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Automated analysis of retinal images

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Outline

- Scale-space filtering
- Retinal image segmentation algorithm (RISA)
- Maximum likelihood estimation
- Retinopathy of prematurity and tortuosity

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Introduction

Many diseases result in retinal changes:

- ROP – engorgement and tortuosity of blood vessels
  - Treatable, but small therapeutic window (days)
- Diabetic retinopathy – major digital retinal image screening programme.
- Hypertension

Examination of retinal blood vessels -> monitoring of diseases

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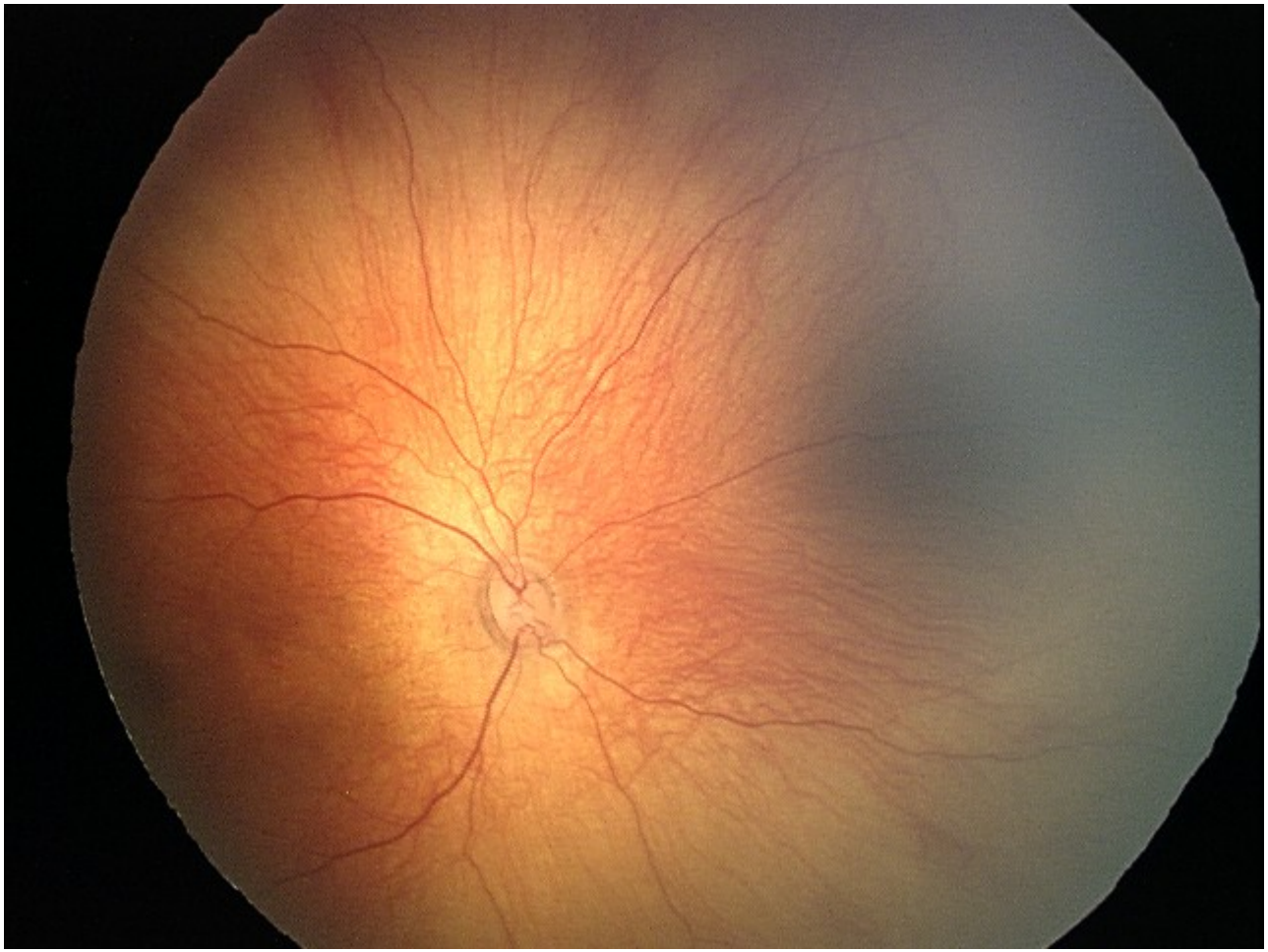
Non-ROP Preterm Example



Infant without ROP (GA 30 weeks, BW 1050g) (City Univ)

