

# TOWARDS A GLAUCOMA RISK INDEX BASED ON SIMULATED HEMODYNAMICS FROM FUNDUS IMAGES

José Ignacio Orlando<sup>1,2</sup>, Joao Barbosa Breda<sup>3</sup>, Karel van Keer<sup>3</sup>  
Matthew B. Blaschko<sup>4</sup>, Pablo J. Blanco<sup>5,6</sup>, and Carlos A. Bulant<sup>1</sup>



<sup>1</sup> CONICET - Pladema Institute, UNICEN, Tandil, Argentina

<sup>2</sup> OPTIMA, Department of Ophthalmology and Optometry, Medical University of Vienna, Vienna, Austria

<sup>3</sup> Research Group Ophthalmology, KU Leuven, Leuven, Belgium

<sup>4</sup> ESAT-PSI, KU Leuven, Leuven, Belgium

<sup>5</sup> National Laboratory for Scientific Computing, LNCC / MCTIC, Petrópolis, Brazil



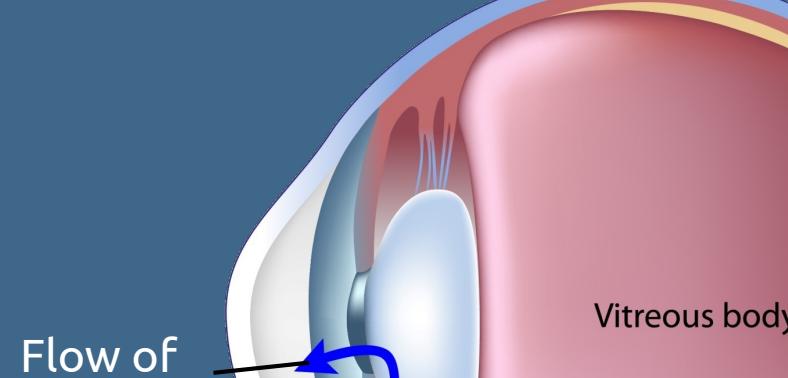
## Glaucoma

- One of the leading causes of **preventable and irreversible blindness** in the World
- **Silent thief of sight:** asymptomatic in its early stages!
- **Early detection** is essential to ensure effective treatments

