

# TRAINABLE V4-LIKE FILTERS FOR DETECTING RETINAL VASCULAR BIFURCATIONS



Azzopardi G.



Petkov N.



University of Groningen, The Netherlands

{g.azzopardi, n.petkov}@rug.nl

## Abstract

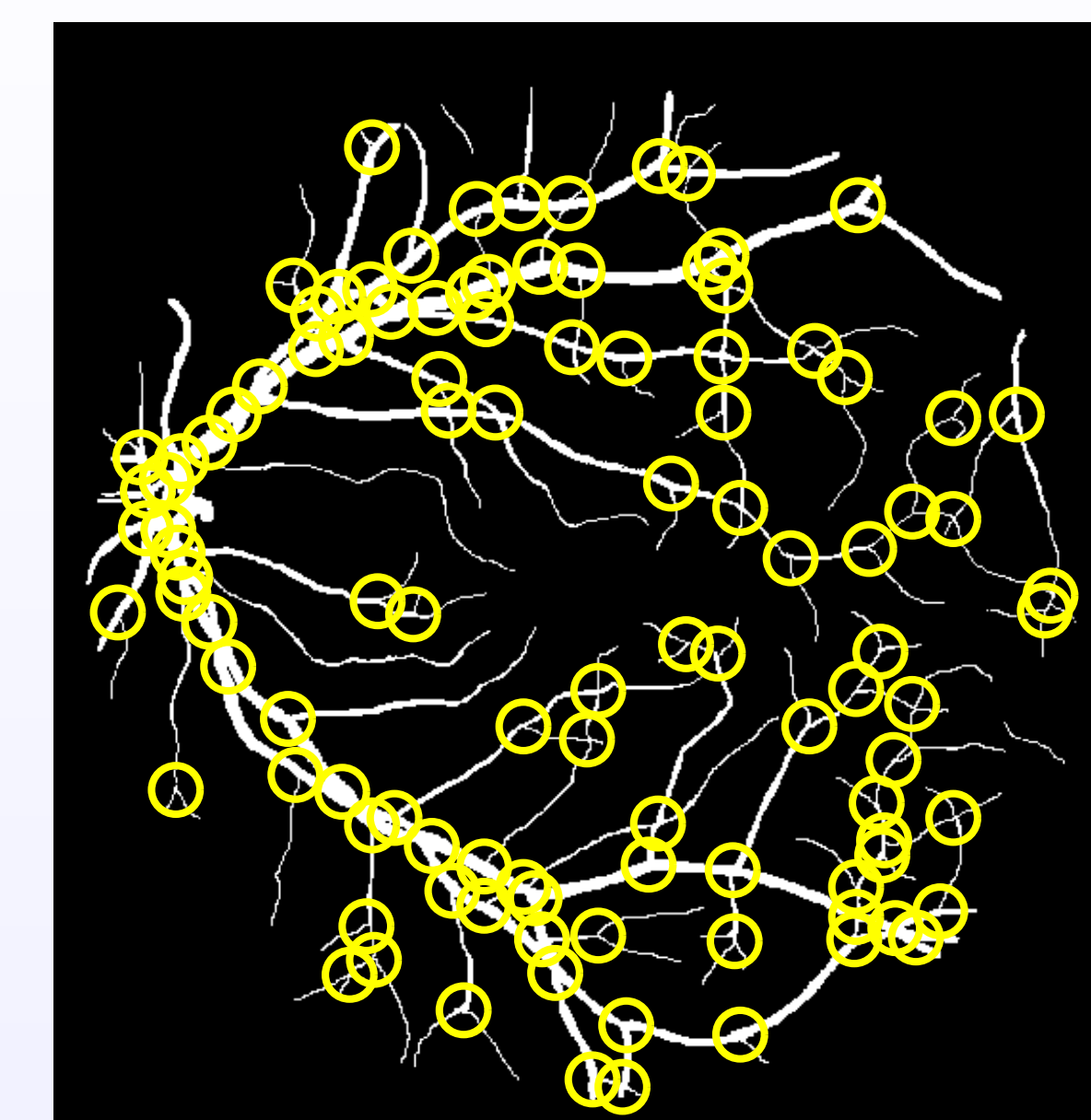
- We propose a novel method to detect vascular bifurcations in retinal fundus images.
- Our method is implemented in **trainable filters** that mimic the properties of some **neurons in area V4** of visual cortex.
- Such a filter is configured by combining given channels of a bank of Gabor filters using an **AND-type** operation.
  - Their selection is determined by an **automatic analysis** of a user-specified feature.
- With only 25 filters we report a **recall rate of 98.52%** at a **precision rate of 95.19%** on 40 images.