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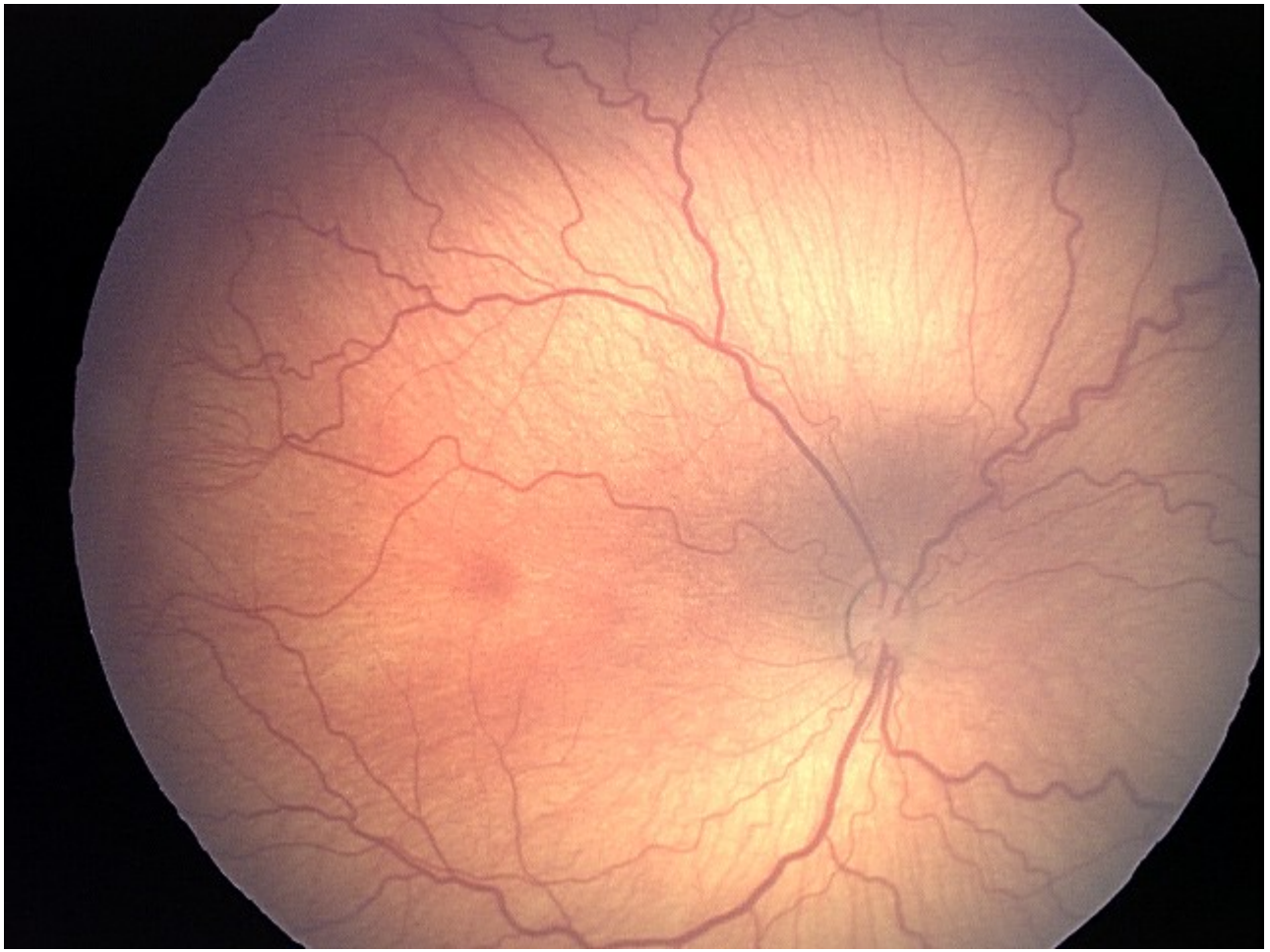
(Treated) ROP Example



Infant with treated ROP (GA 27 weeks, BW 870g) (City Univ)

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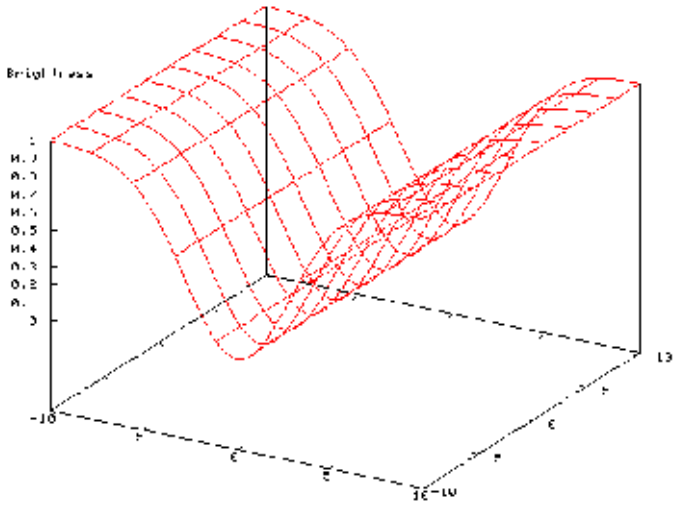
Filtering for vessel-type features



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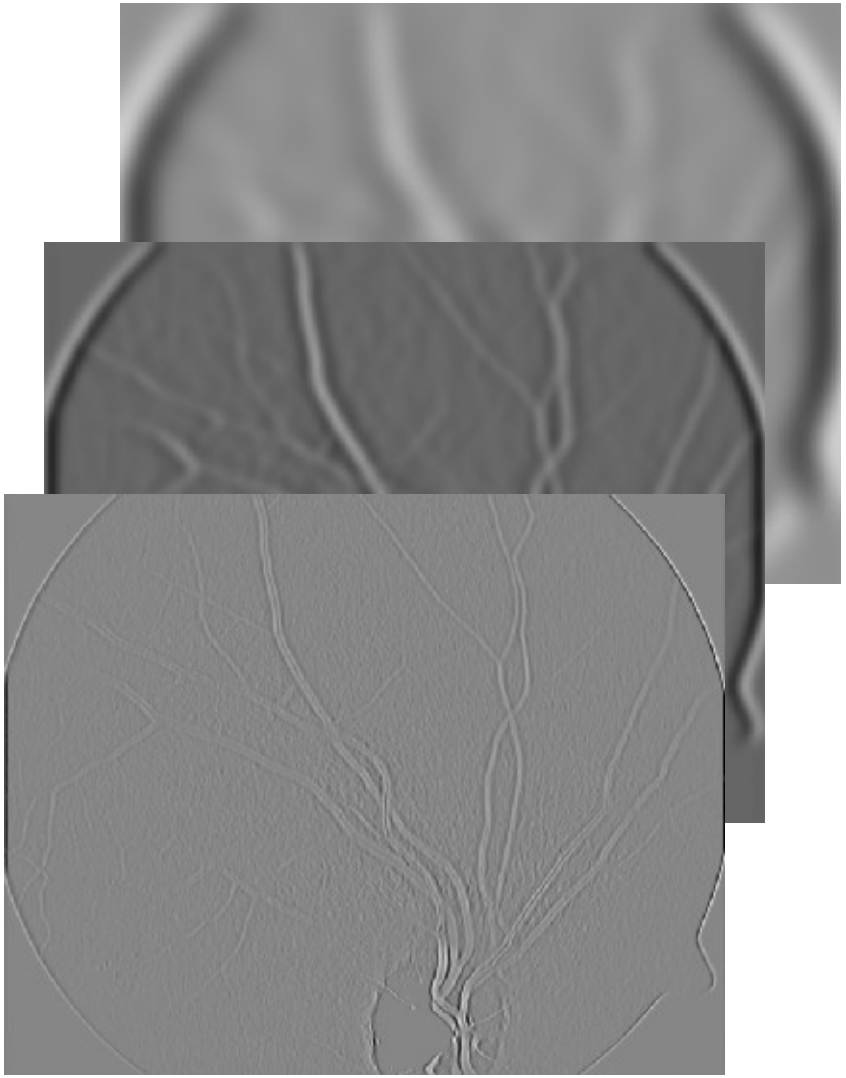
Scale space filtering



