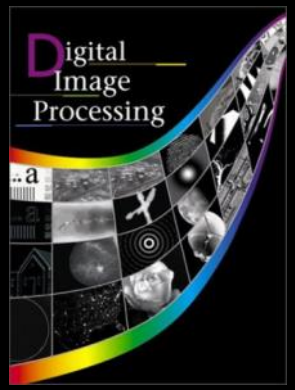

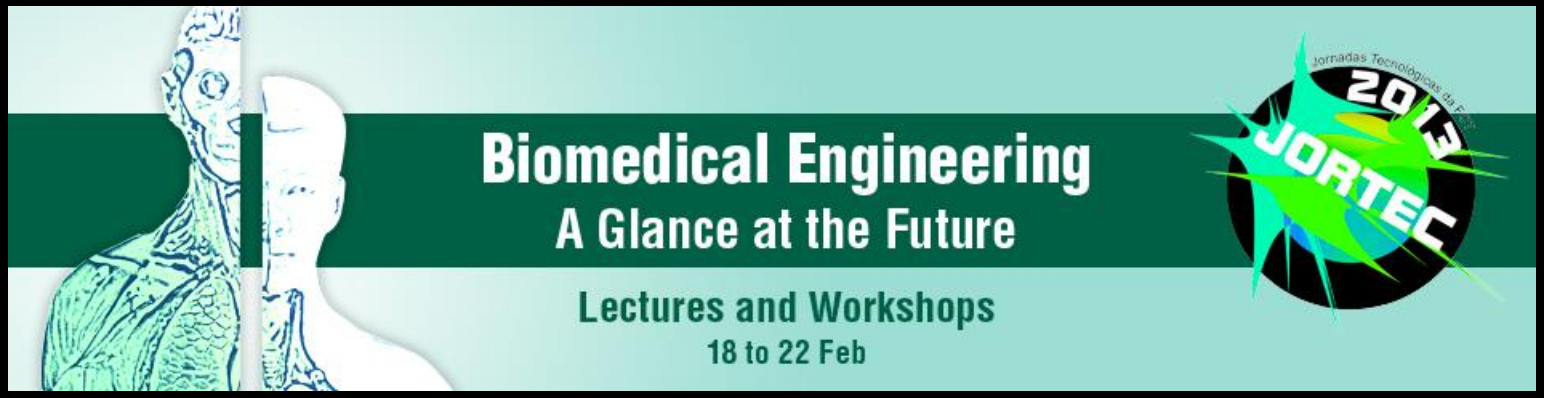

Biomedical Applications of Digital Image Processing

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UNINOVA

CA3
Computational Intelligence Research Group

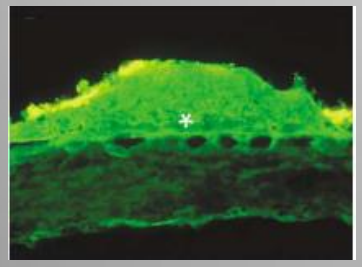
OUTLINE

- Retinography applications
- Biology and Bacteria's applications
- Conclusions

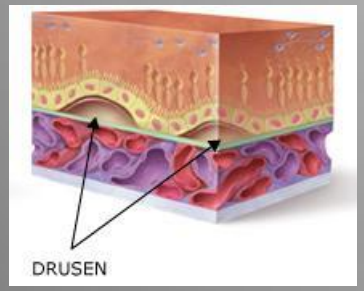
RETINAL DRUSEN DETECTION

Drusen Detection

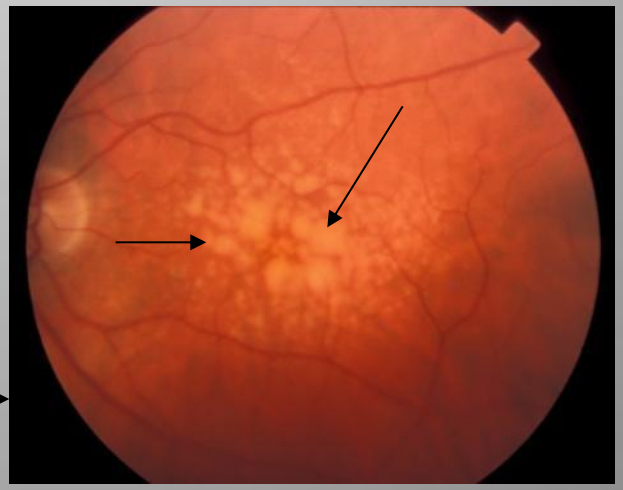
- Drusen are retina abnormalities caused by accumulation of extracellular materials beneath retina surface
- ARMD indicator and can produce loss of vision
- Visible in retina Fundus photography as yellowish spots around the macula
- Objective: To detect and quantify affected area



Transversal view

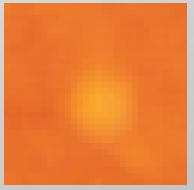


Surface view

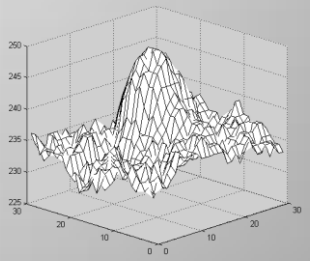


CONSIDERATIONS

- Assumption: retina images allow 3D shape estimation
  - In a 2D grey scale image the intensity value can represent the 3rd coordinate (depth)



2D view



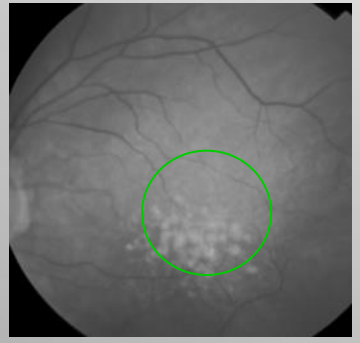
Estimated 3D view

- Proposed algorithm:
  - Step 1 – Illumination correction
  - Step 2 – detection of retina spots that can be related to Drusen
  - Step 3 – modelling of each retina spot using a 3D function

AD3RI Methodology

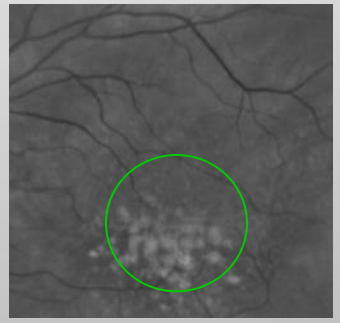
ROI Definition

Green Channel

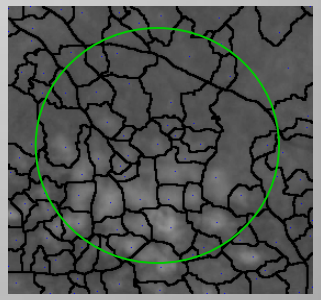


Correct illumination

Norm. Contrast



Locate Drusen spots (GPL algorithm)

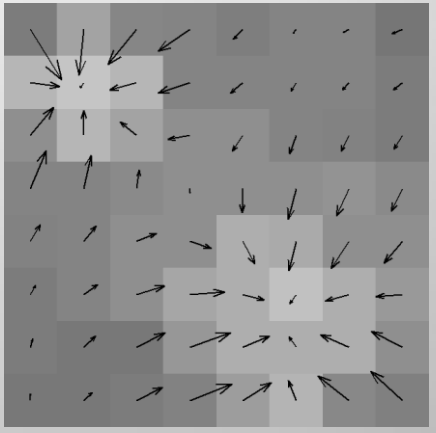


Gradient Path Labelling (GPL)

Original image

Image gradient (Sobel operator)

Step1



Labels propagation

Step2

1	2	3	4	5	6	7	8
9	1	4	5	6	7	10	11
1	12	6	6	7	10	11	13
14	15	16	7	17	10	13	18
19	20	21	7	7	10	18	22
23	24	25	25	25	7	22	26
27	28	29	30	7	31	32	33
34	35	36	37	37	38	39	40