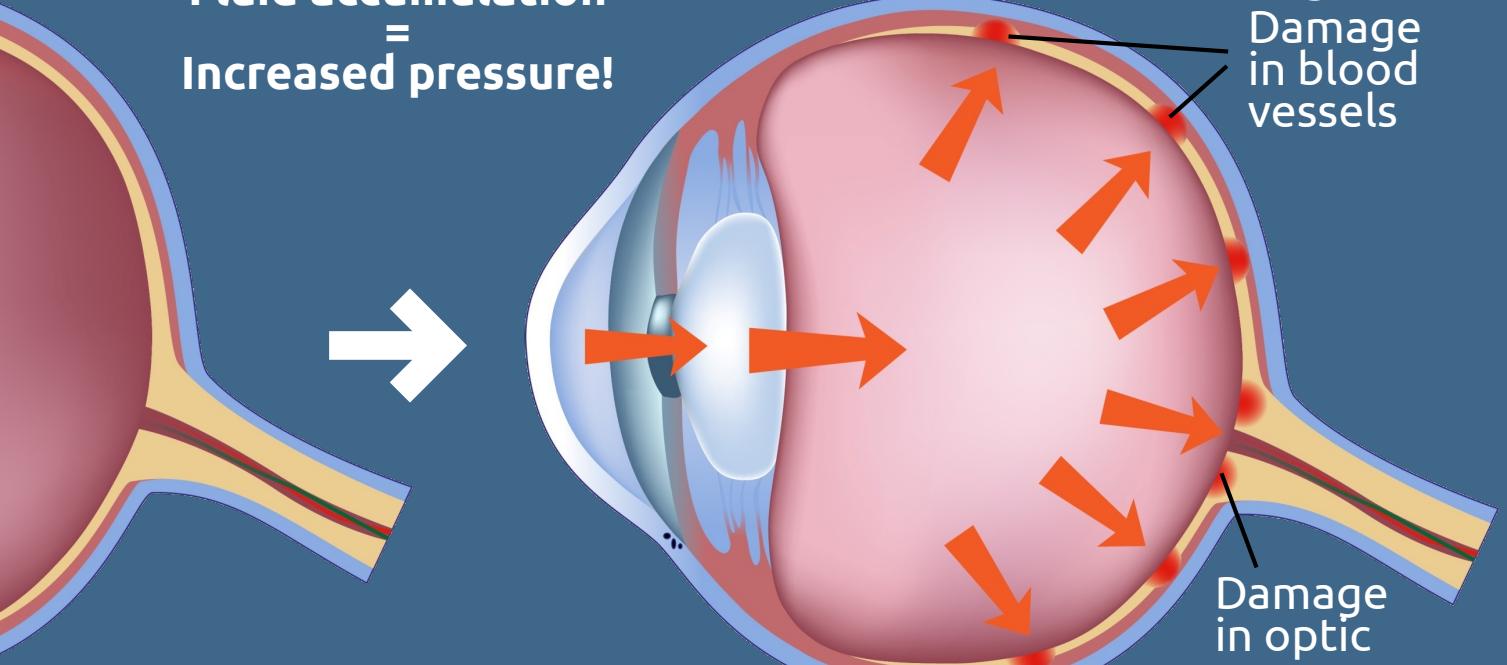
## Motivation

- **Intra-ocular pressure (IOP)** is the major treatable risk factor
- Glaucoma also **induces changes in the hemodynamics** of the retrobulbar vessels
- The **hemodynamics of the retinal arterioles cannot be studied** as no imaging device allows to quantify such a behavior