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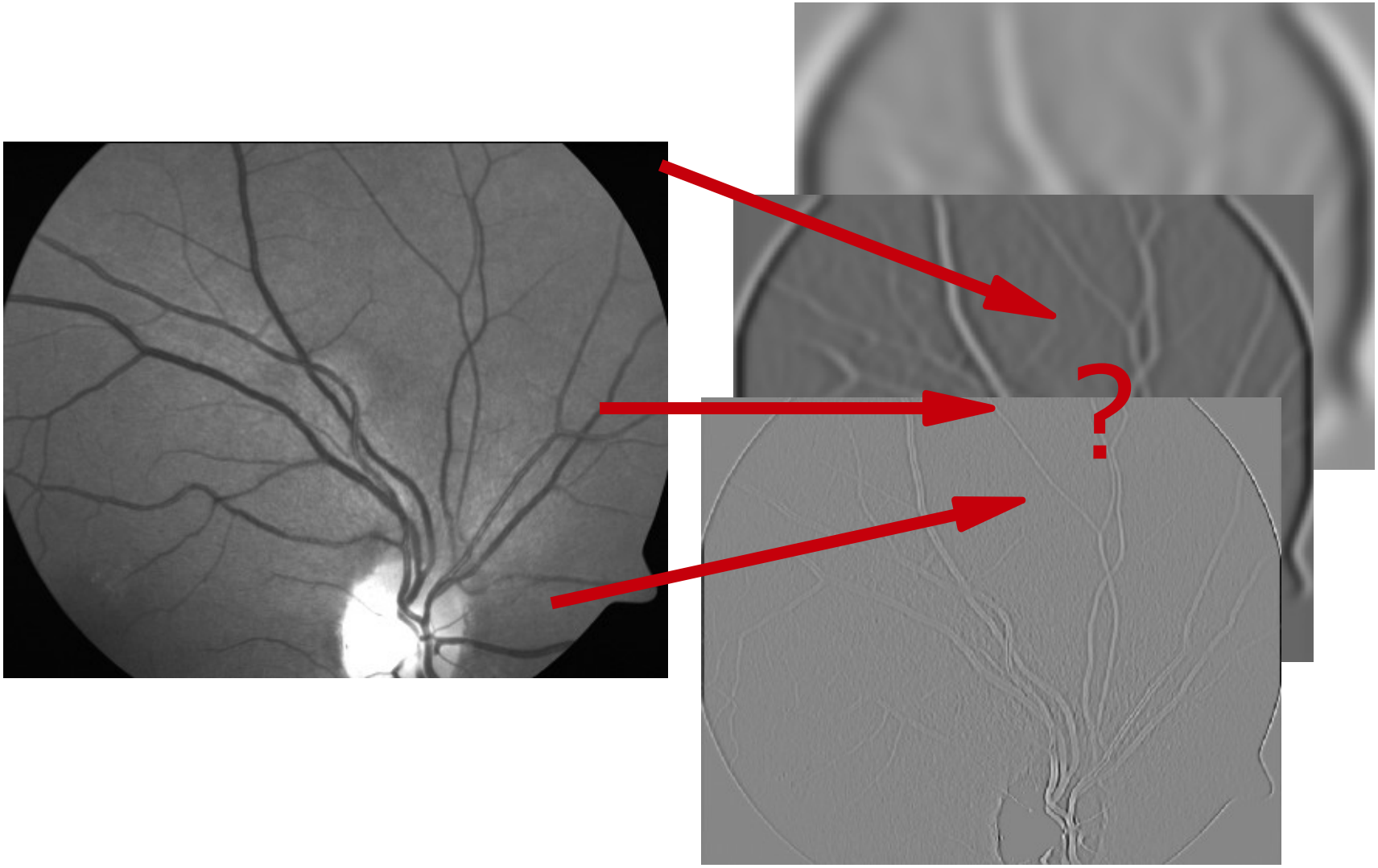
Scale space filtering



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Retinal Image Segmentation Algorithm (RISA)

- Obtain local curvatures and gradients
- Choose strongest response across the different scales
- Threshold to obtain seed points for a region growing algorithm:
  - High local curvatures, low gradient indicate vessel
  - Low local curvatures, low gradient indicate background
- Seed and run the region growing algorithm