Apply label compatibilities

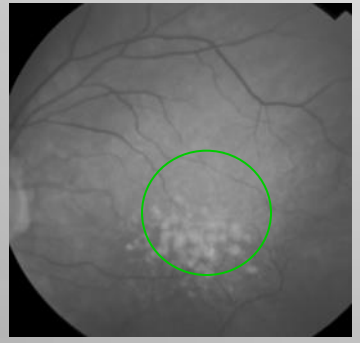
Step3

1	1	1	1	1	1	7	7
1	1	1	1	1	7	7	7
1	1	1	1	7	7	7	7
1	1	1	7	7	7	7	7
1	1	7	7	7	7	7	7
1	7	7	7	7	7	7	7
1	7	7	7	7	7	7	7
1	7	7	7	7	7	7	7

AD3RI METHODOLOGY

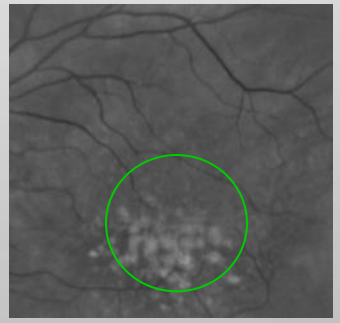
ROI Definition

Green Channel

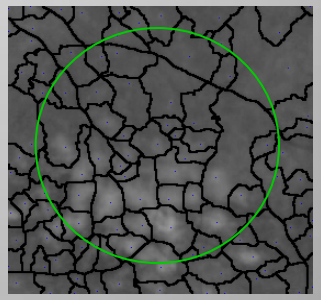


Correct illumination

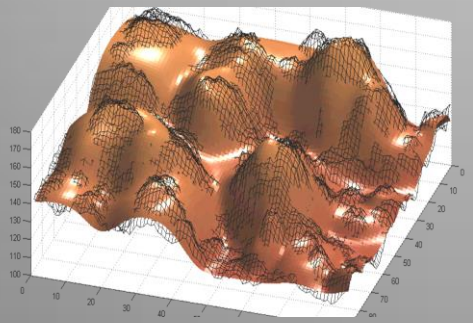
Norm. Contrast

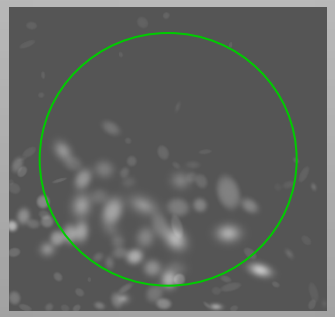


Locate Drusen spots (GPL algorithm)

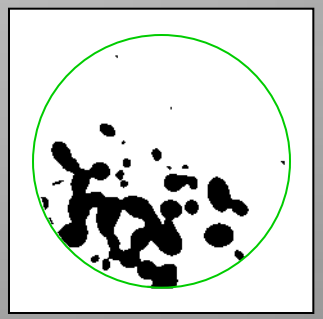


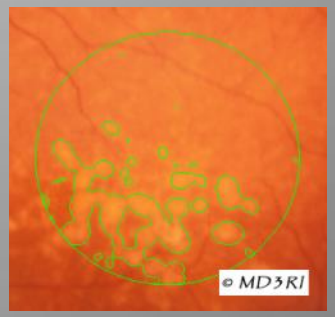
Model Drusen spots





Threshold model





EVALUATION TESTS – PIXEL LEVEL

AD3RI

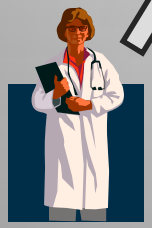
MD3RI

Pixel level Comparison (TP, FP, TN, FN)

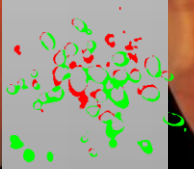
Pixel level analysis

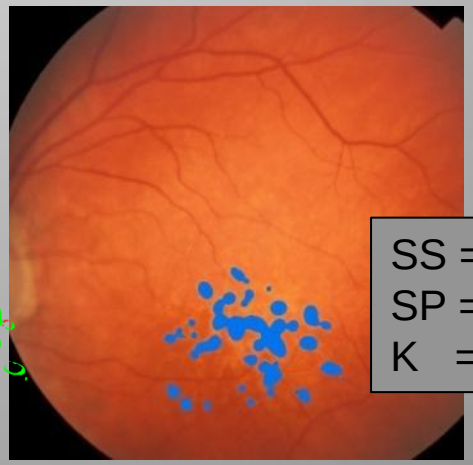
Sensitivity / Specificity

Kappa coefficient



MD3RI





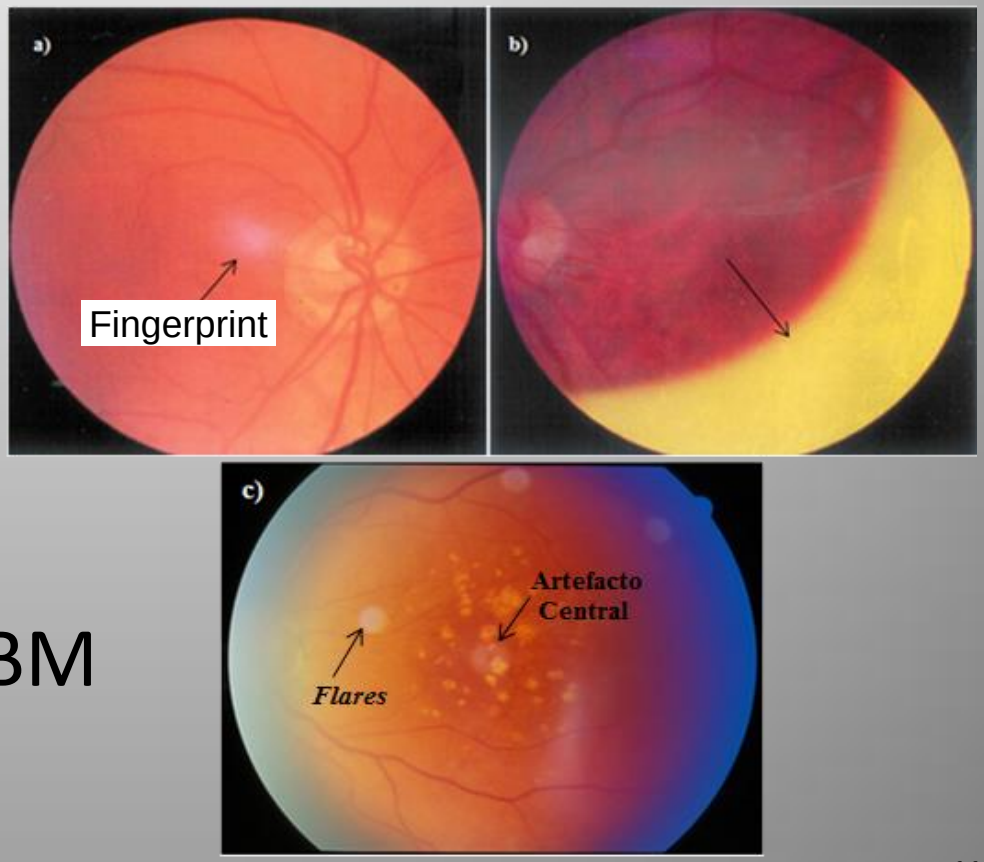
AD3RI

SS = 0.69
SP = 0.96
K = 0.58

IMAGE ARTIFACTS DETECTION

Fundus image Acquisition problems

- Images' quality can be affected by:
  - Bad collaboration from the patient
  - Dust over the lens



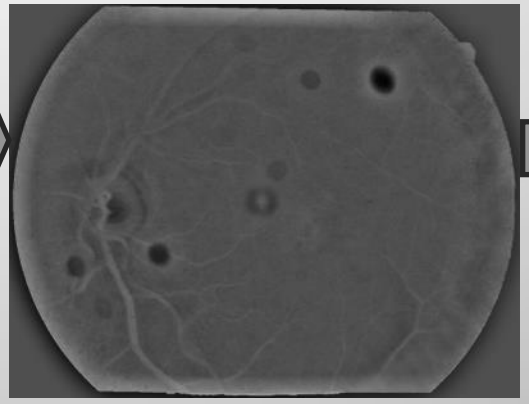
- The effects are:
  - Non-uniform illumination
  - Flares (artifacts)
  - Central Artifact