## Motivation

To automate a time consuming manual process



Retinal fundus image



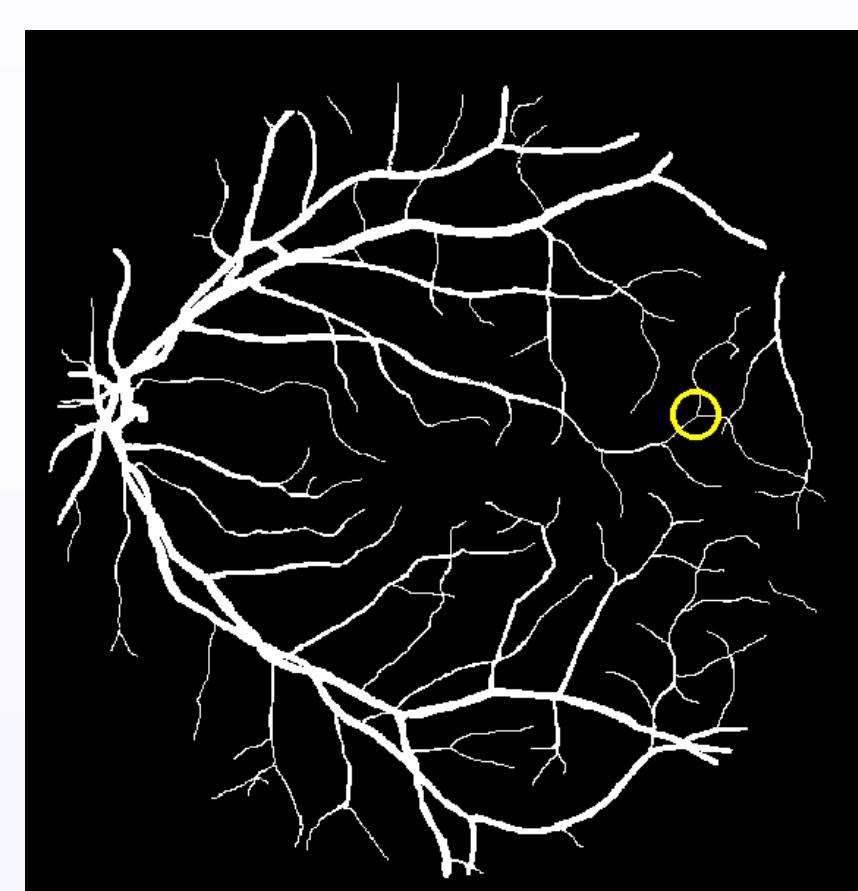
Marked bifurcations

## Method: Filter configuration

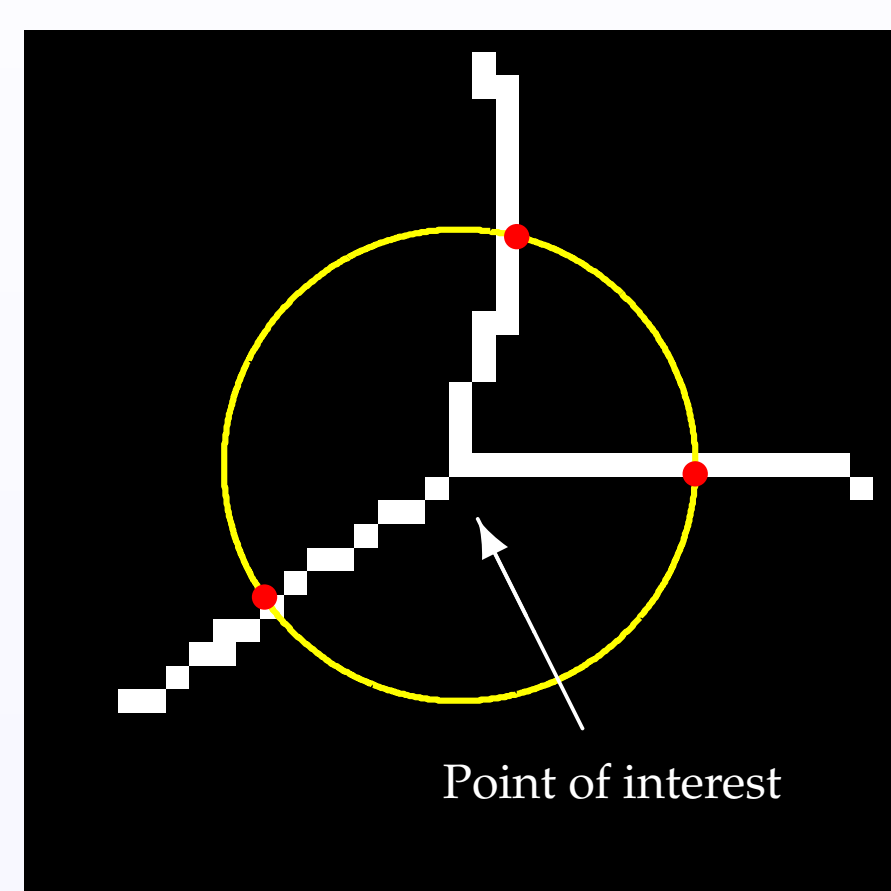
### a. Automatic analysis of a specified feature