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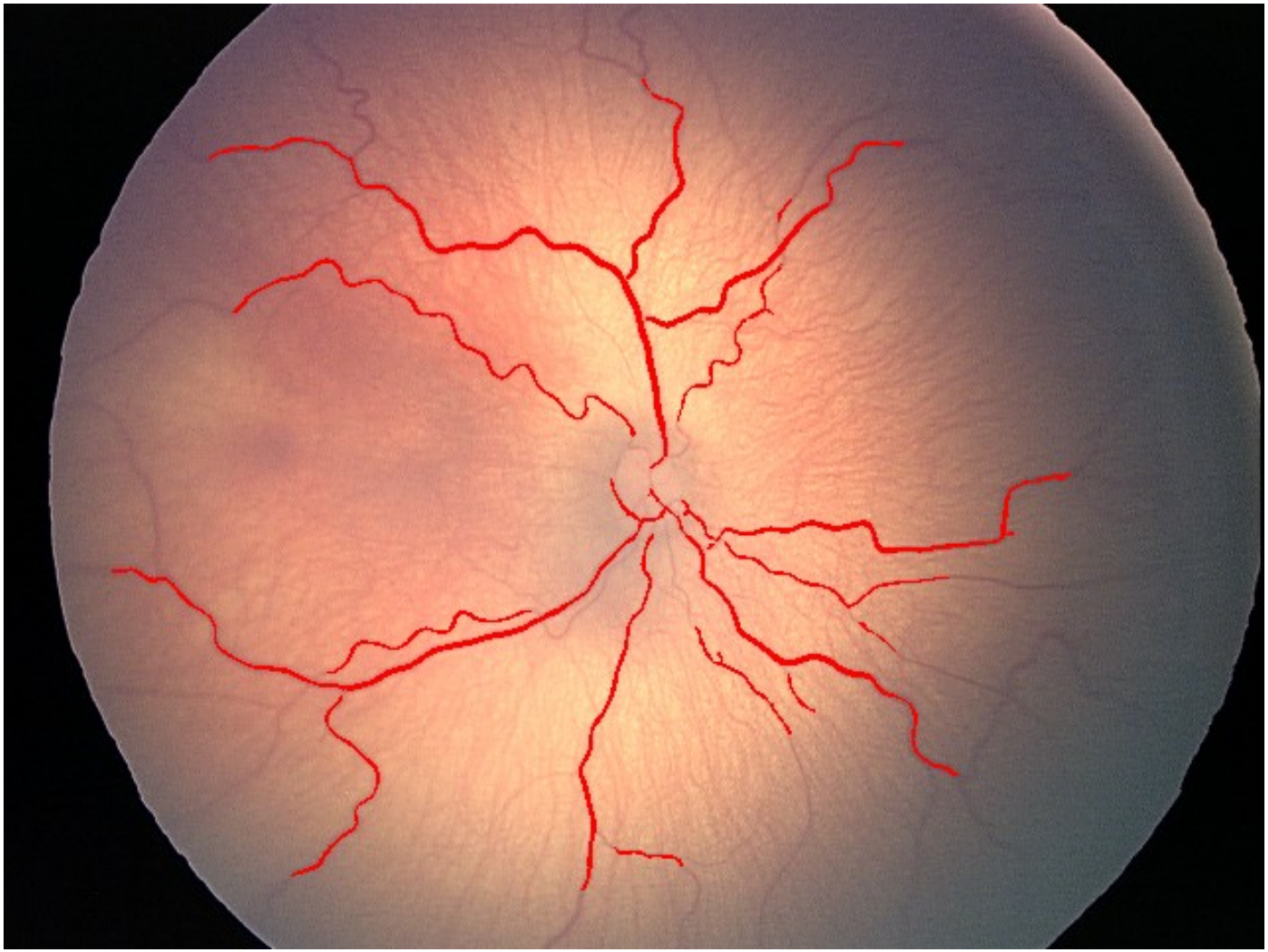
RISA



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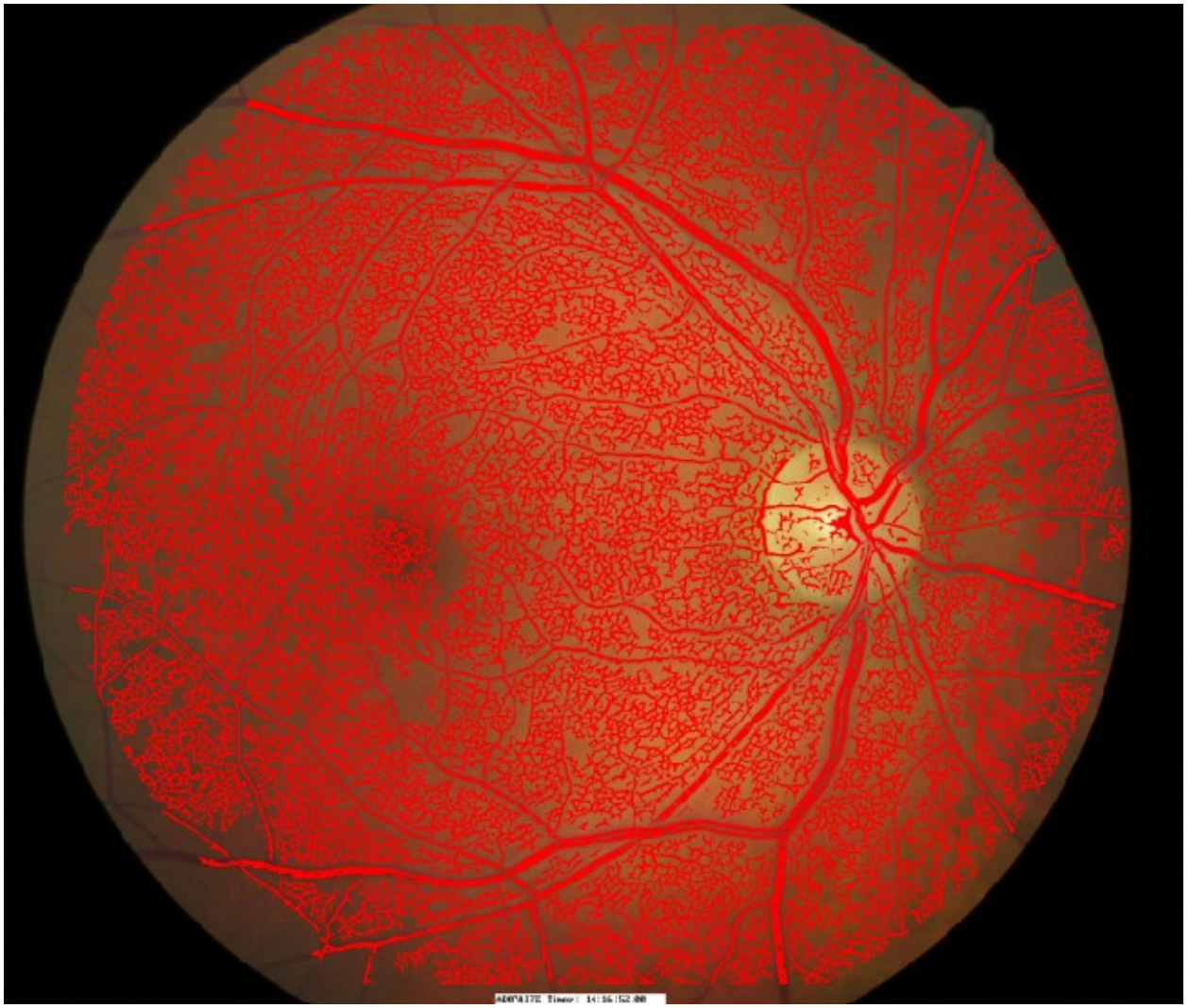
RISA