- MSc João Soares MIEBM

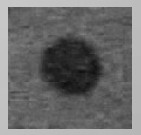
DETECTION PROCEDURE

Image

Saturation Channel



Template Matching



Template

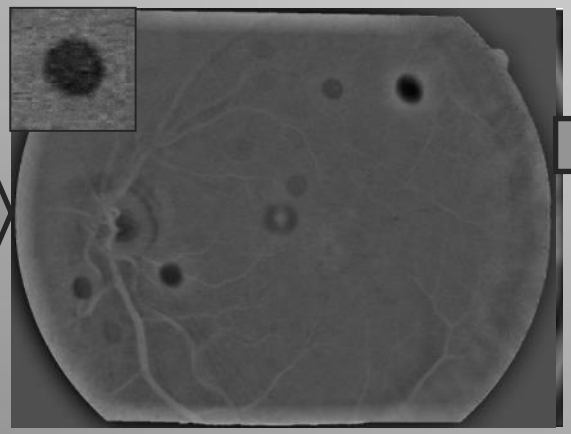
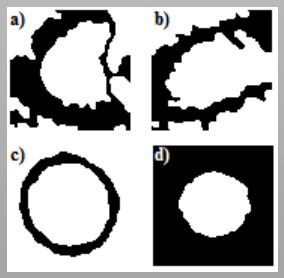
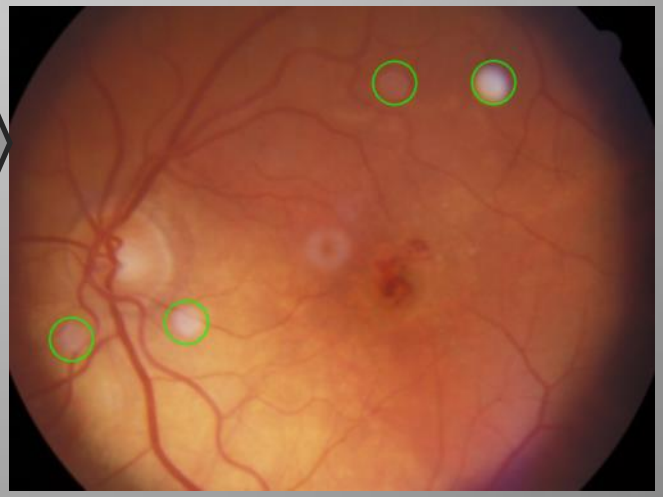


Image and Template correlation

Flare validation





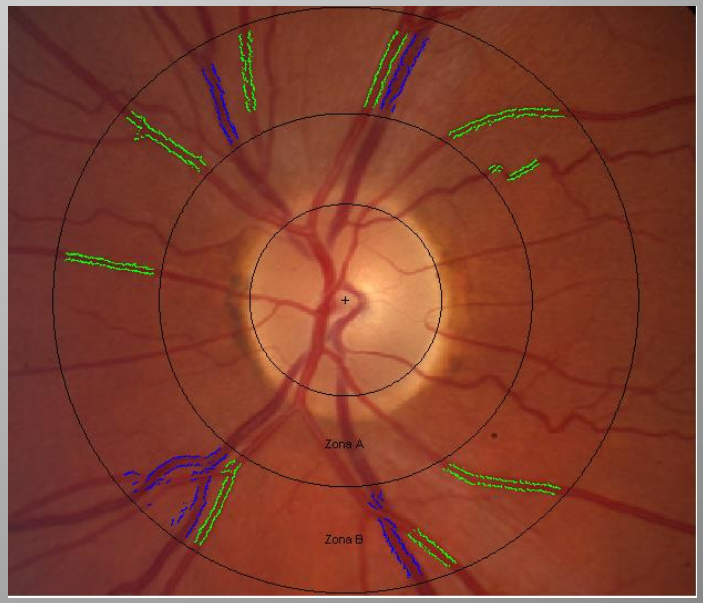
ARTERIOLAR TO VENULAR RATIO (AVR)

Arteriolar to Venular Ratio (AVR)

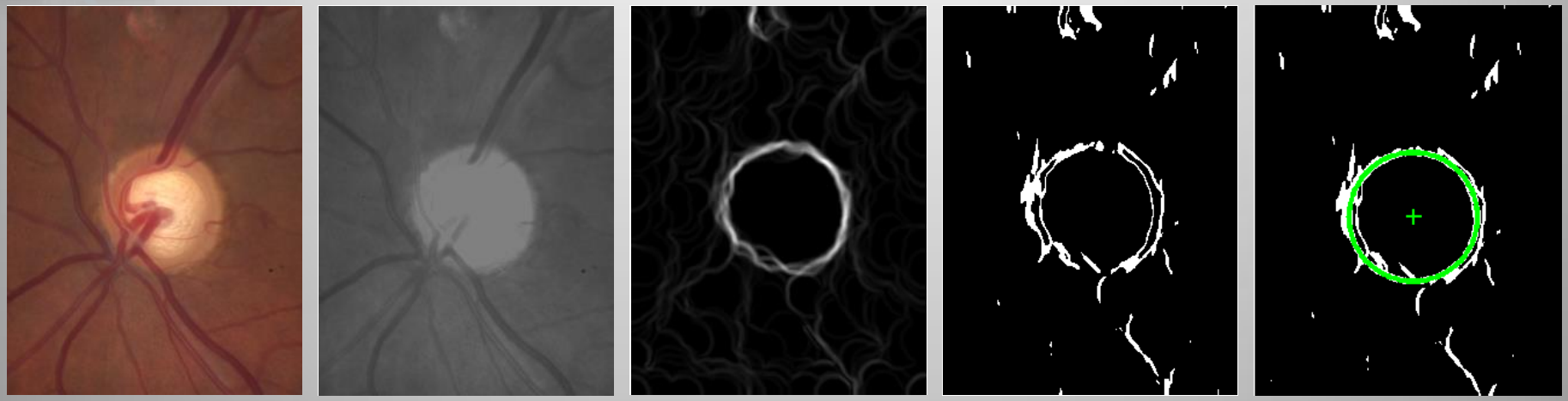
- The retina arteriolar to venular diameter ratio is suggested to reflect generalized vascular alterations and to predict the risk of cardiovascular diseases.

- Procedure:
  - Optic disk detection
  - Vessels detection
  - Arteriole / Venule Classification
  - AVR calculation

