Segmentation of the optic nerve head driven by disc divergence and gradient boosting

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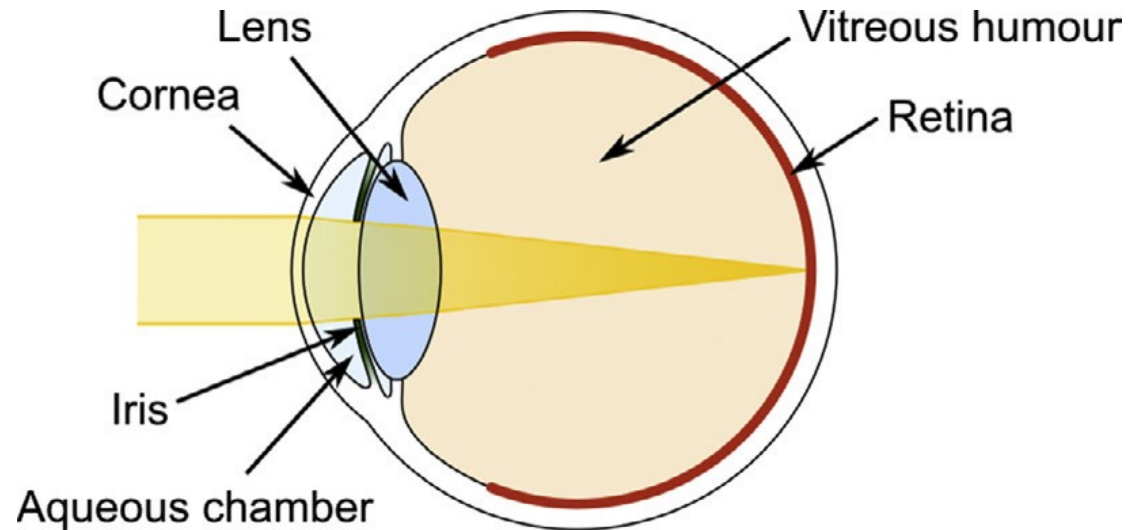
Computer Graphics Charles University

Motivation

- Availability of medical images
- Slow manual examination
- Need for fast automatic methods
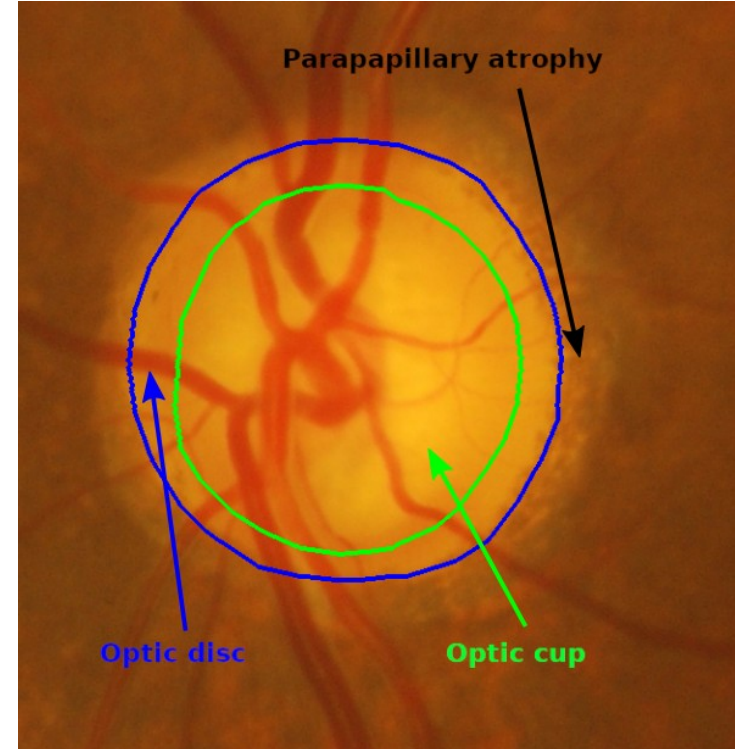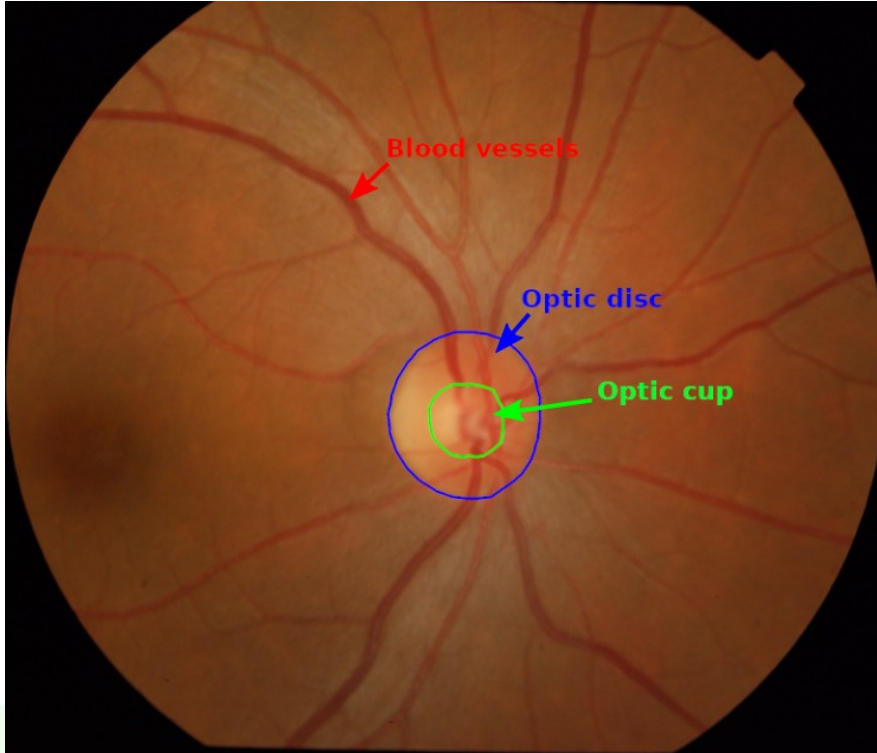- Eye diseases
  - Glaucoma