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RISA Problems

Region growing reliability:

- Disjoint vessels never marked
- Runaway marking of background

Only information from the strongest scale is used, the rest discarded

Output is simple binary classification of vessel/background for each image pixel

Maximum likelihood estimation

Model the image as vessels and noise:

- Use a parameterized model for blood vessel structures :
  - Gaussian shaped valley profile with parameters:
    - vessel width, height (contrast), orientation
- An estimated model for the image noise.

From the model, calculate the likelihood that image data are due to a putative vessel.

Maximize the likelihood to find the "most-likely" of the vessel parameters

Uses the outputs of the scale-space filtering as the "input data."
Local estimates -> fast

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Simple thresholding

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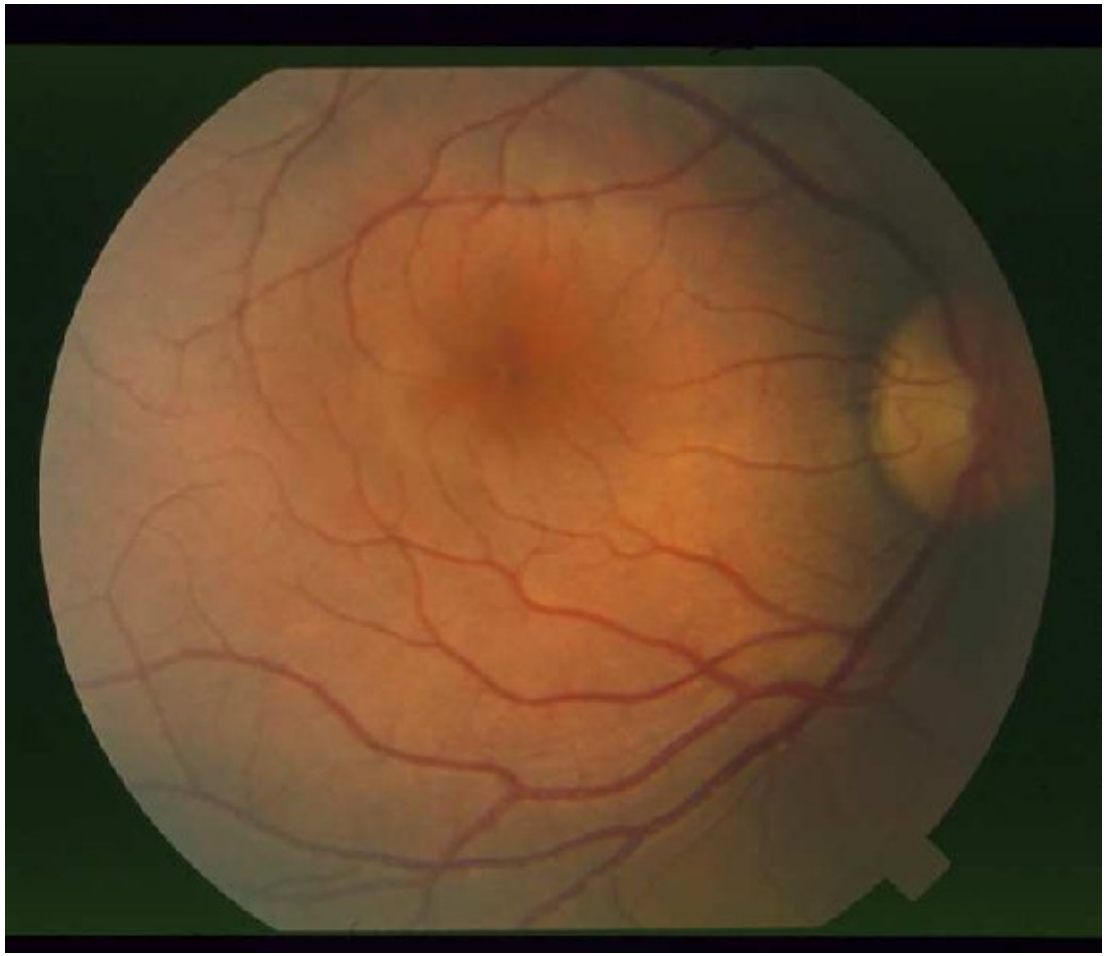
Example: (STARE datebase image 0240)