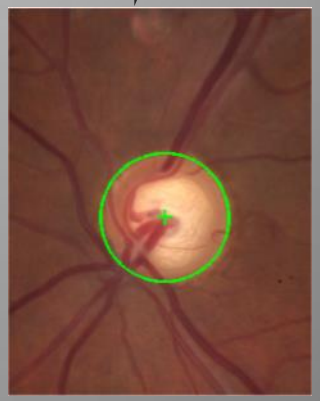
– MSc Student Tânia Tomaz MIEBM



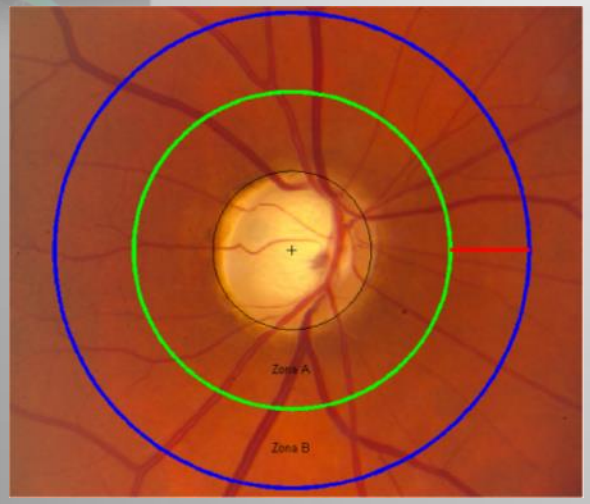
Optic disk detection

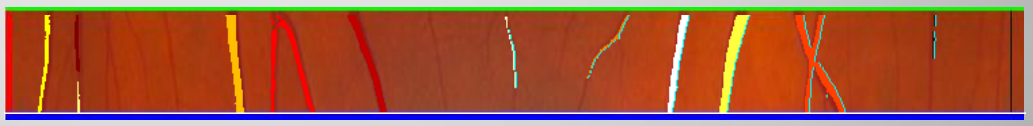


Morphologic Close → Edge Detection → Threshold → Hough Transform →

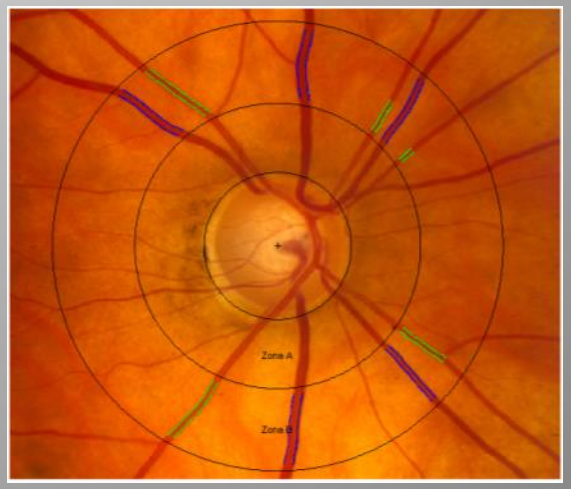


Vessels Detection and Classification





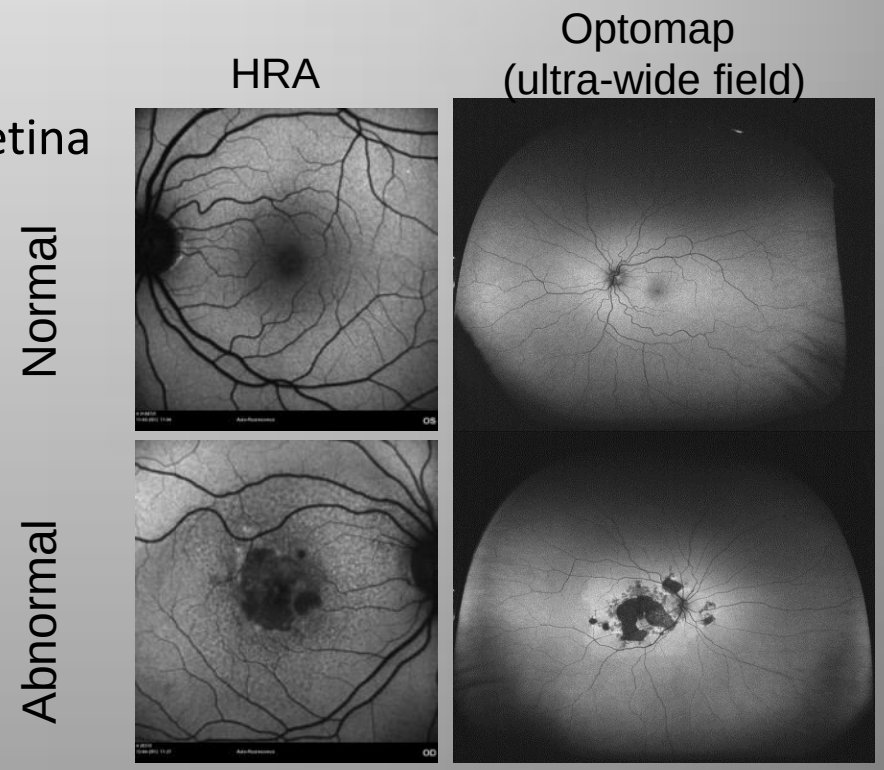
Circular projection → Vessels detection → Vessels classification



DETECT ABNORMAL IMAGES

DETECTION OF ABNORMAL IMAGES

- **Objective**: On screening and using Retinal Auto-fluorescence images, detect patients that have retinal abnormalities and need to visit their ophthalmologist
- Procedure:
  - Detect deviations from a normal retina auto-fluorescence pattern
- MSc Students:
  - Sara Praça MIEBM
  - Carlos Lopes MIEEC

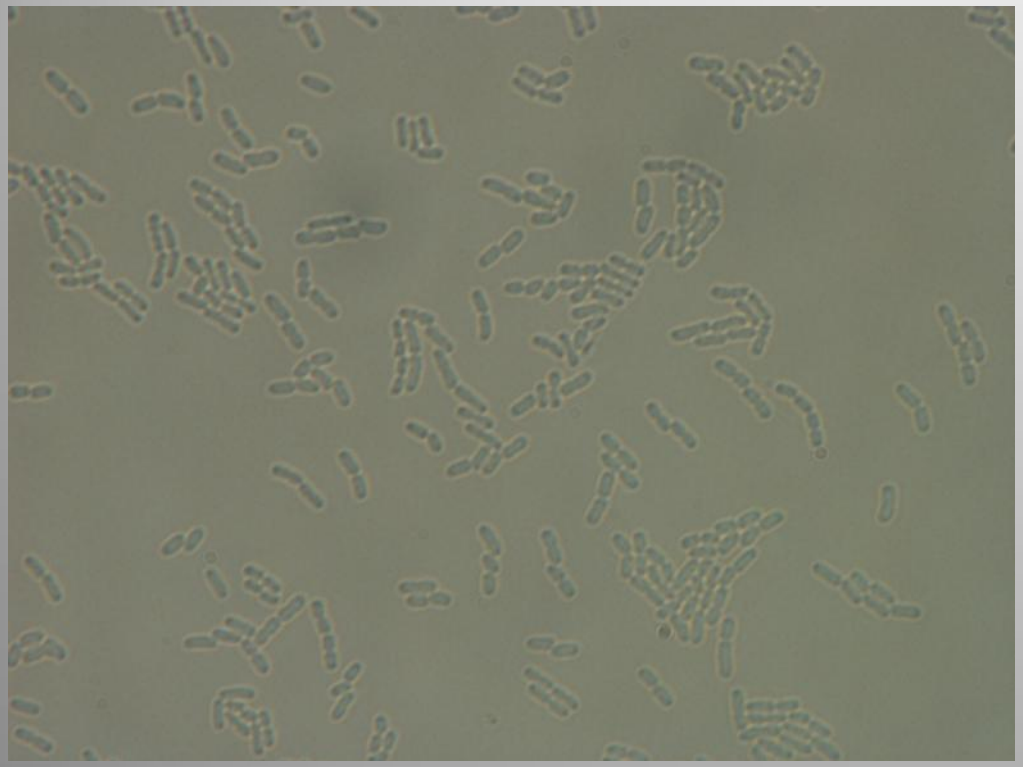


BACTERIA SEGMENTATION

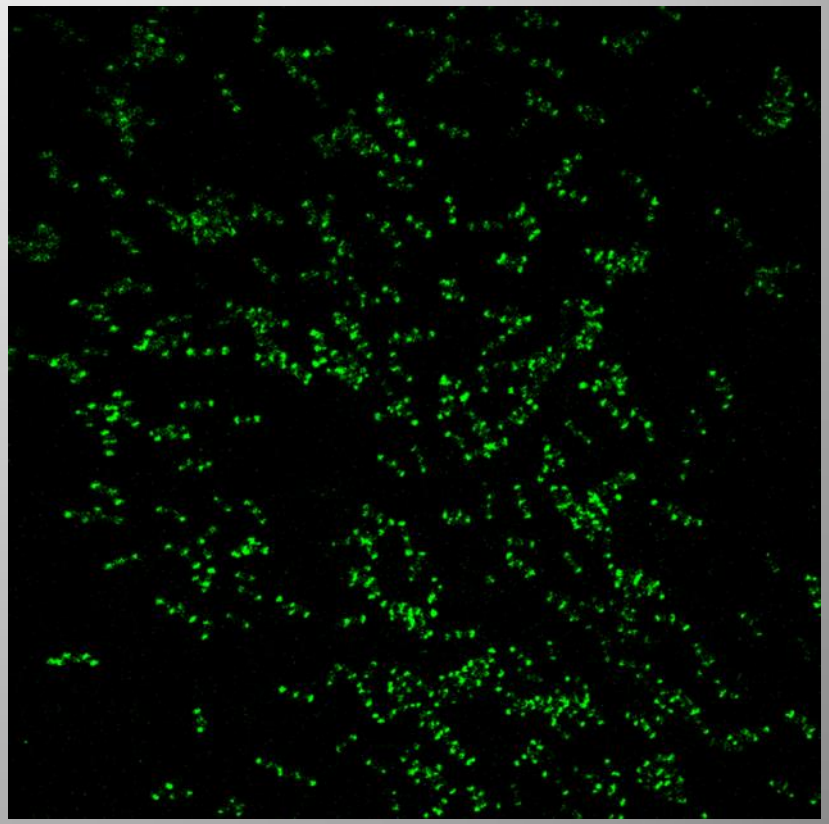
Why bacteria segmentation and tracking?