## Healthy eye



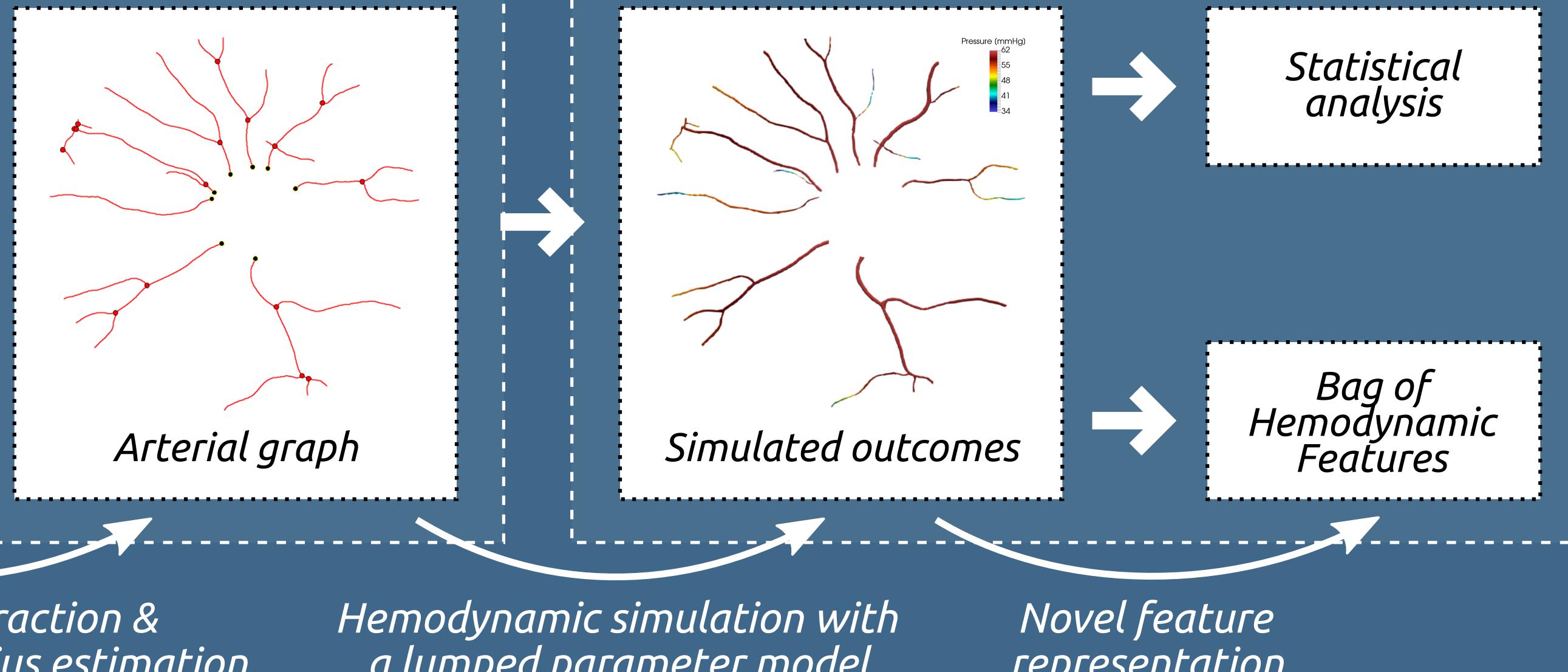
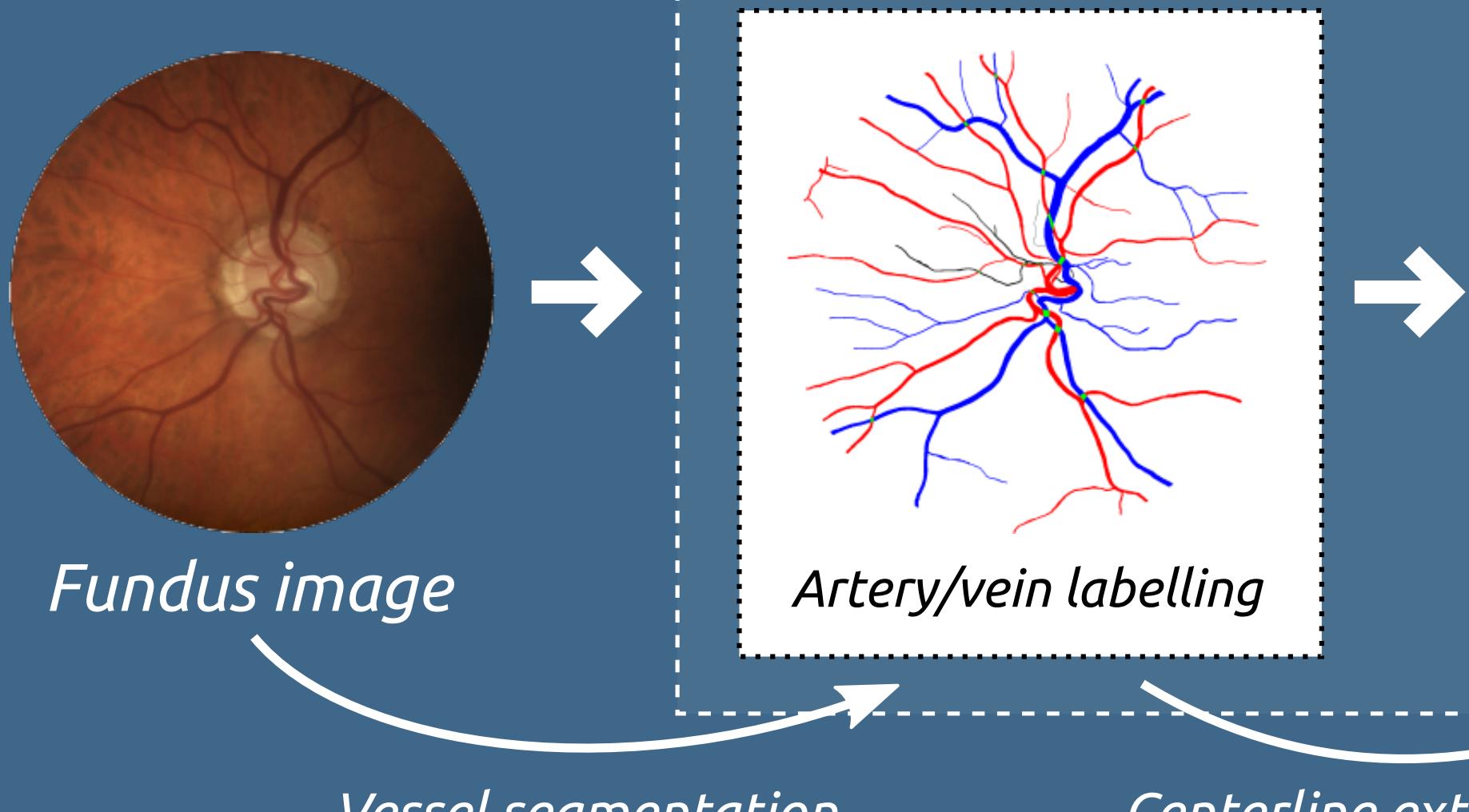
## Glaucoma progress