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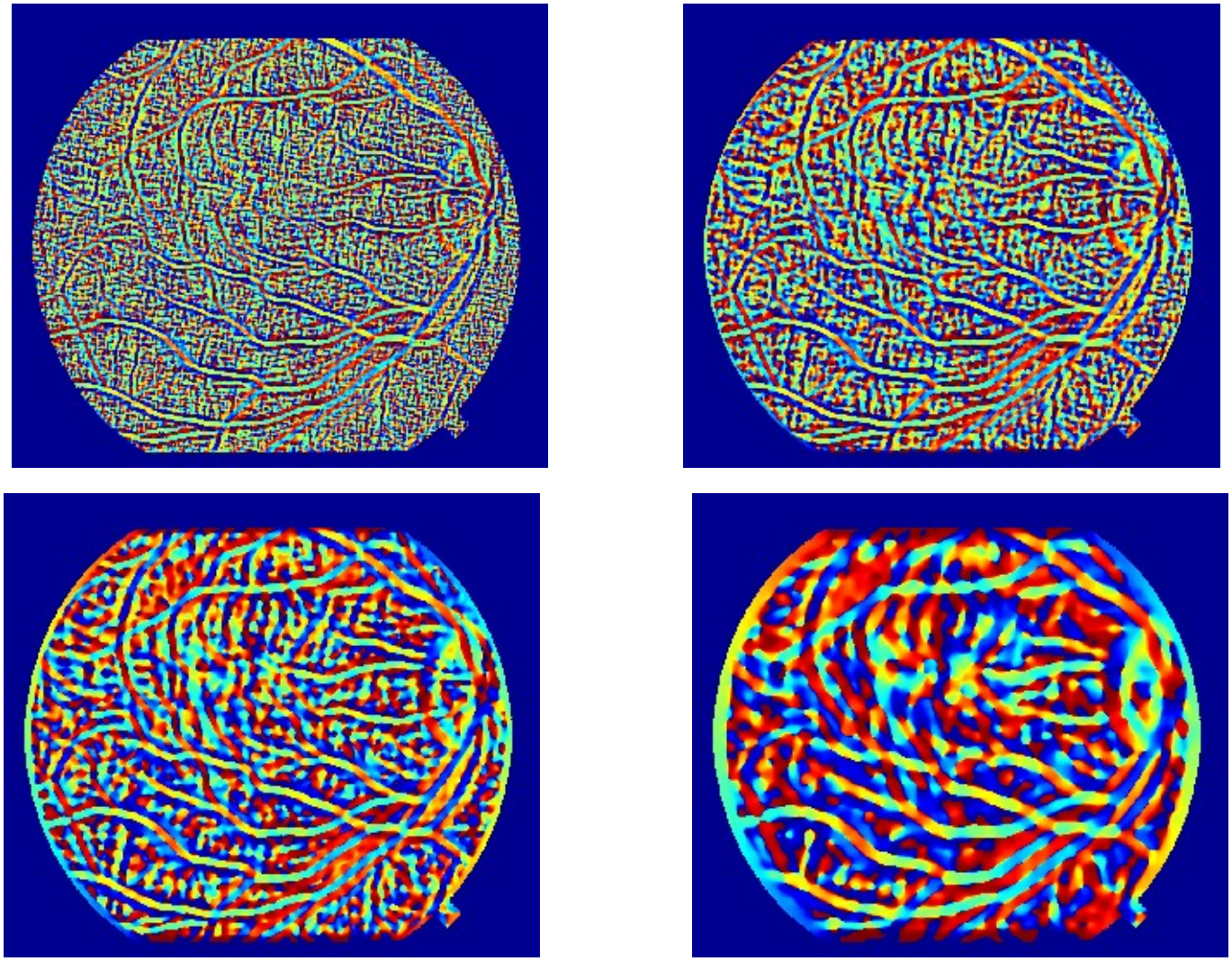
Vessel orientation fields from curvature filters



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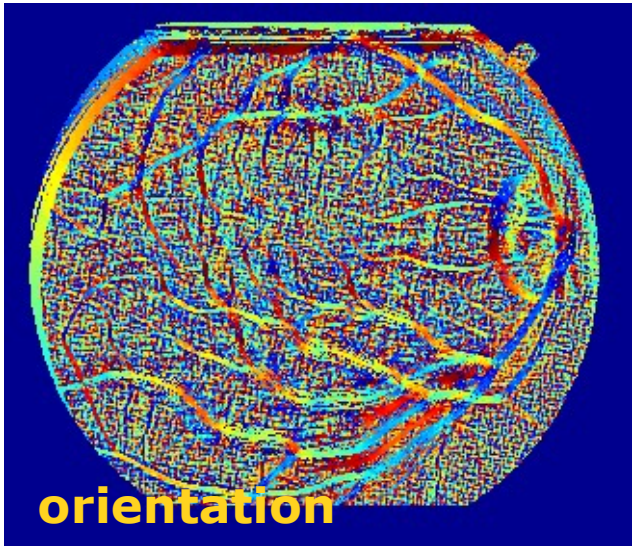
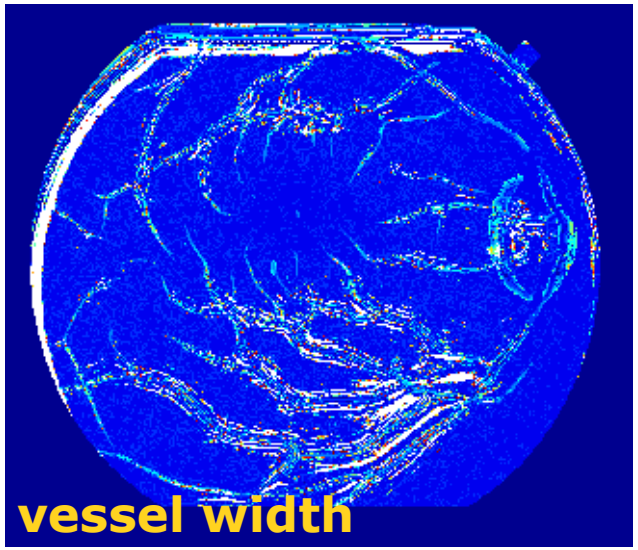
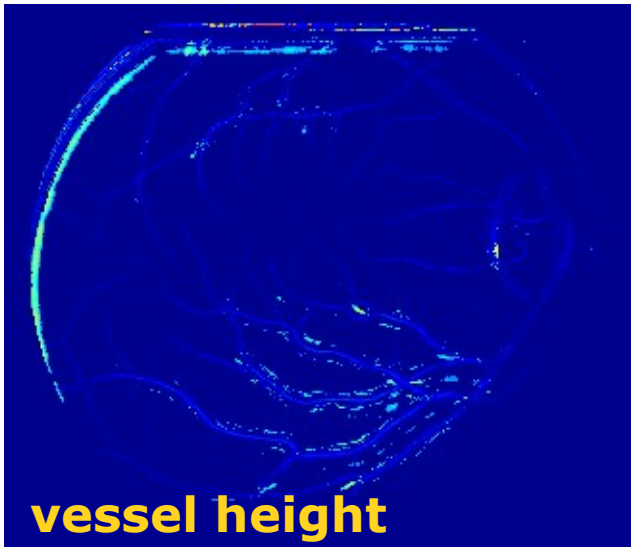
Maximum likelihood estimate fields