- The need of reliable and fast methods of single cell evaluation for statistically significant studies
- Extraction of individual cells information from bacterial populations with large number of elements
- Avoid manual analysis which is fastidious, time consuming and subject to observer variances

THE PROBLEM

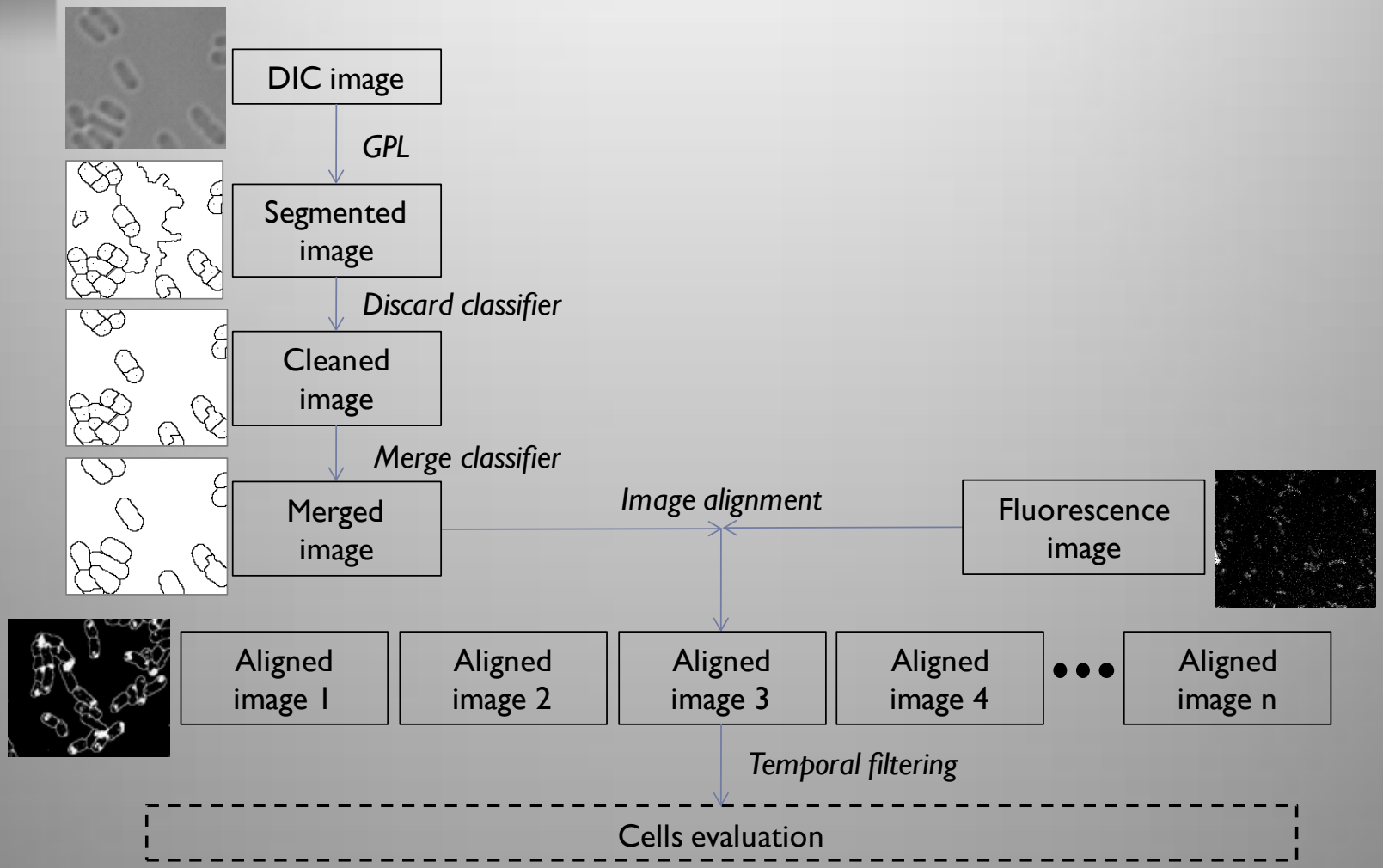


DIC - Diferential Interference Contrast Microscopy image