## Our contributions

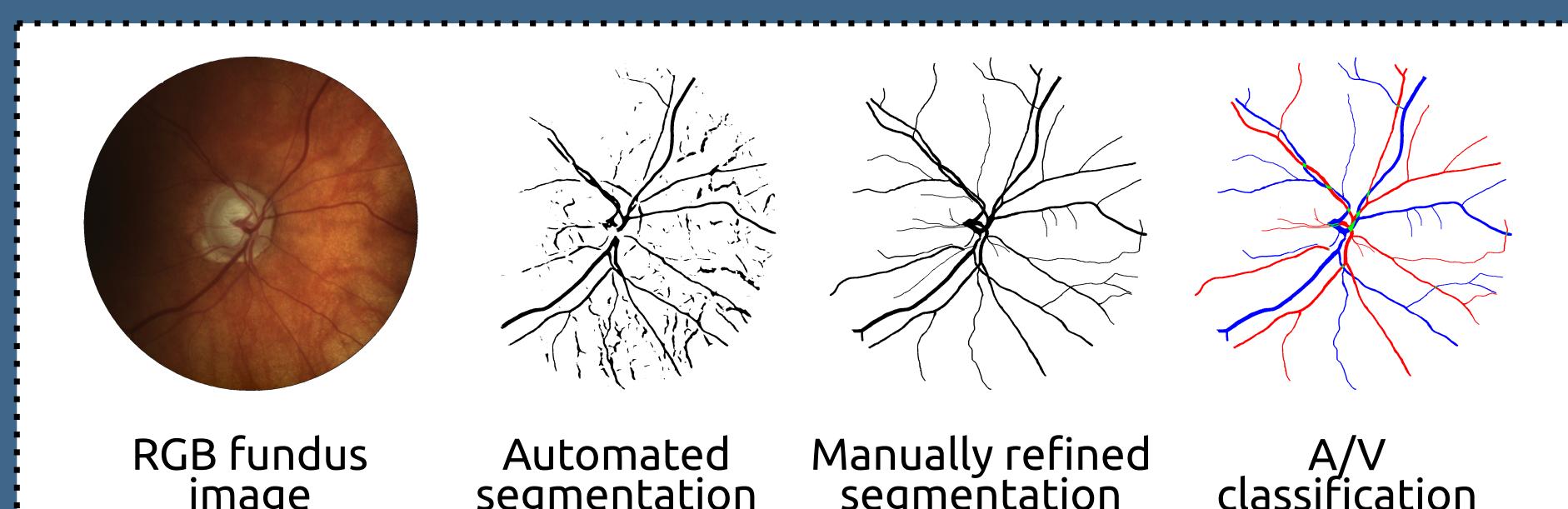
- A first method for characterizing the hemodynamics of the retinal arterioles based on simulated parameters obtained with a 0D model
- A novel feature representation approach to summarize the outcomes.
- A new data set of fundus images with A/V segmentations and glaucoma labels.