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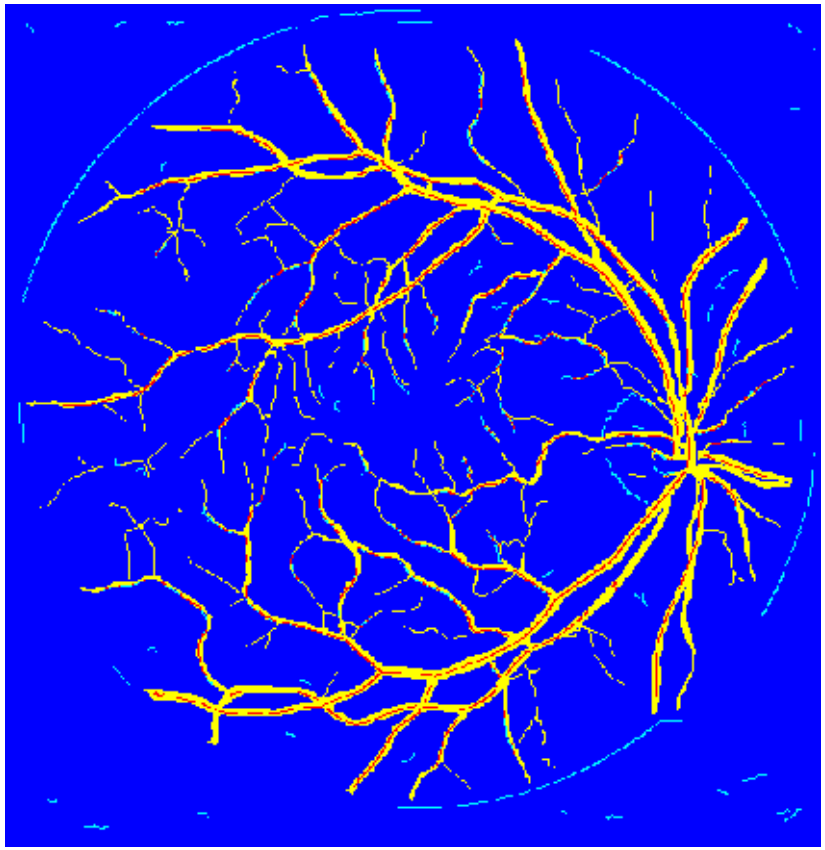
Vessel Sementation Example



Vessel segmentation based of maximum likelihood output fields
(Image 10 from DRIVE database.
Human grading: yellow(vessel), blue(background))

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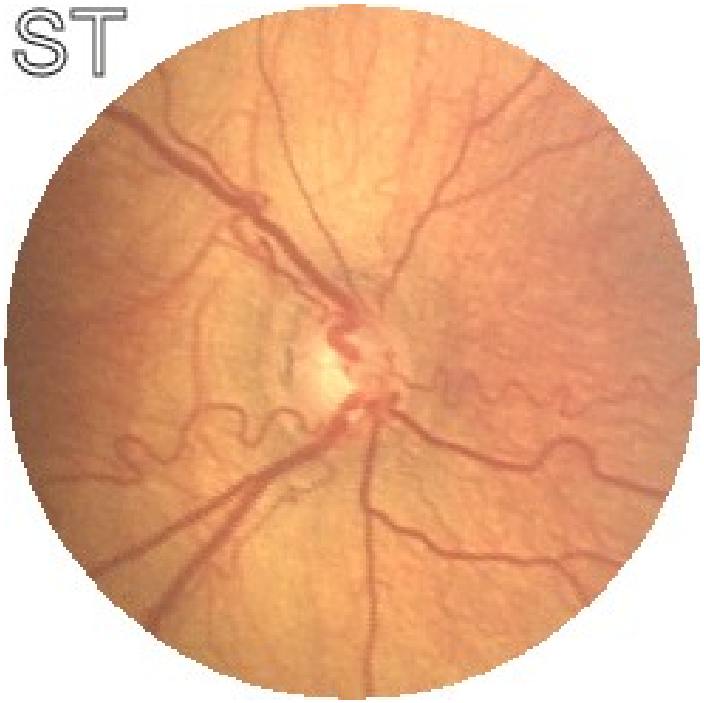
Tortuosity measurement for Retinopathy of Prematurity



60° RetCam image of 25 week GA with stage 3 ROP.

(Clare Wilson, Alistair Fielder, at City University)