Retinal imaging

- Fundus camera
- OCT (Optical Coherence Tomography)
- Reconstruction
- Imaging artefacts

The human eye as an optical system.

Trucco E MacGillivray T Xu Y. Computational Retinal Image Analysis : Tools Applications and Perspectives. London United Kingdom: Academic Press; 2019

Optic nerve head

Related work

Major survey articles [Almazroa et al. 2015][Thakur et al. 2018]
Retinal image preprocessing
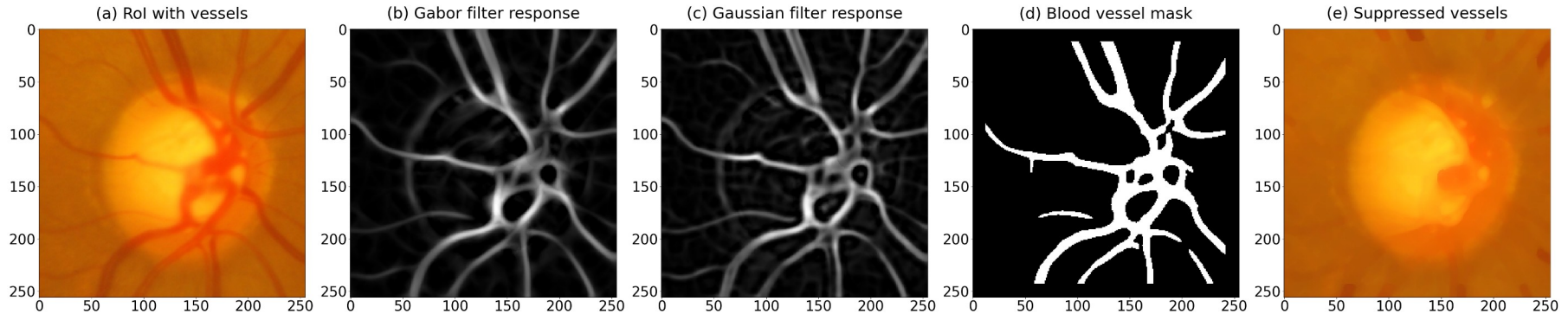- Region of interest detection [Liu et al. 2008]
- Blood vessel segmentation and inpainting [Khan et al. 2019]

ONH segmentation techniques
- Thresholding [Ashish et al. 2015]
- Unsupervised clustering
- Active contour and level set methods
- Superpixel classification [Cheng et al. 2013]
- Convolutional neural networks [Panda et al. 2021][Zhang et al. 2021]

Retinal image preprocessing

- Region of interest constructed around the highest response after convolution with peak-seeking kernel
- Blood vessel extraction by filter matching