## Our method



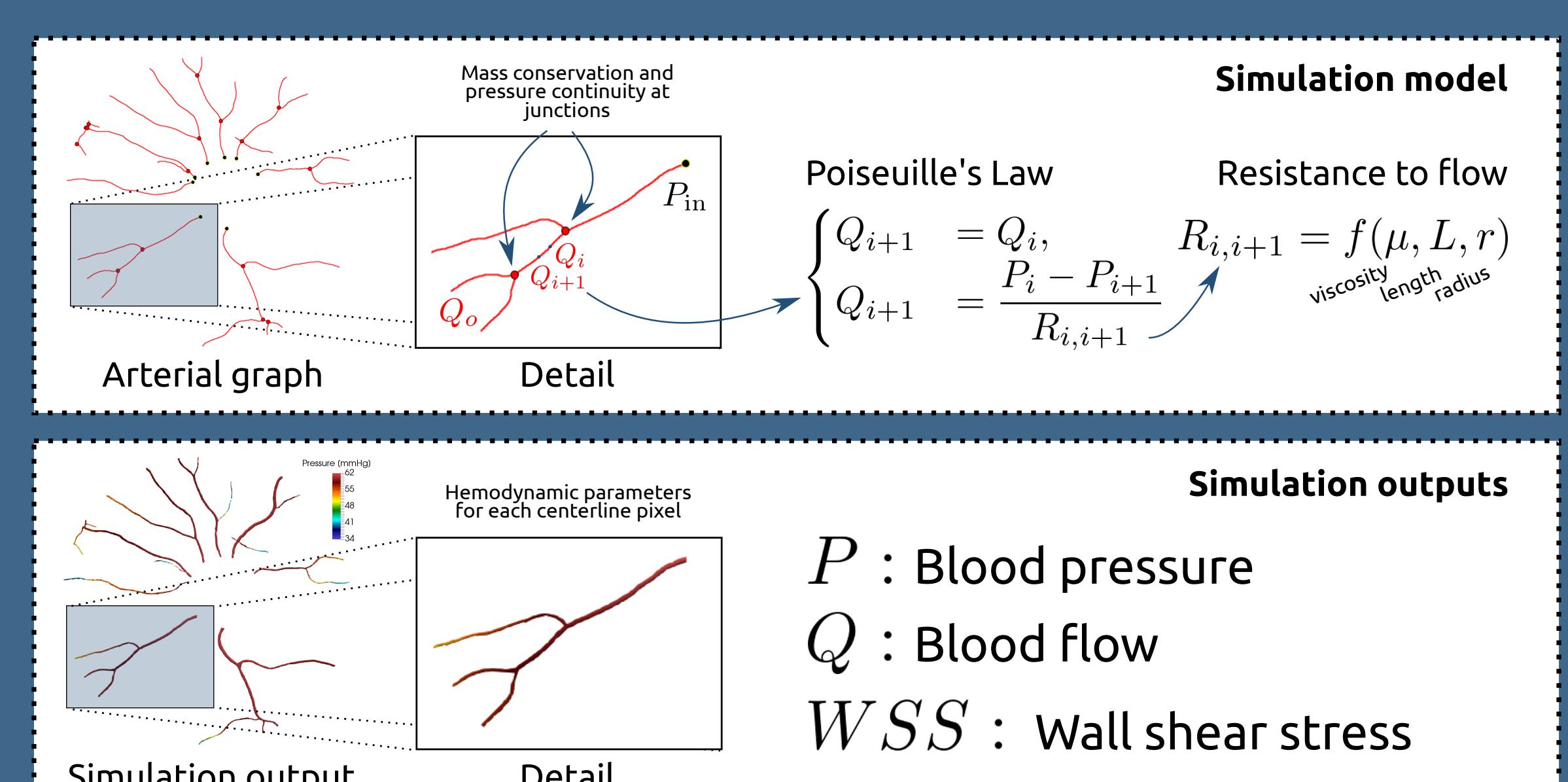
## 1 - Arterial Graph Extraction

- We release LES-AV, a new database of fundus pictures!
- 22 fundus pictures (11 healthy, 11 glaucomatous)
- Disease labels + vessel segmentation + A/V classification
- Vessels pre-segmented using a patch-based U-Net were manually corrected and labelled as arteries and veins
- Arterial tree mapped to a graph with pixelwise radius