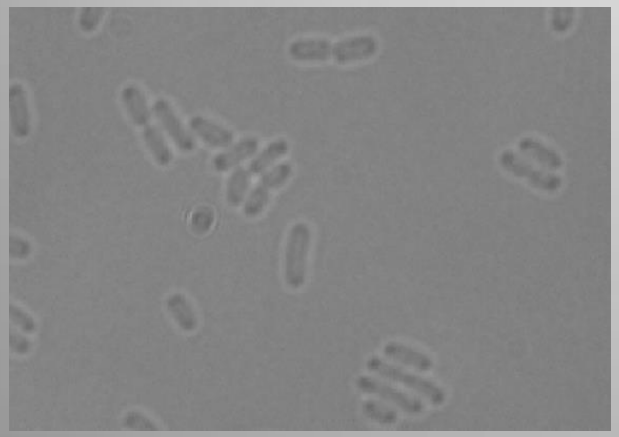


Confocal Fluorescence Microscopy image

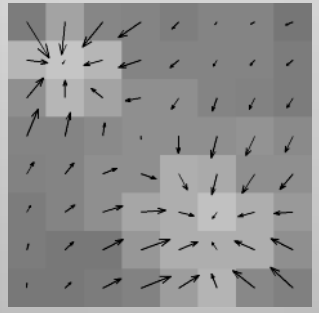
Image processing steps



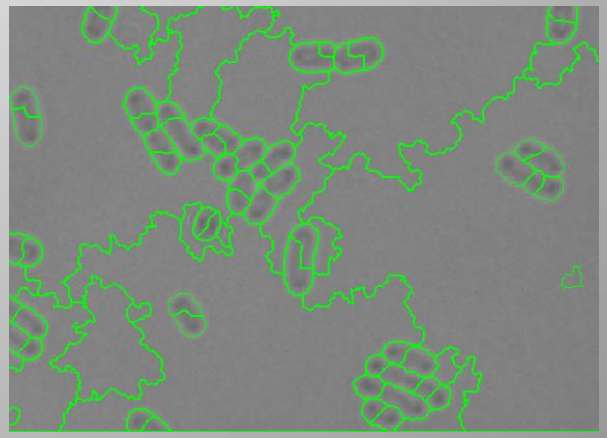
BACTERIA (OVER)SEGMENTATON



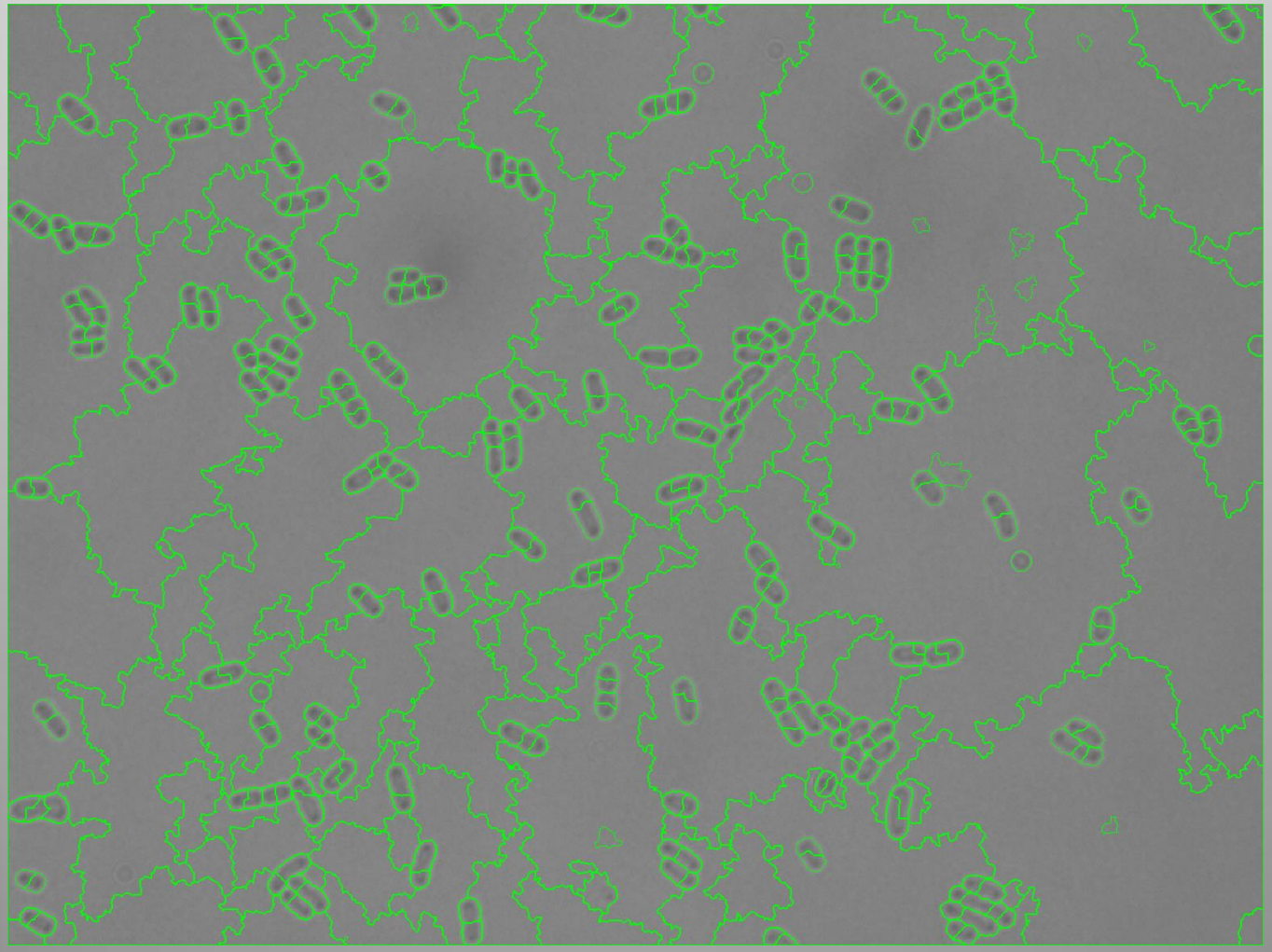
Original image



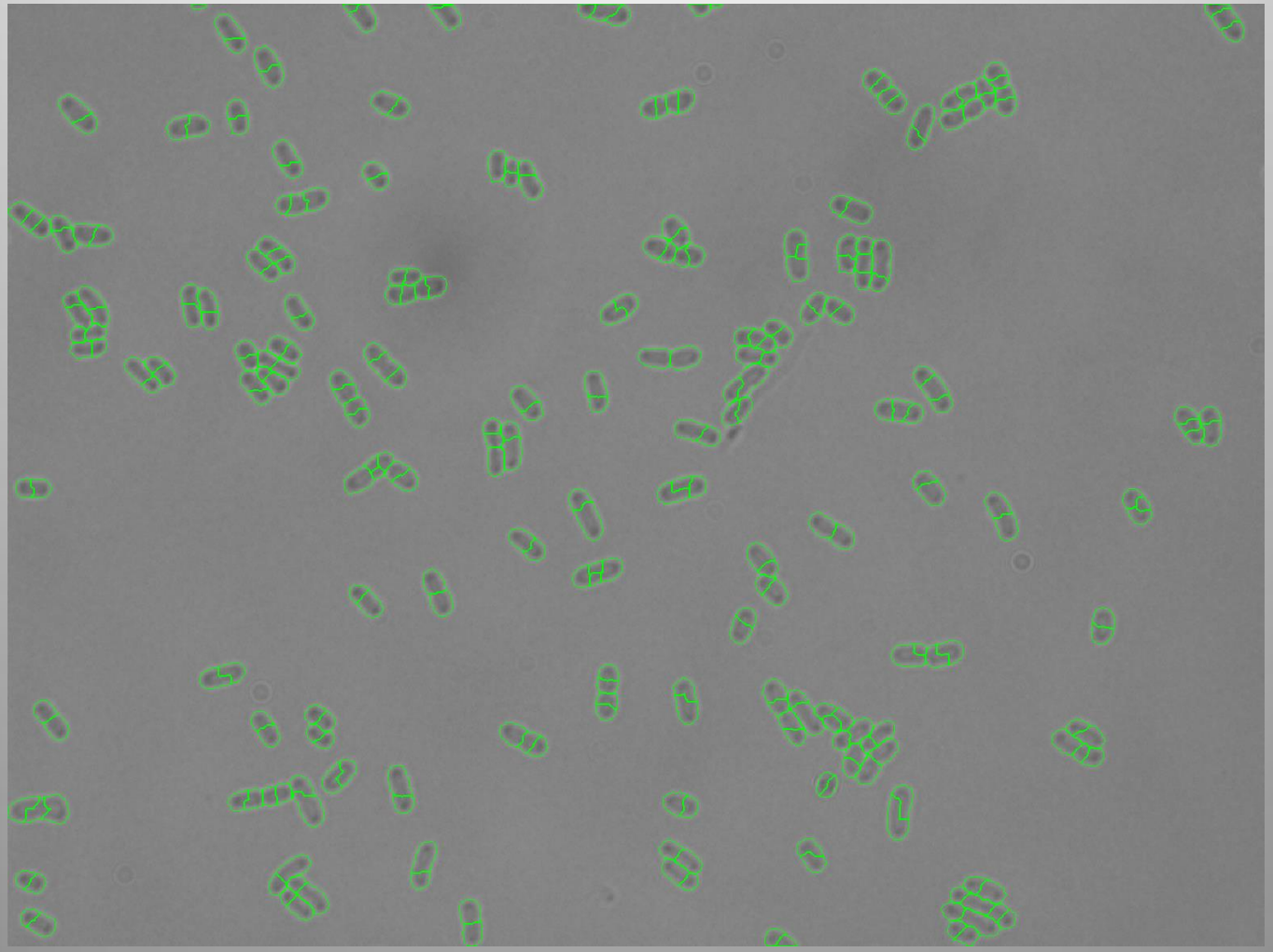
Gradient Path Labelling
(Sobel operator)