Extract information about:

- Dominant oriented line segments (red markers) around the point of interest



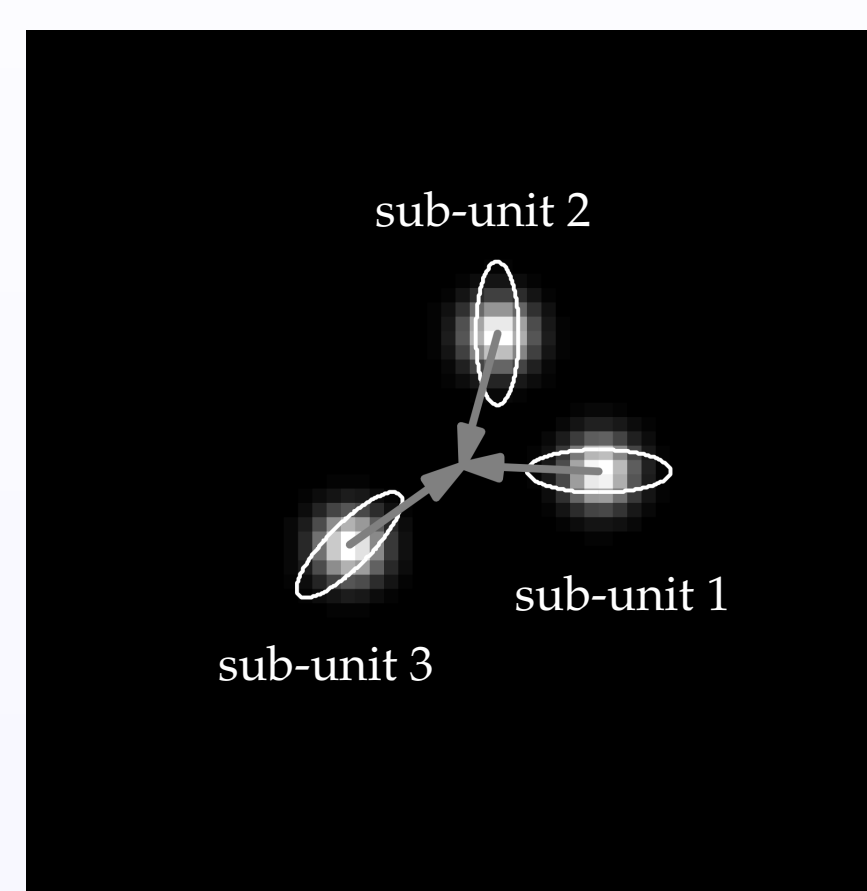
User selects a feature



Selected feature

### b. Configuration of sub-units

Sub-units: detectors of line segments

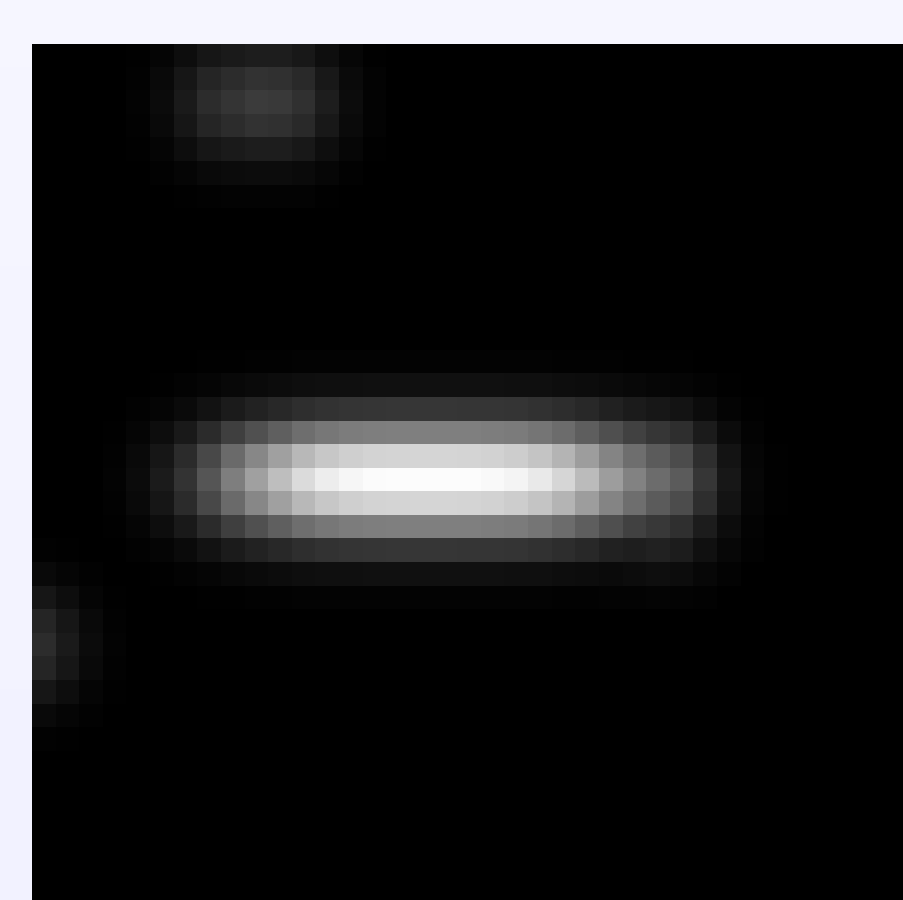


Configured sub-units

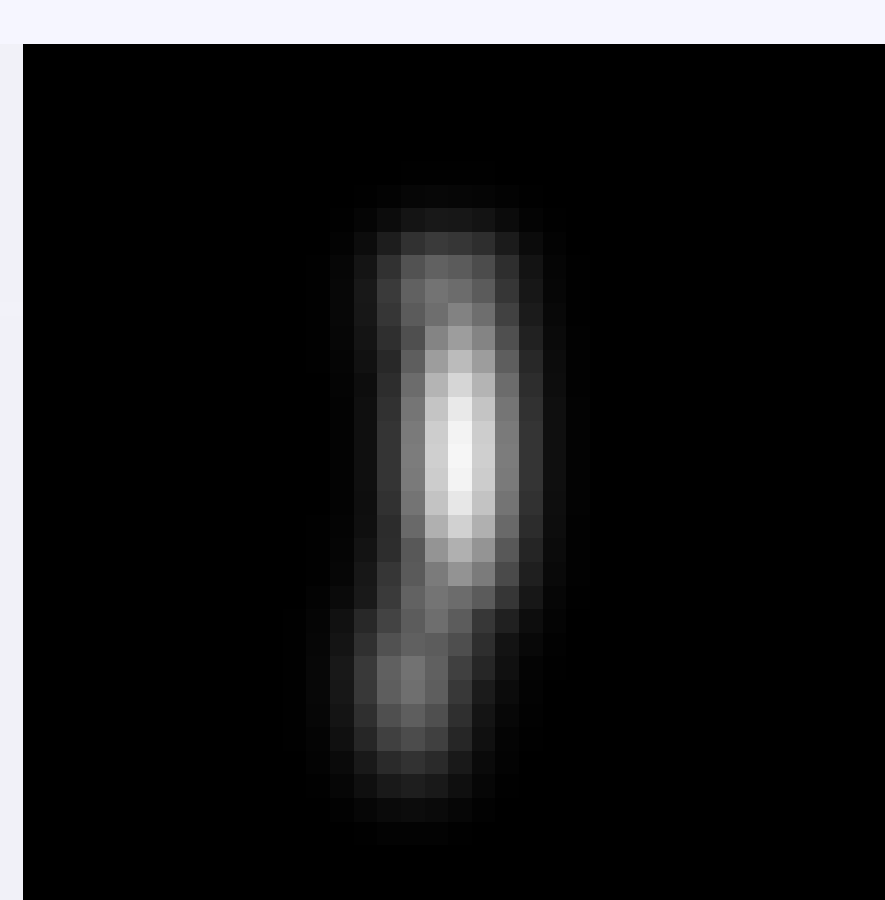
Computation of a sub-unit output at position  $(x, y)$ :

1. Filter image with a **Gabor filter** (bright ellipse) of preferred orientation and wavelength
2. **Weight** the responses of the Gabor filter with a **Gaussian function** (circular blob) centered at  $(x, y)$
3. Output is the **maximum** value of the weighted responses, **shifted** in the direction of the arrow