(a) RoI with vessels   (b) Gabor filter response   (c) Gaussian filter response   (d) Blood vessel mask   (e) Suppressed vessels
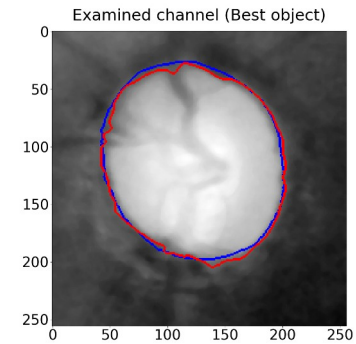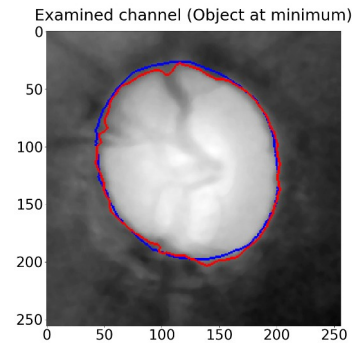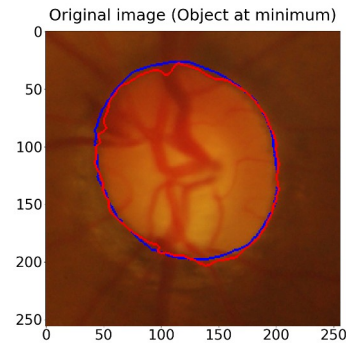
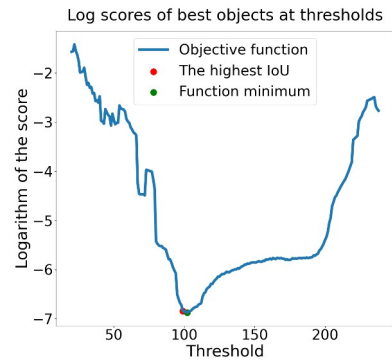**Optic disc segmentation**

Disc divergence

- Formula $\epsilon = \phi \, \nu \, \delta \, \lambda$
- ϕ – ellipse divergence
- ν – vessel coverage
- δ – contrast with neighbourhood
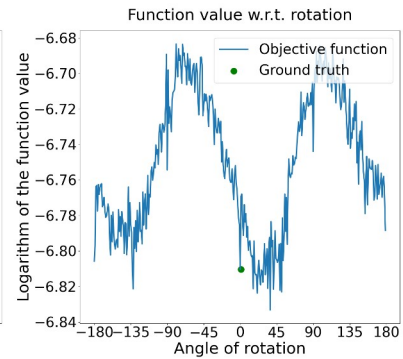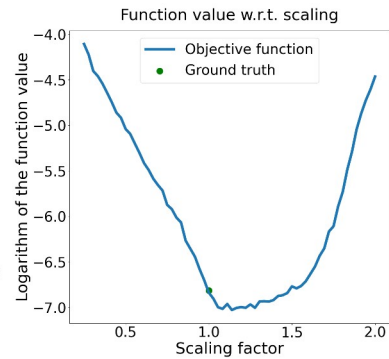- λ – ROI intersection penalisation
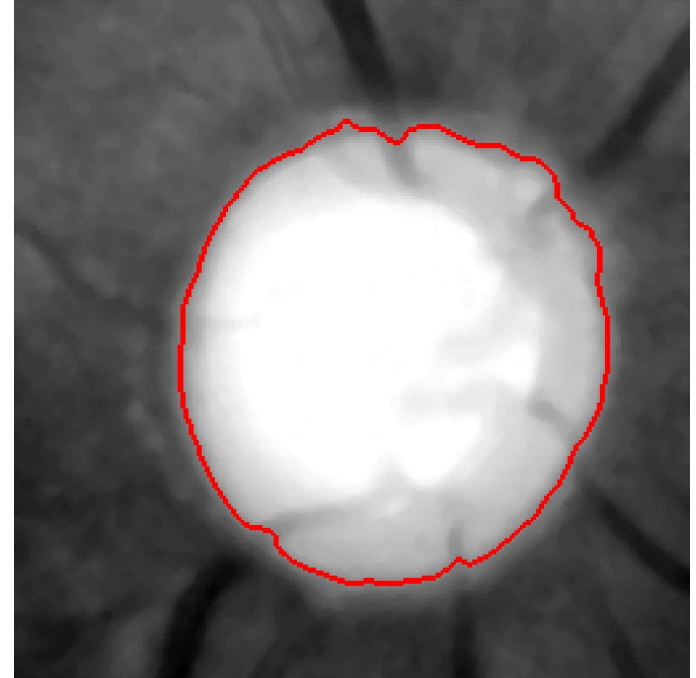
Disc divergence optimisation