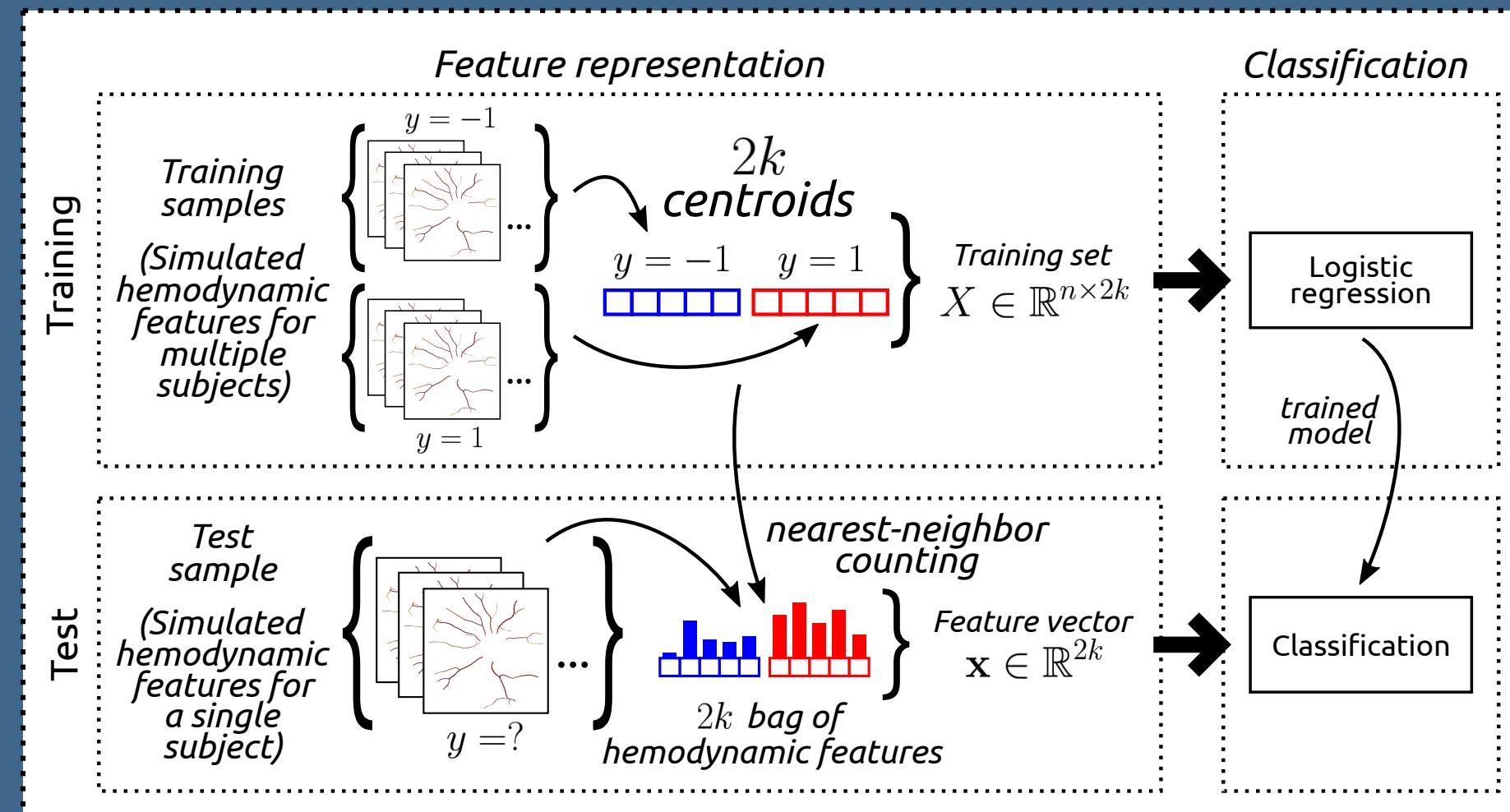
- Computational mesh:
  - Arterial graph + pixel-wise cross-sectional radius
- Computational model:
  - Resistive-analog model, 0D, based on Poiseuille's law
- Parameters:
  - Blood viscosity (radius dependent)
  - Total flow ( $Q_T$ , taken from literature)
  - Retinal artery blood pressure ( $P_{in}$ , taken from literature)
- Boundary conditions:
  - Flow distribution based on Murray's law
  - Inlet:  $P_{in}$
  - Outlet:  $Q_{in} : \sum_o Q_o = Q_T$