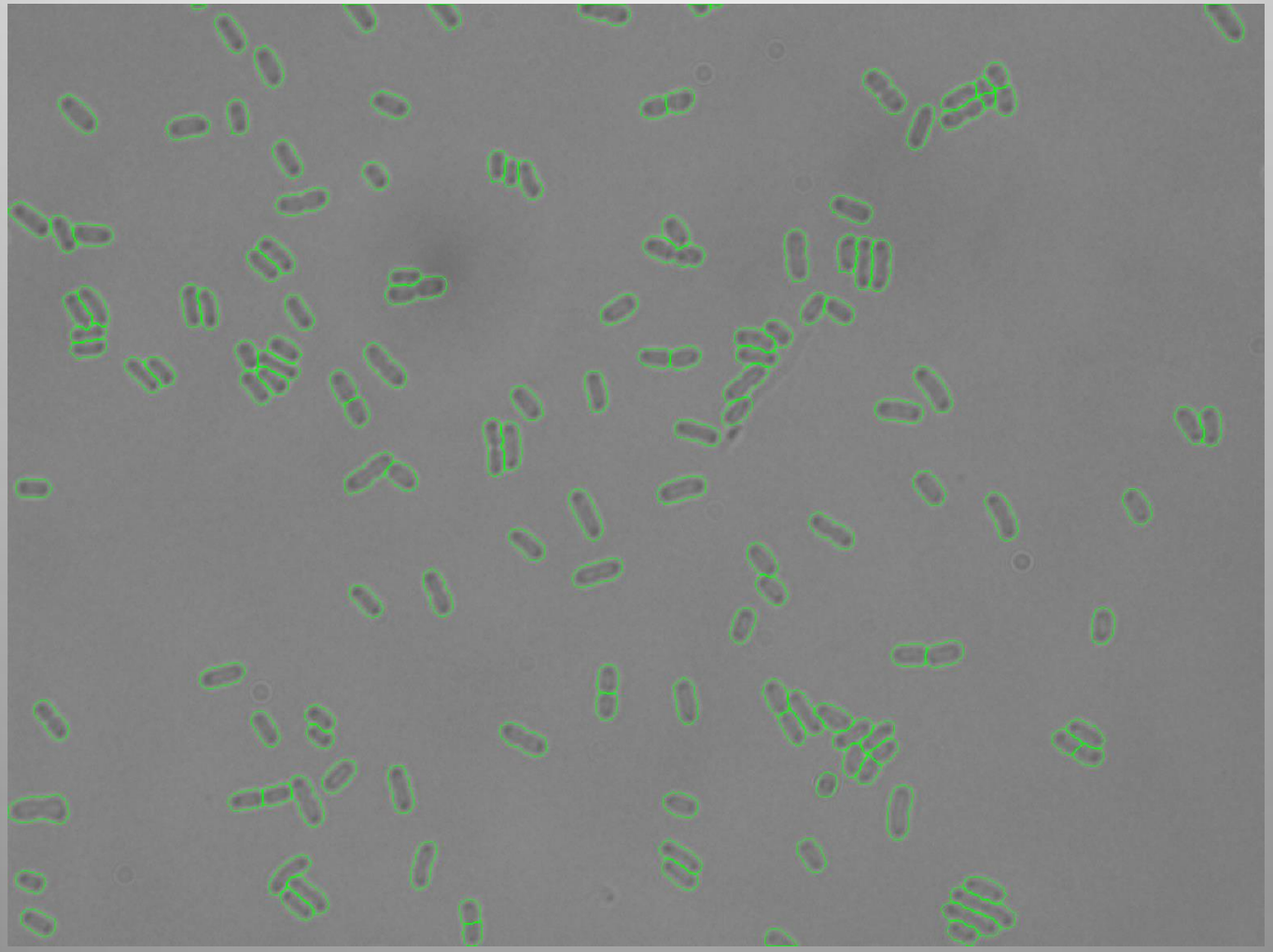
OVERSEGMENTED IMAGE



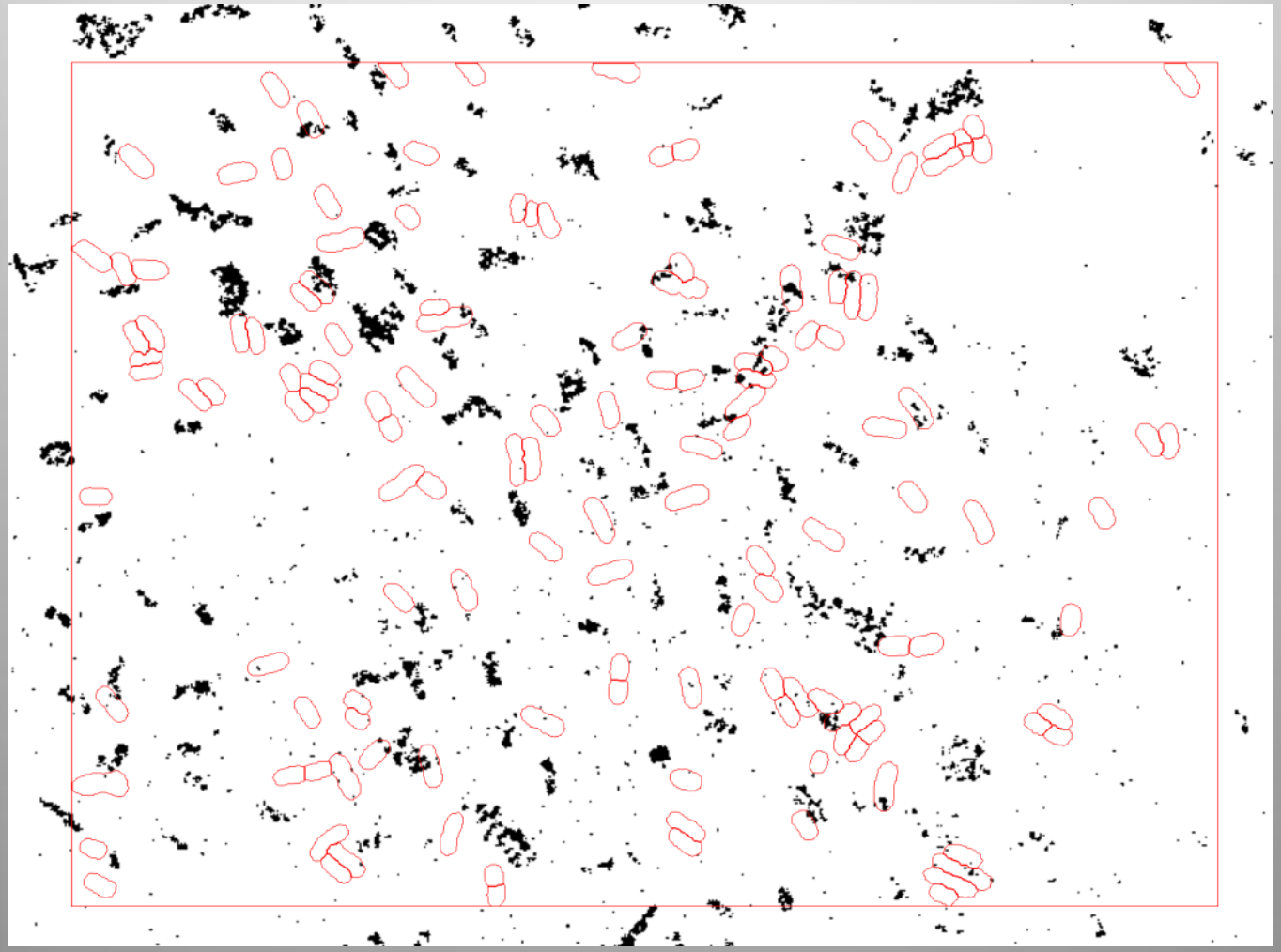
"CLEANED" IMAGE BY CART DECISION TREE



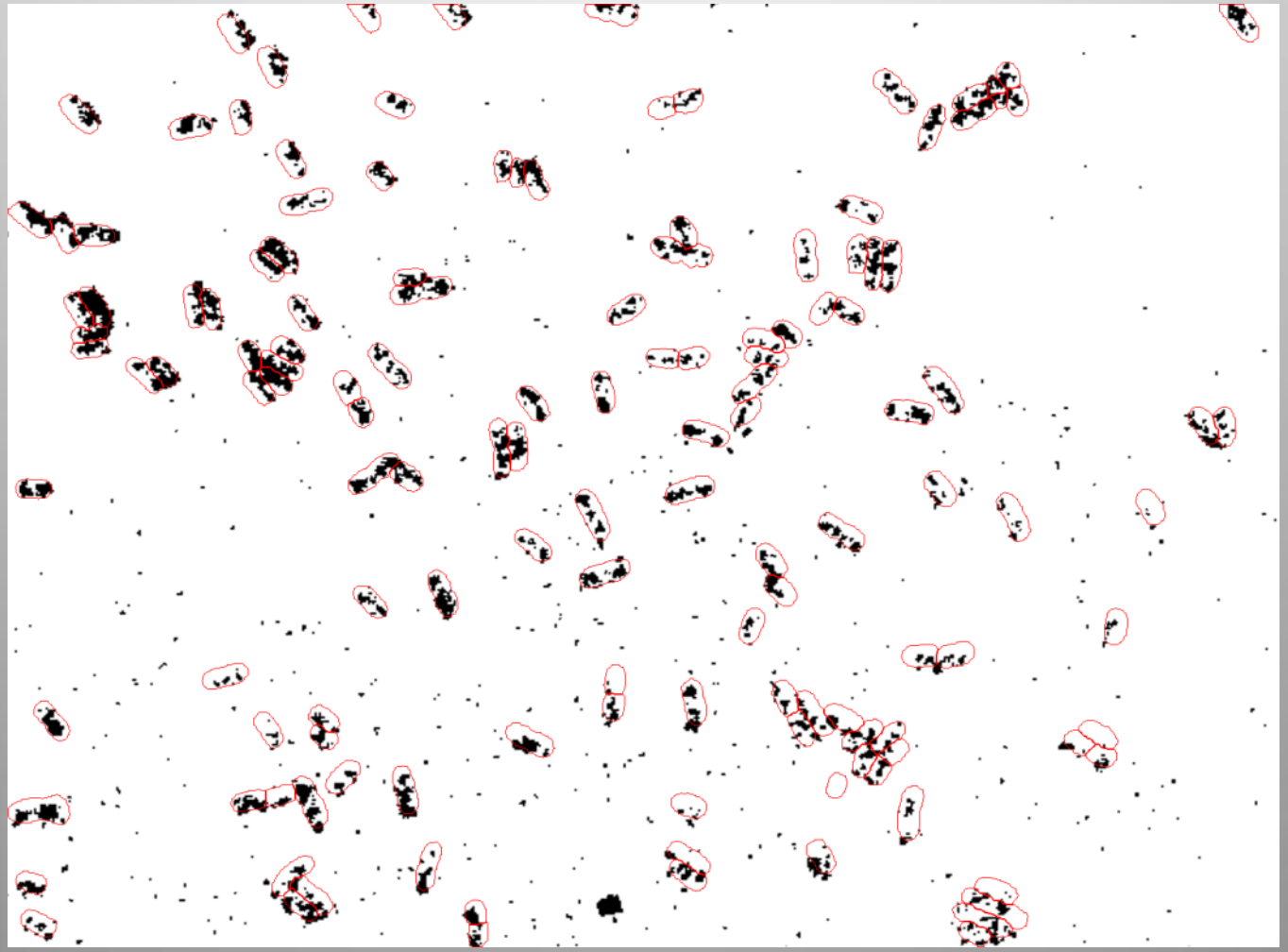
"Merged image" by CART decision tree



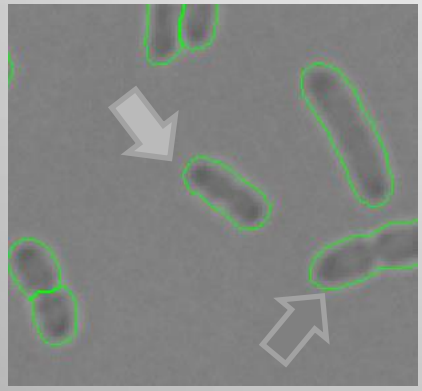
DIC and Fluorescence images alignment



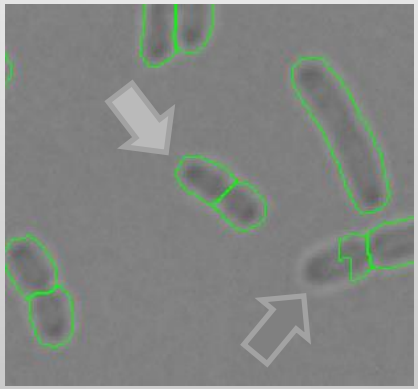
DIC and Fluorescence images aligned



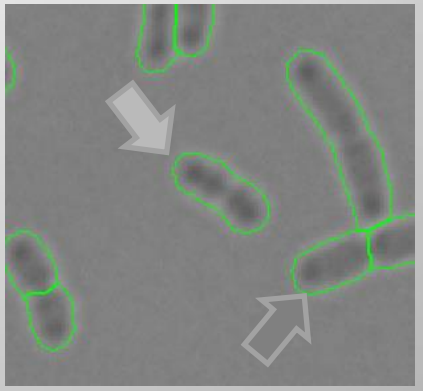
INTER-FRAME CORRECTION



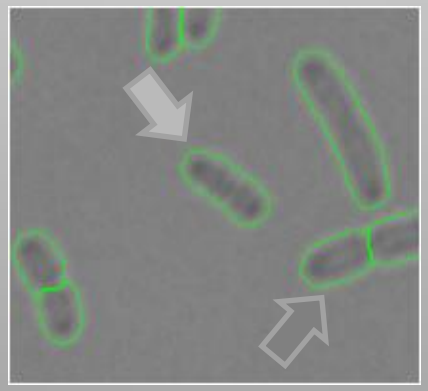
frame n-1



frame n

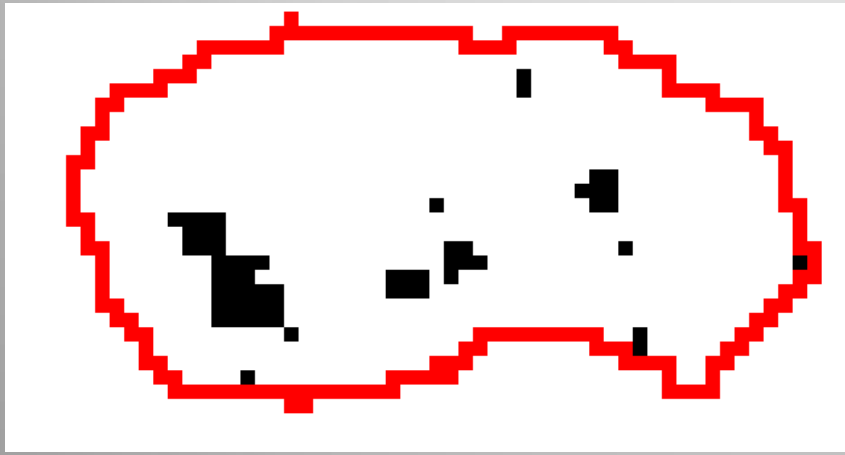


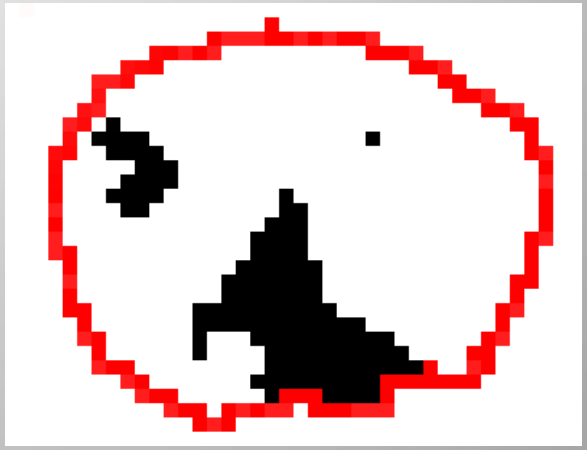
frame n+1

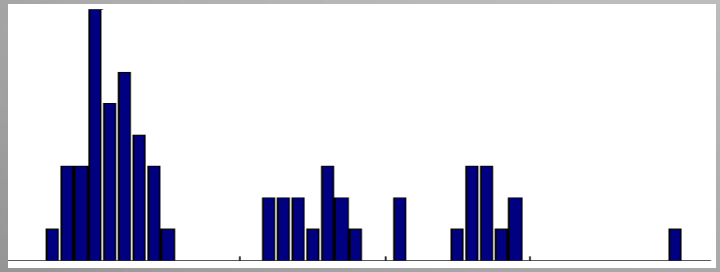


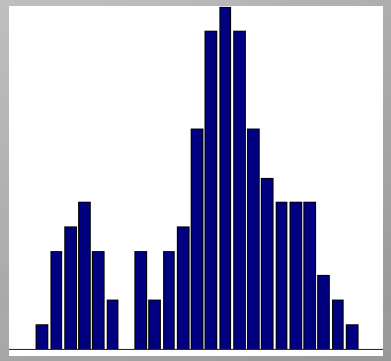
frame n after inter-frame correction

Individual cells fluorescence evaluation









Credits

- This work was developed in close collaboration with the Laboratory of Biosystem Dynamics, Department of Signal Processing, Tampere University of Technology (TUT)
- Special thanks to Professor André Ribeiro (TUT)
- Local contributors:
  - MSc Leonardo Martins (finished) - MIEBM
  - MSc Cátia Queimadelas (finished) - MIEBM
  - MSc João Rodrigues (on going) - MIEBM
  - MSc Pedro Ferreira (just started) – MIEEC

CONCLUSIONS

- The proposed method shown to be able to extract the necessary information from individual cells with acceptable error

- The method can be used to support studies if gene expression dynamics using tsr-venus proteins to assess the kinetics of expression of the gene of interest

- The evaluation of more time-series and possible improvements on image quality will certainly lead to error reduction and improved cell evaluation

THANK YOU FOR YOUR ATTENTION