Optic disc segmentation
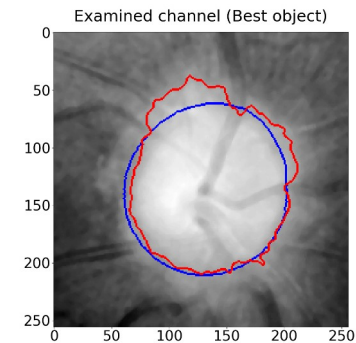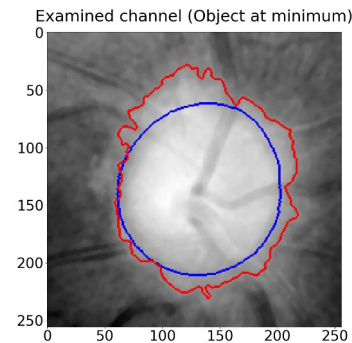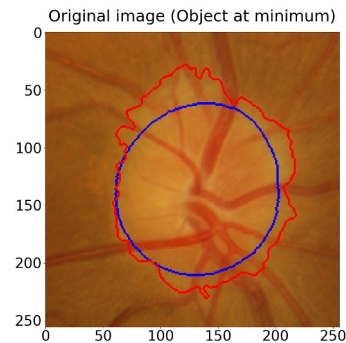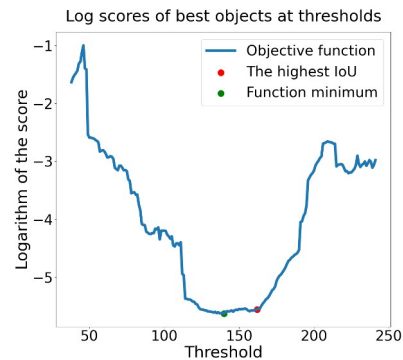
Ground truth divergence