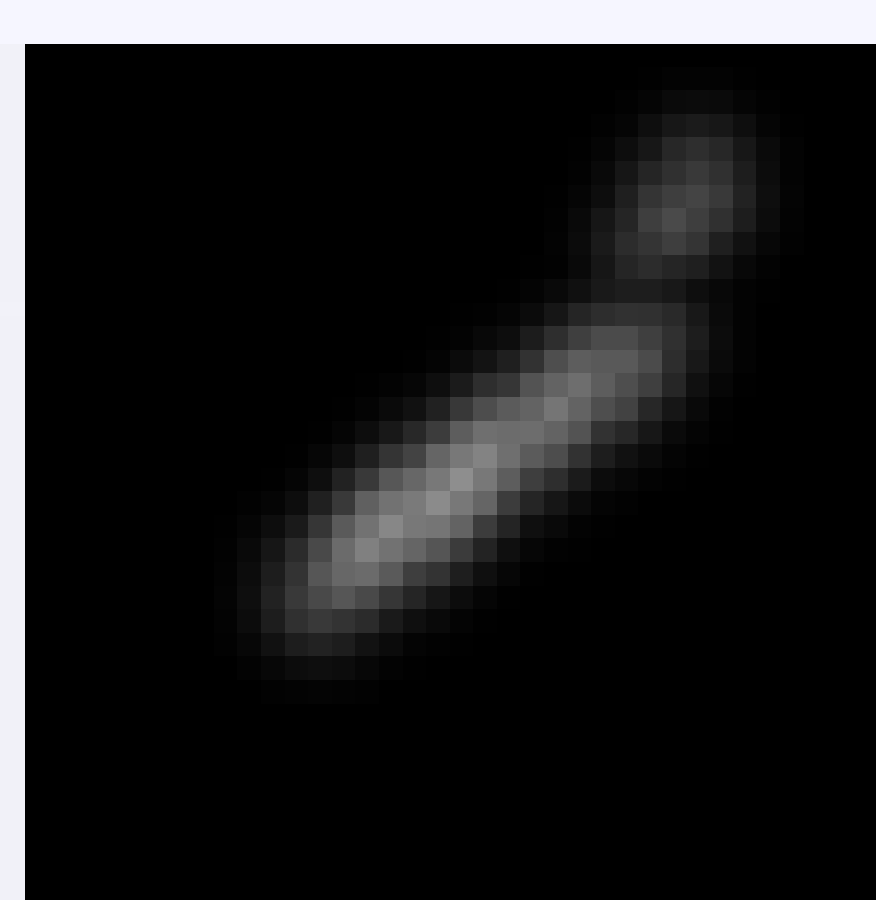
### c. Combine sub-unit responses



Sub-unit 1 output

