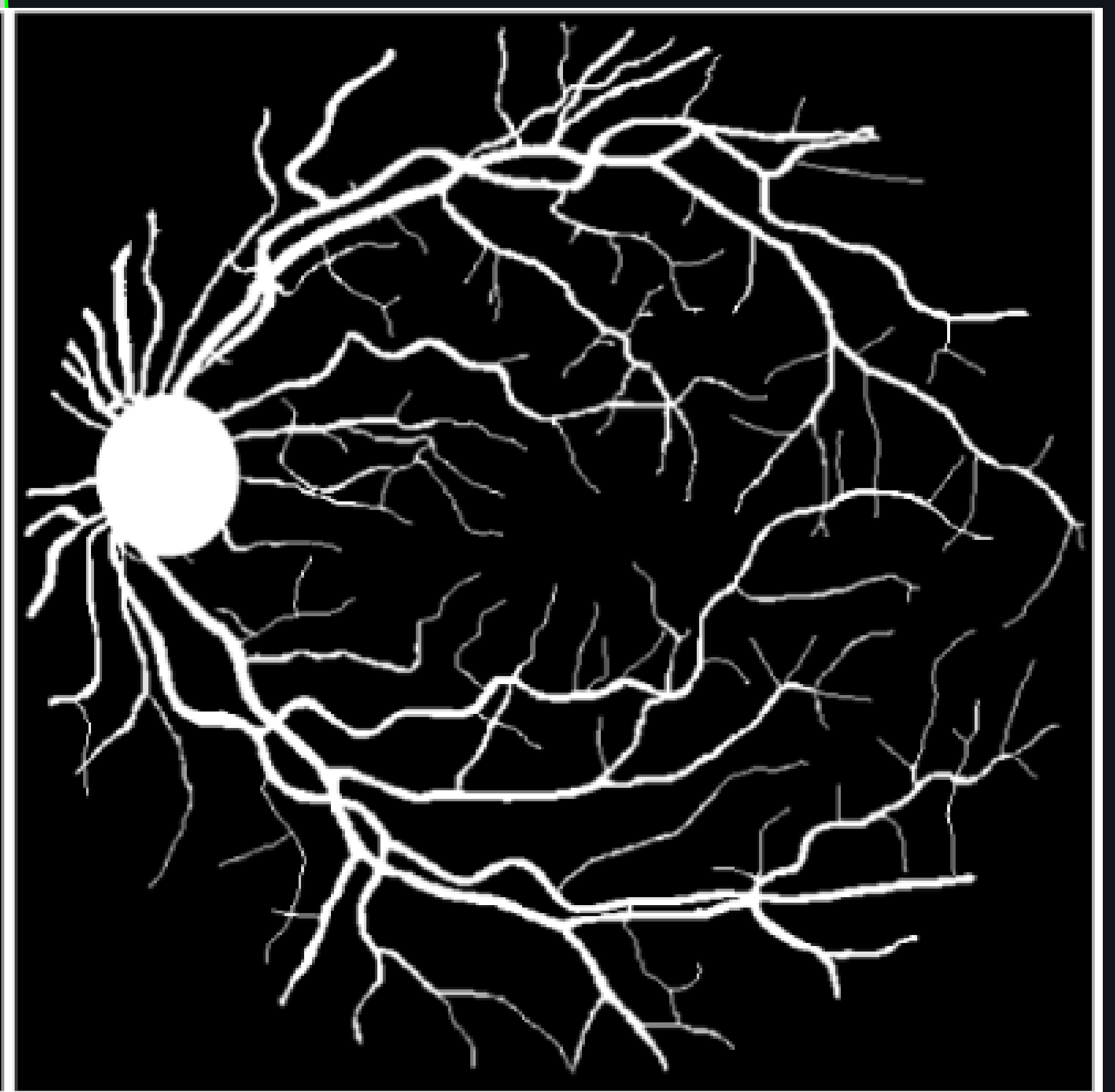
Segmentation after post-processing



Dice: 0.848

CC: 1

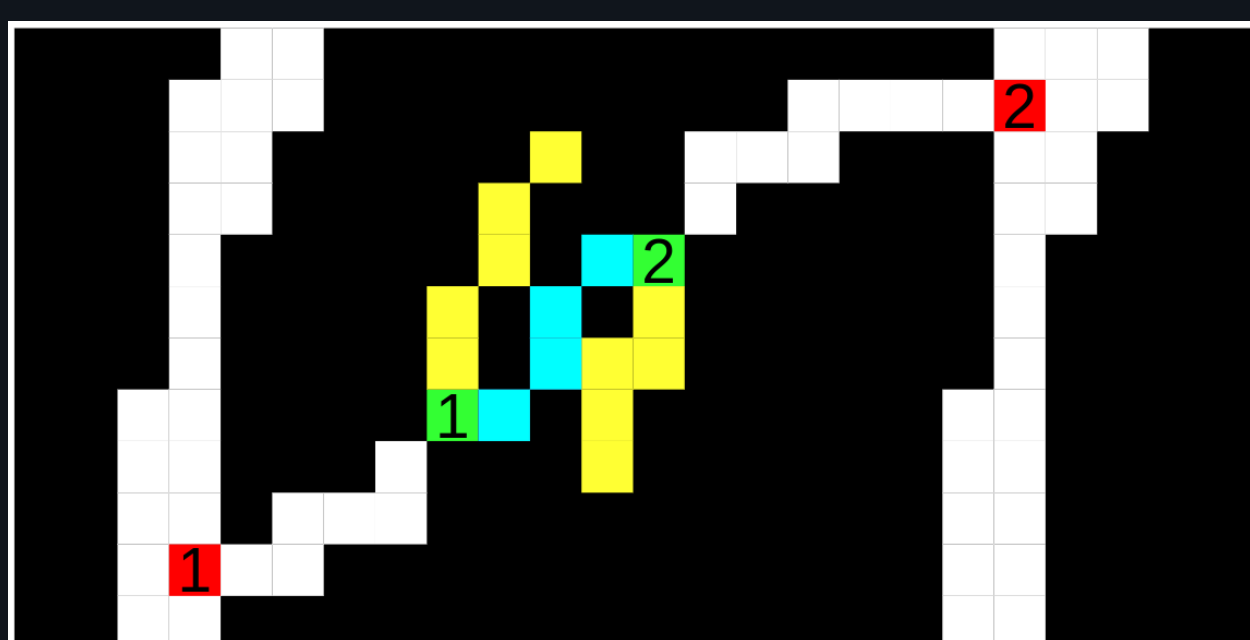
Groundtruth



Dice: 1.0

CC: 1

Inner branches reconnections



1-2 is a closest pair of endpoints (green). 1-1 and 2-2 are endpoint-crosspoint (red) pairs. The pair of 1 goes top/right and the pair of 2 goes bot/left. The endpoint 1 is positioned at bot/left of the endpoint 2. There are no vessels between endpoints pair 1-2. Yellow and cyan paths are anatomically coherent vessels patterns.

Conclusions & Future works

- The method ensures a **connected structure** for retinal vessels Deep-Learning segmentation.
- The method **enables measurements** as vessels length, vessels tortuosity, depth of the vessels tree structure, ... in a more **reliable manner**.
- Vessel paths are unpredictable** due to the **individuality of vessel** structures, making it firmly impossible to assert a **path correctness**.
- Two** avenues to explore:
 - Rely on **mean measurements** for diagnosis while acknowledging **limitations**.
 - Develop diagnostic strategies that **directly analyze fundus** images to **overcome segmentation-related drawbacks**.