Optic disc segmentation
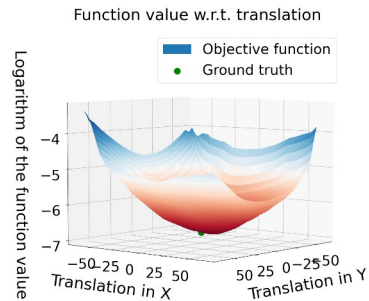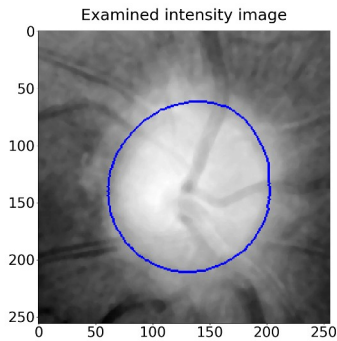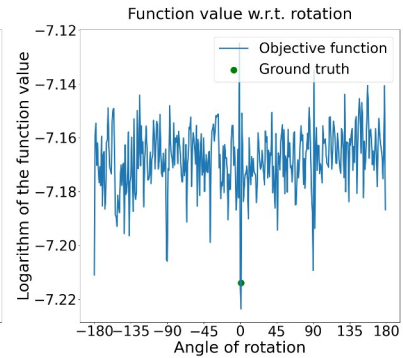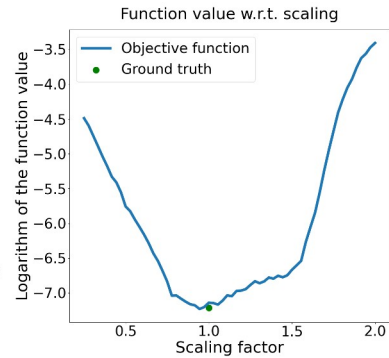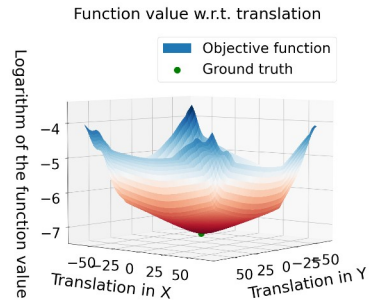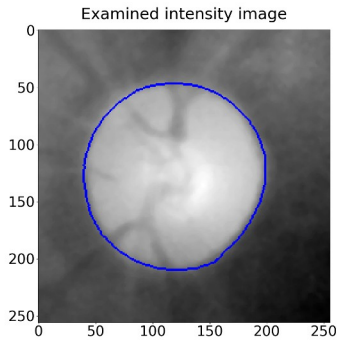
Optic disc segmentation
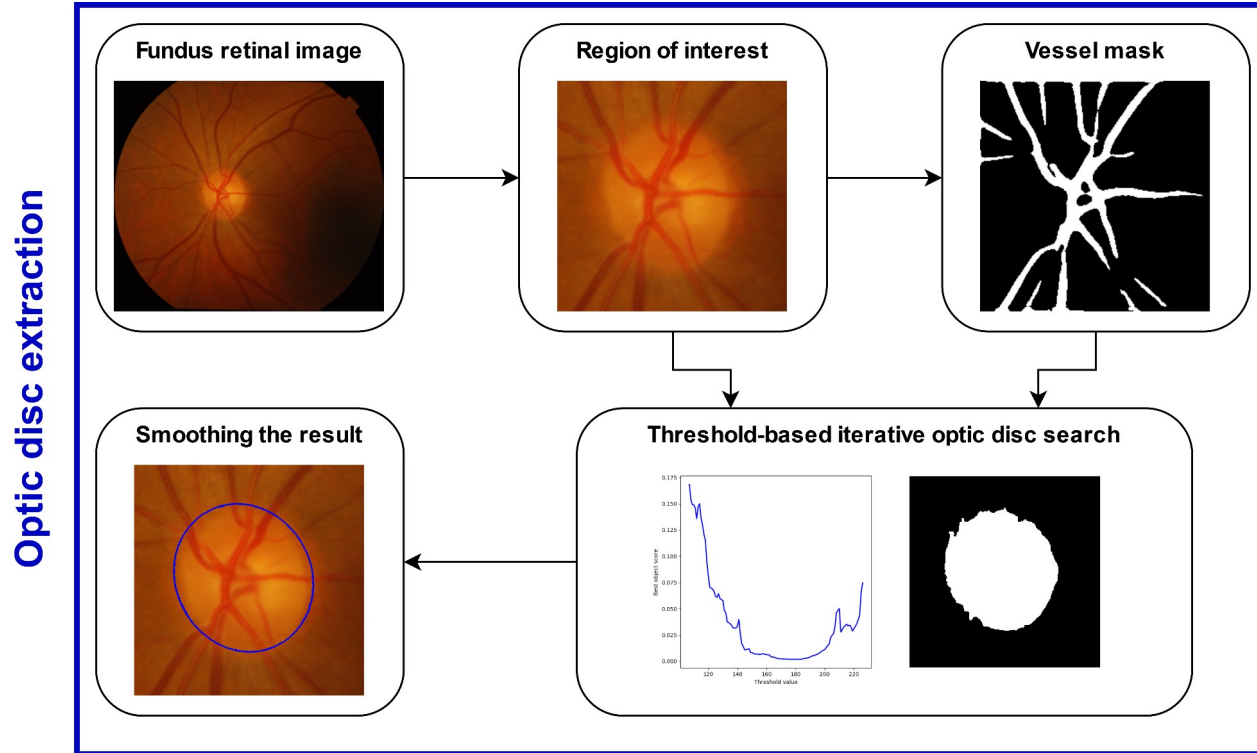
Optic cup segmentation
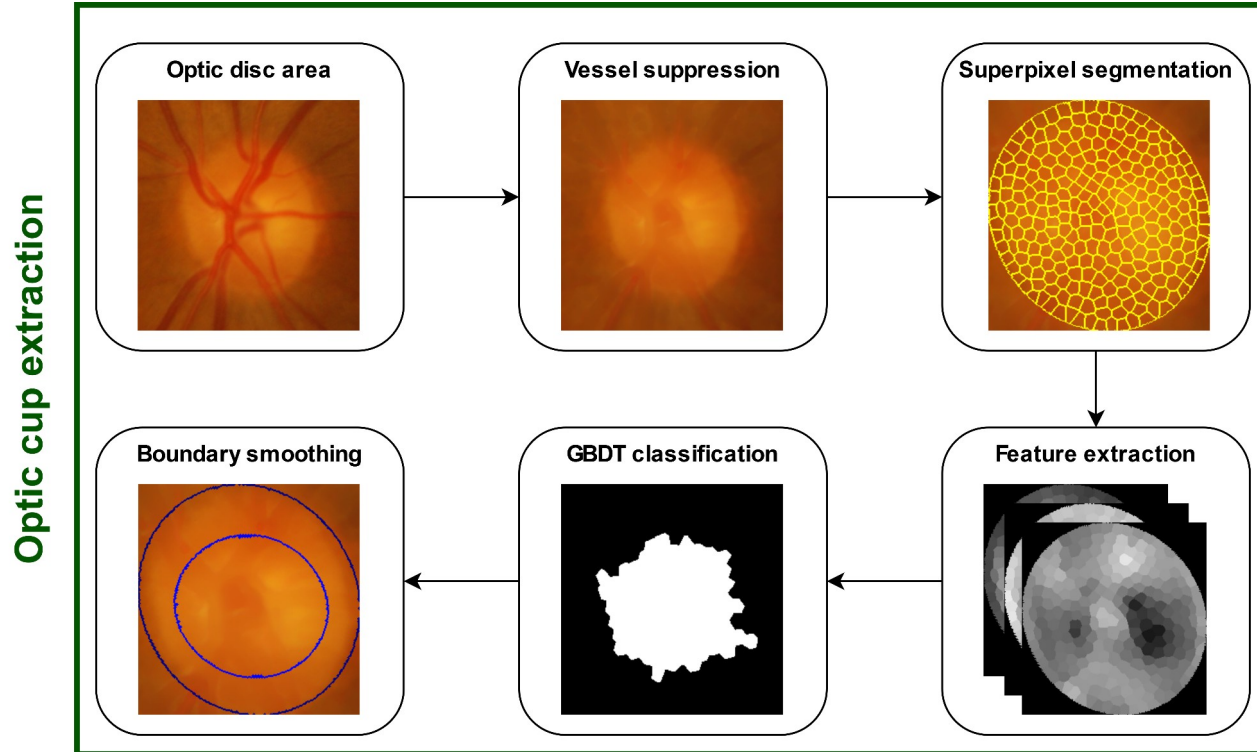
Superpixel features