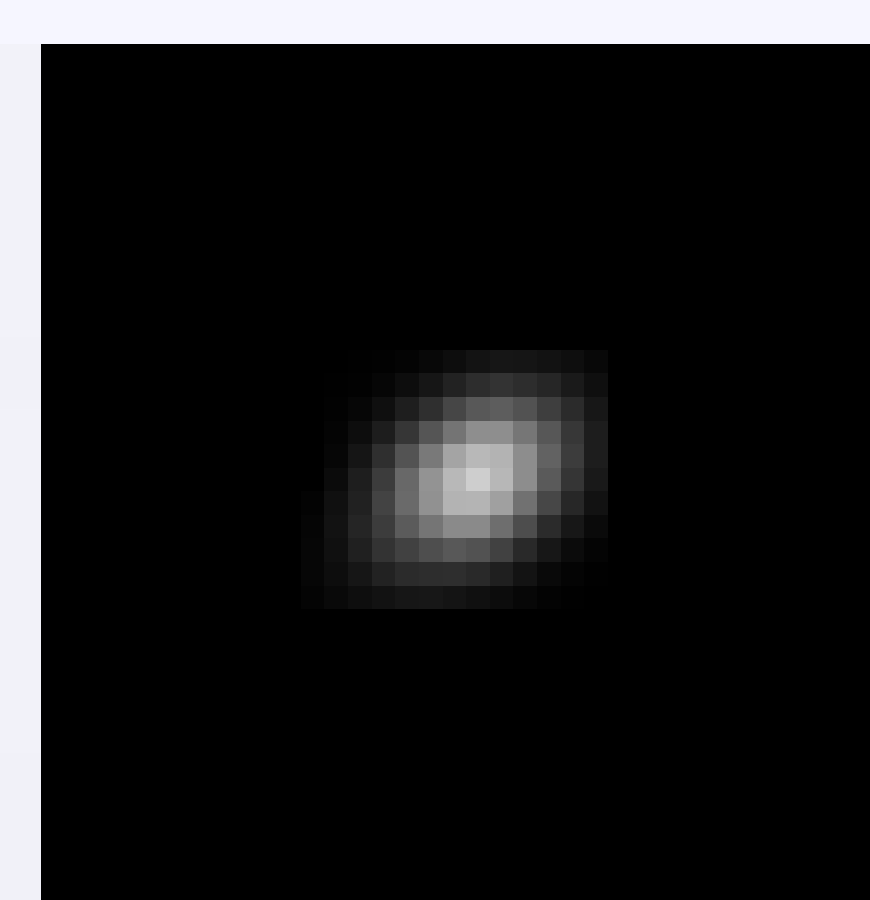


Sub-unit 2 output



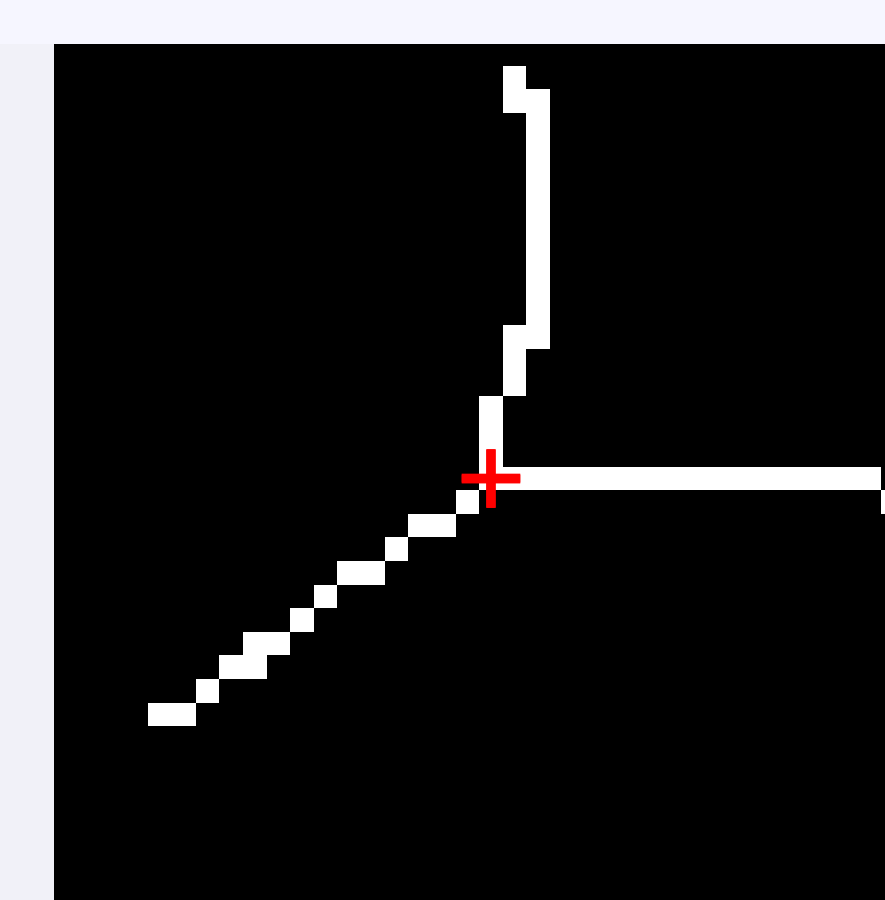
Sub-unit 3 output