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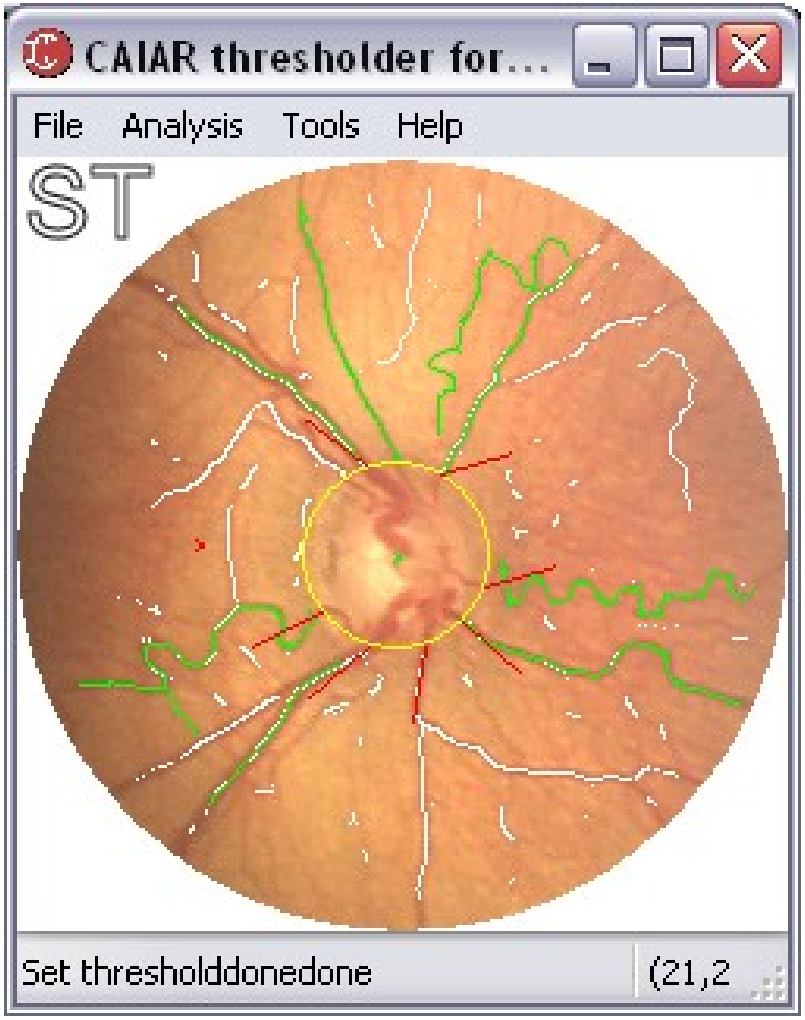
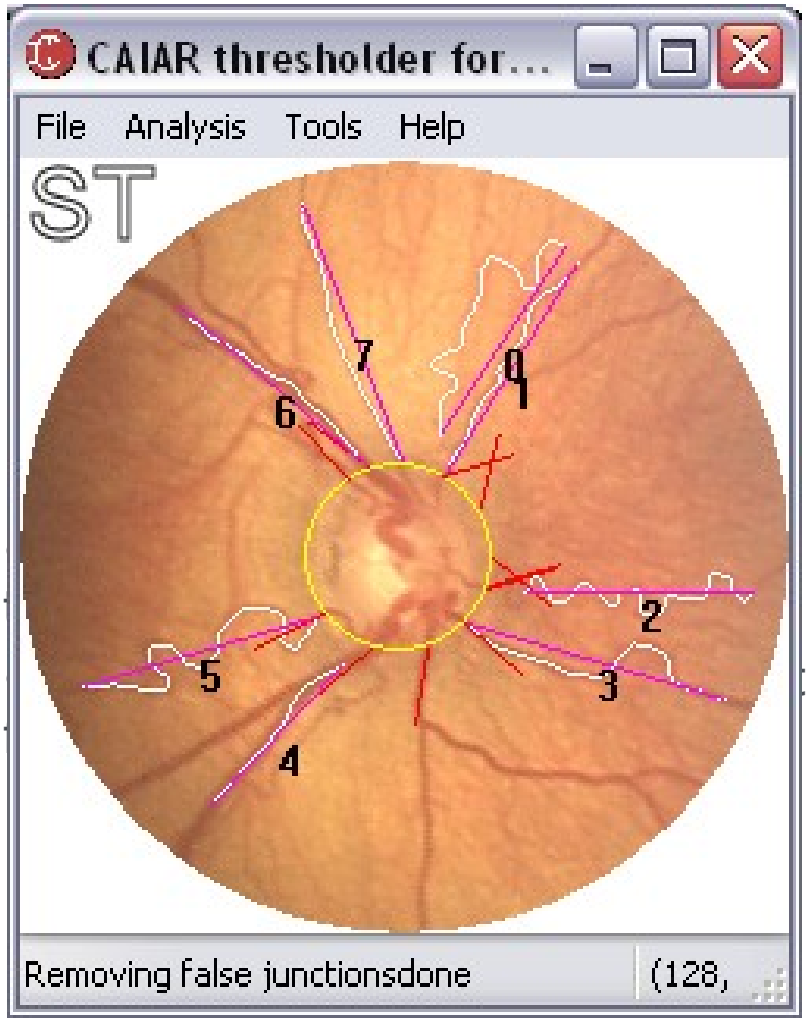
Tortuosity measurement for Retinopathy of Prematurity





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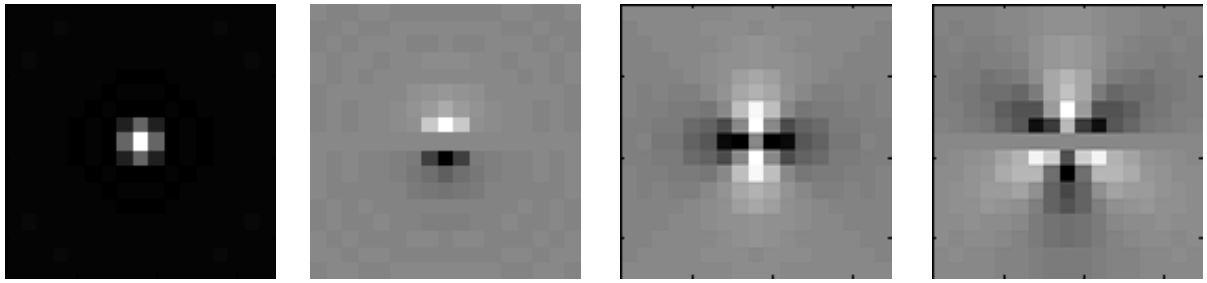
Further Work and Outlook

Reliability: process is only semi-automated at present

Model validity

Extension to filter on other types of features
e.g., features of different order rotational symmetry:



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