## 2 - Hemodynamic Simulation

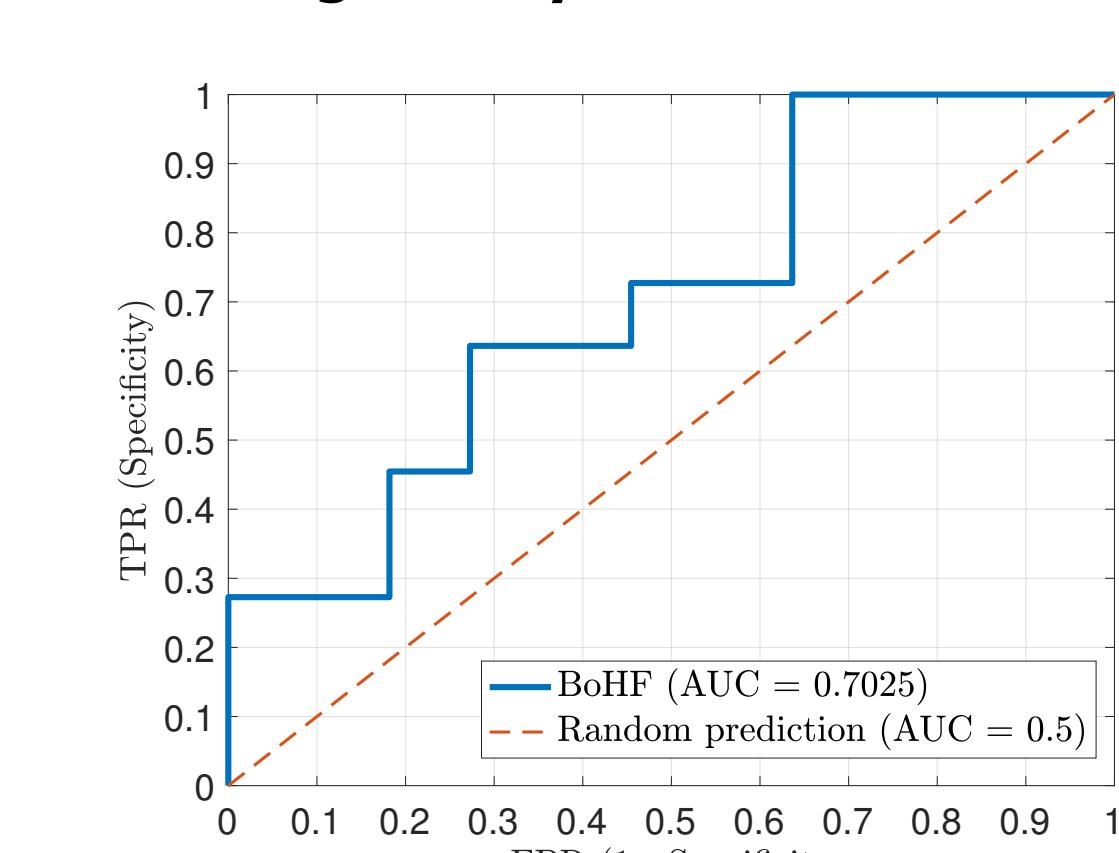


## 3 - Bag of Hemodynamic Features

- A novel approach for summarizing hemodynamic variables on a fixed-length feature vector for ML based analysis