=



Filter output

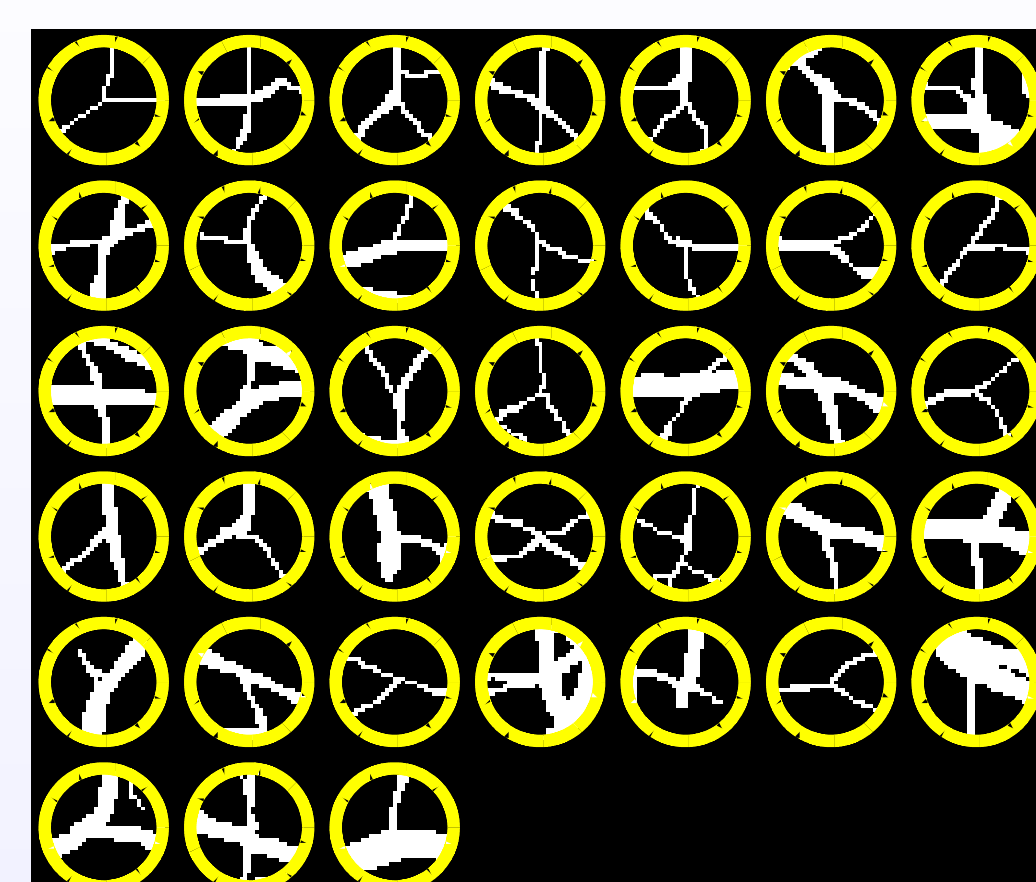
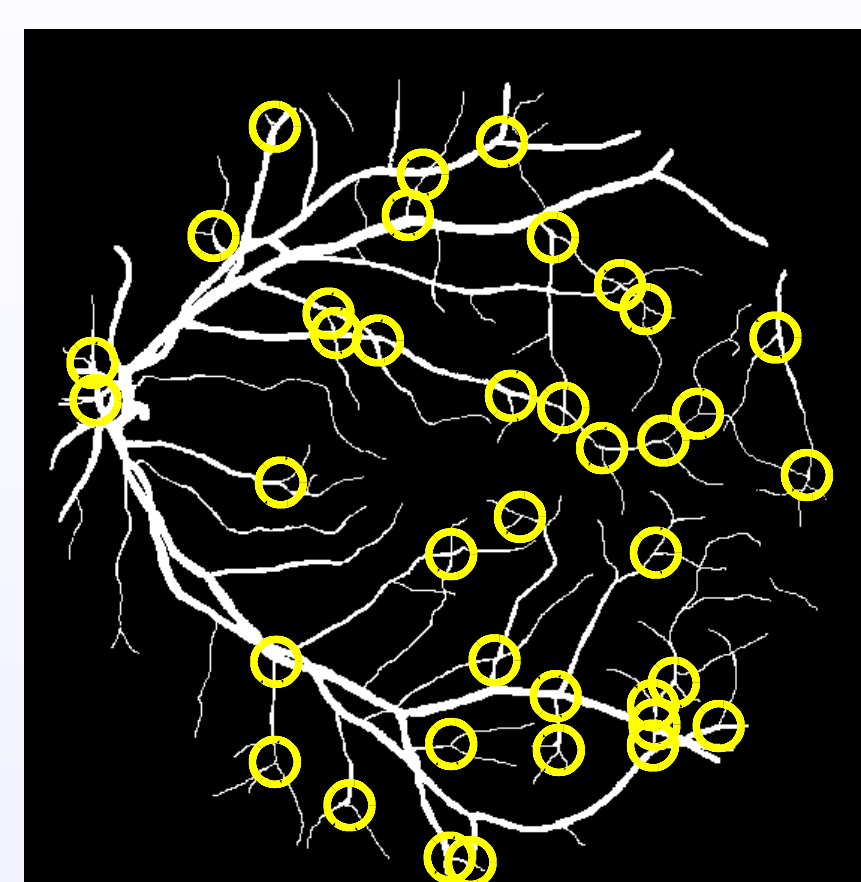
→