- Mean/variance in colour channels: RGB, HSV, L*a*b*
- Left/right eye estimation, distance from the optic centre or vessel cluster, Centre surround statistics
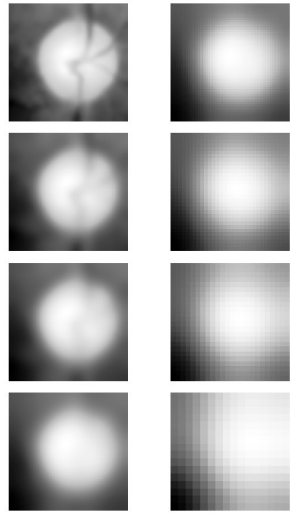
Gaussian pyramid
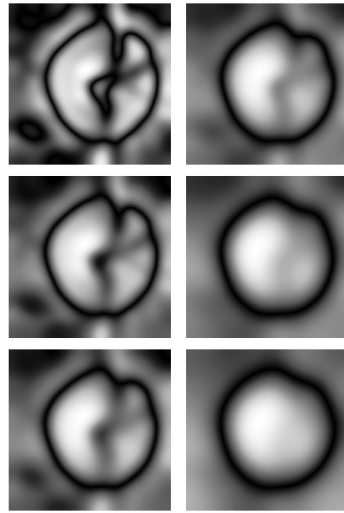
Pyramid level differences
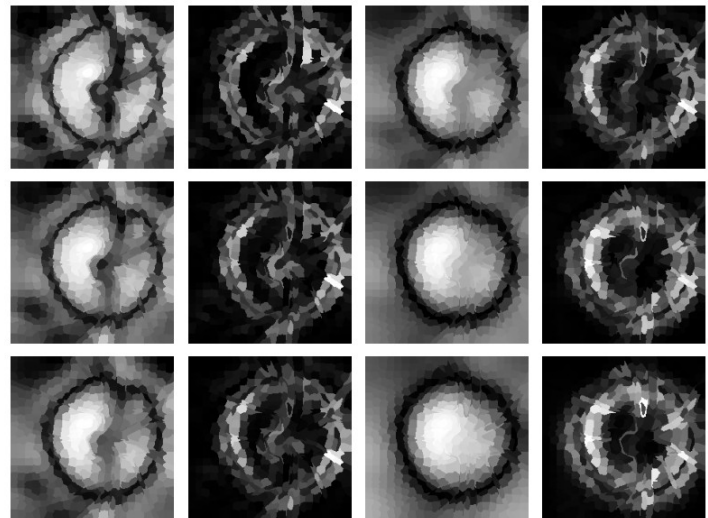
Centre surround statistics (mean/variance)