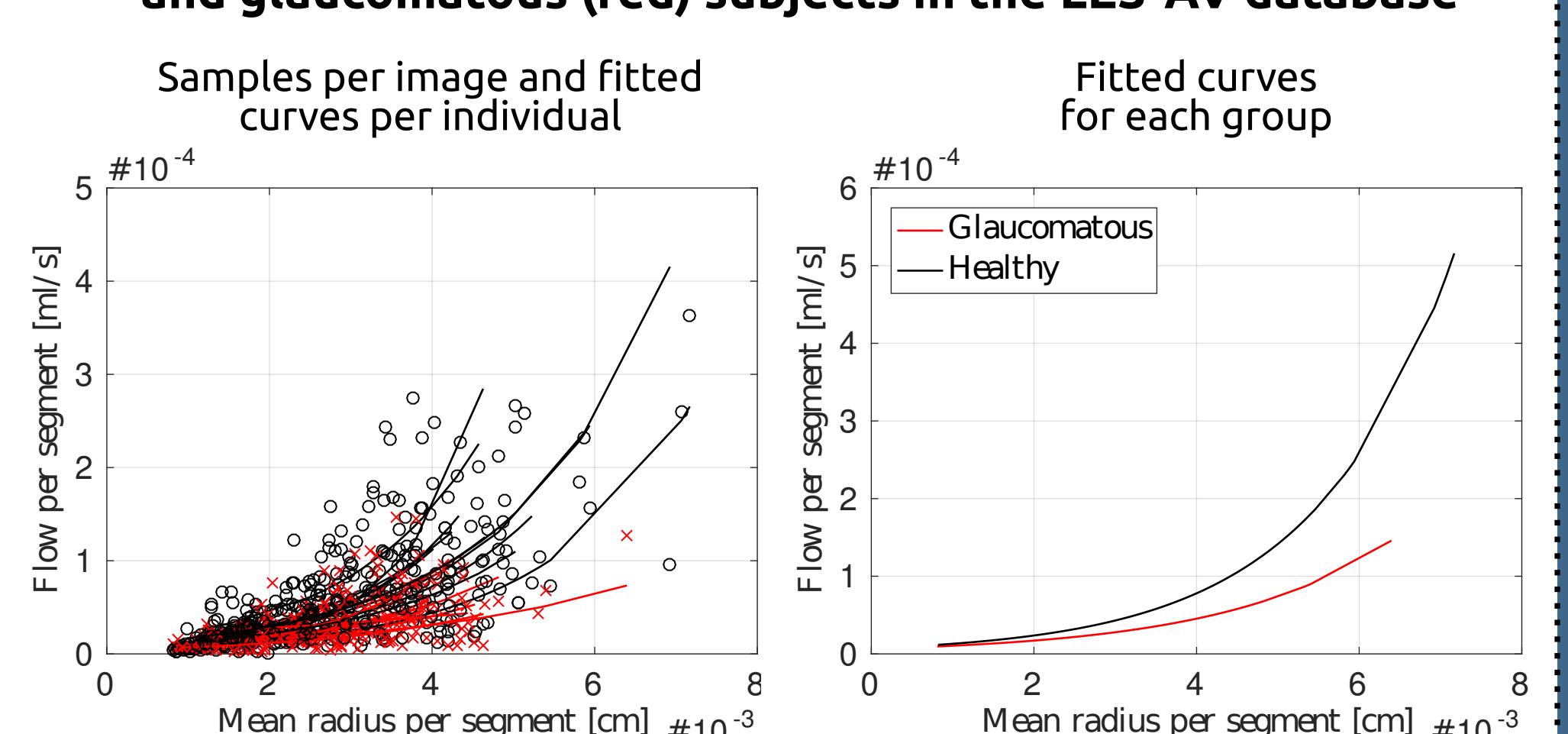


- L2 regularized logistic regression + BoHF for detecting glaucomatous patients in a cross validation setting in LES/AV



## Results

- Mean radius vs. flow rate per segment for healthy (black) and glaucomatous (red) subjects in the LES-AV database



## Conclusions and future works

- We presented a first method to characterize the hemodynamics of the retinal arterioles in glaucoma
- Future works: (i) automatize the A/V classification process, (ii) analyze other complex simulation models, (iii) use patient-specific input parameters, and (iv) integrate hemodynamics and DL features

## References

- [1] Abegao Pinto, L., et al.: **Ocular blood flow in glaucoma-the Leuven Eye Study.** Acta Ophthalmologica. 94(6) (2016) 592-598
- [2] Liu, D., et al.: **Image-based blood flow simulation in the retinal circulation.** In: IFMBE Proceedings, Springer (2009) 1963-1966



Further information, code and data!

Project webpage: <https://ignaciotoro.github.io/publication/miccai-hemodynamics/>  
E-mail: jose.orlando@meduniwien.ac.at

MICCAI2018  
Granada  
SPAIN