Local maximum

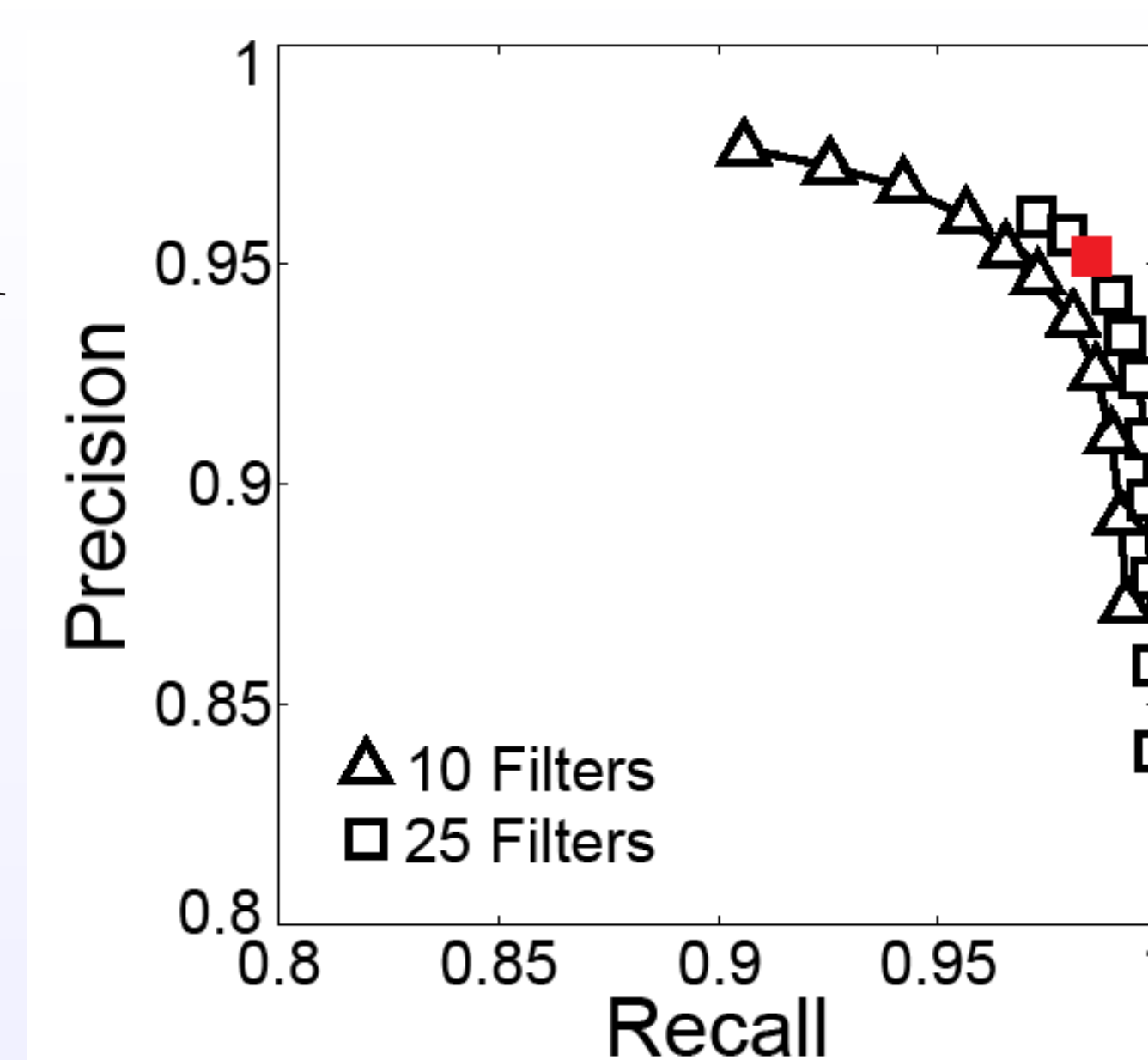
## Filter application example

A single filter detects 38 out of 107 bifurcations



## Results

- **Dataset:** 40 binary images from the DRIVE dataset [1]
- **Results**
  - Recall rate: 98.52%
  - Precision rate: 95.19%



## Conclusion

- **Effective** for the concerned medical application
- **Trainable filters** can be used in various applications

## Reference

- [1] Staal J., Abramoff M.D., Niemeijer M., Viergever M.A., van Ginneken B., Ridge-based vessel segmentation in color images of the retina, in *IEEE Transactions on Medical Imaging*, 2004