Data augmentation

- Balanced selection of superpixels (cup/neuroretinal rim)
- Random transformations (mirror/rotation)
- Imbalanced dataset – varying number of transformations

Density of the optic cup coverage in three datasets
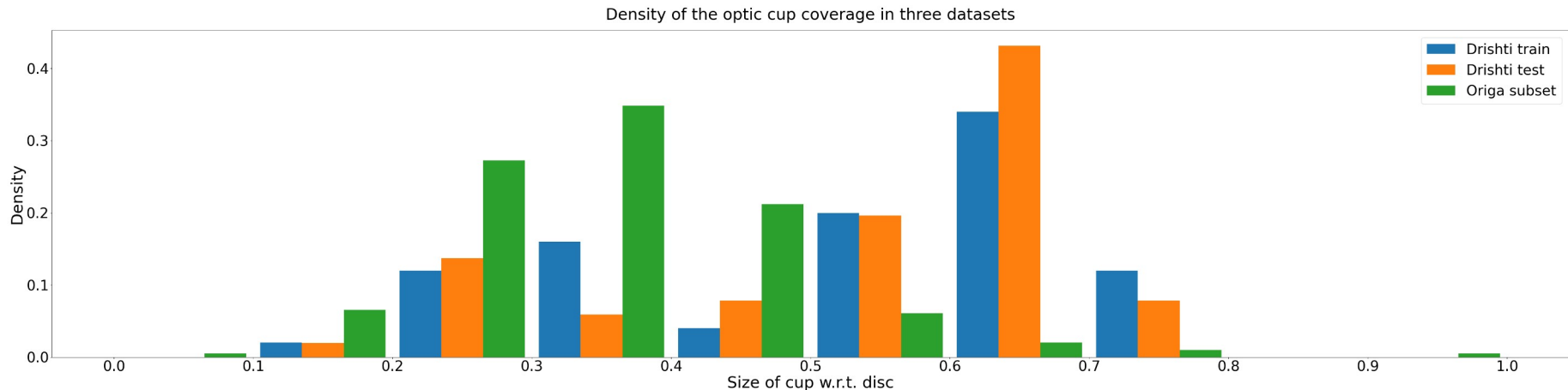
Gradient boosting

- Gradient boosted decision trees (GBDT)
- Superpixel classification – traditionally SVM

Training	Drishti		Origa	
Testing	Drishti	Origa	Drishti	Origa
GBDT	**0.7858**	0.5986	**0.6513**	0.7236
SVM RBF	0.7356	0.5895	0.6500	0.7060
SVM Linear	0.7401	0.5902	0.6328	0.7098
Random Forest	0.7726	**0.6027**	0.6274	**0.7240**

Optic cup segmentation

Results (Disc segmentation)

- Blue – ground truth
- Red – segmentation
- Rows from the top:
  - Drishti GS1
  - Origa
  - Drions-DB
- Columns from the left:
  - The best result
  - The mean result
  - The median result
  - The worst result
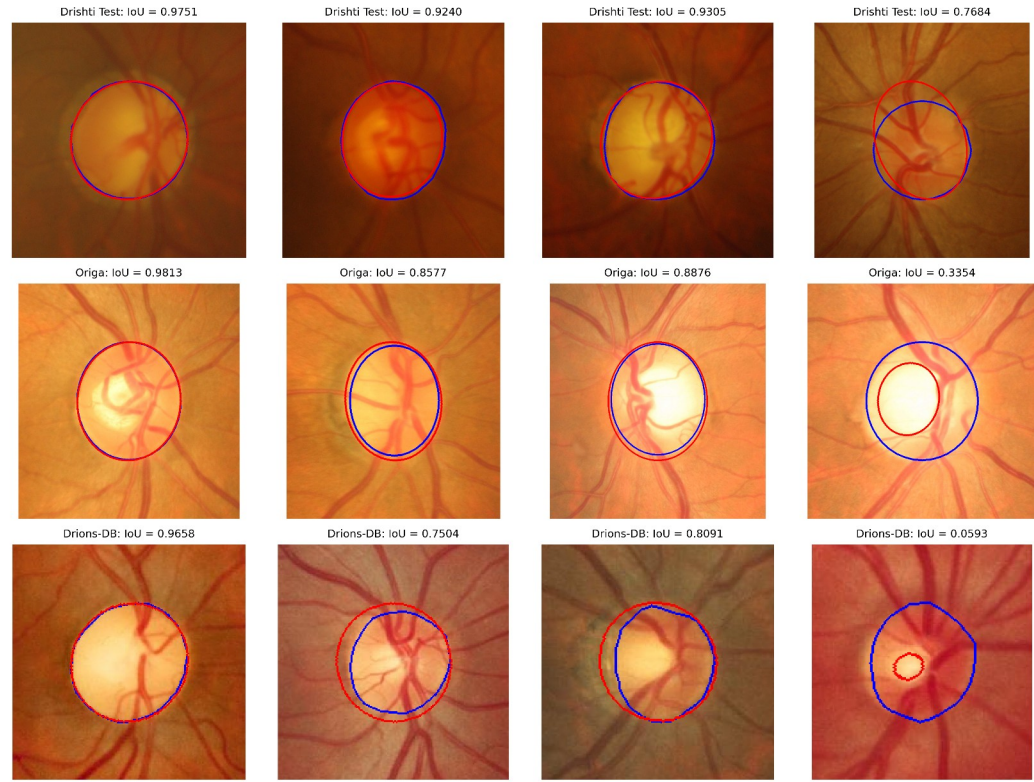
Results (Cup segmentation)

- Blue – ground truth
- Red – segmentation
- Drishti and Origa images
- Columns from the left:
  - The best results
  - The mean results
  - The median results
  - The worst results

References

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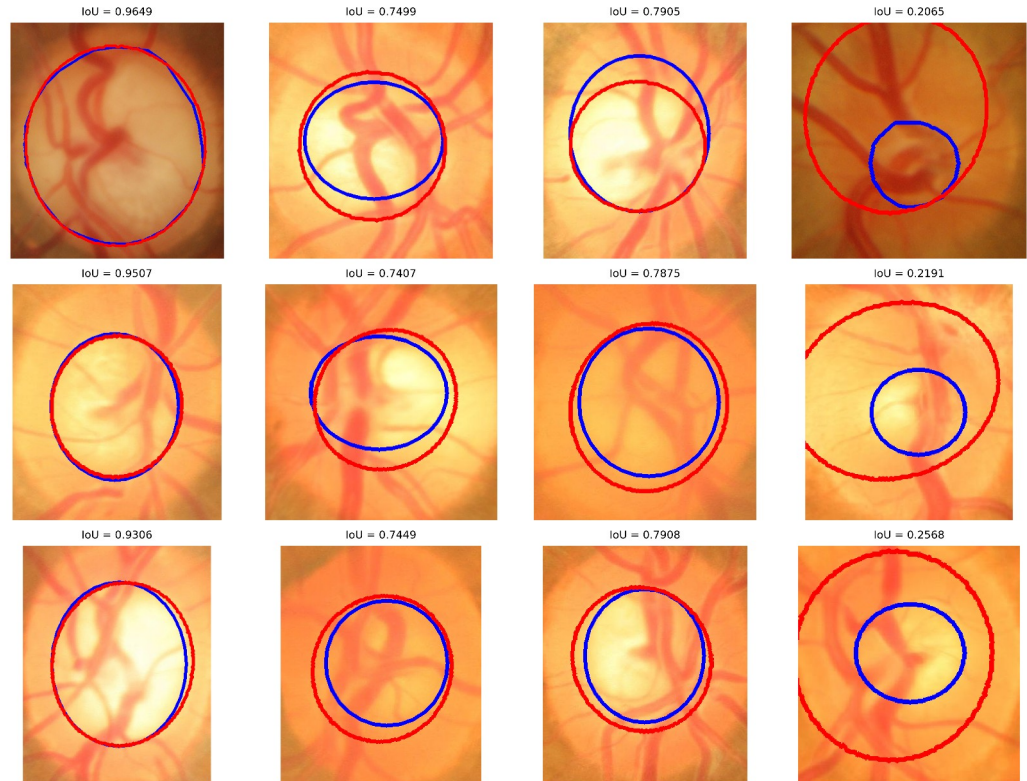- Niharika Thakur, Mamta Juneja, Survey on segmentation and classification approaches of optic cup and optic disc for diagnosis of glaucoma, Biomedical Signal Processing and Control, Volume 42, 2018, Pages 162-189
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Thank you for listening