

# Quantitative Conjunctival Provocation Test



István Sárándi<sup>1</sup>, Thomas Deserno<sup>1</sup>, Dan Classen<sup>2</sup>,  
Oliver Pfaar<sup>2</sup>, Anatoli Astvatsatourov<sup>3,4</sup>, Ralph Mösges<sup>3,5</sup>  
isarandi@mi.rwth-aachen.de

<sup>1</sup>Dept. of Medical Informatics, RWTH Aachen University

<sup>2</sup>Center of Rhinology and Allergology, Wiesbaden

<sup>3</sup>Institute of Medical Statistics, Informatics and Epidemiology, University Hospital Cologne

<sup>4</sup>Department of Ophthalmology, University Hospital Cologne

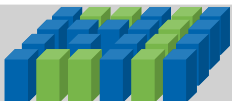
<sup>5</sup>Allergy Center of Excellence, Medical Faculty, University of Cologne



# Overview

---

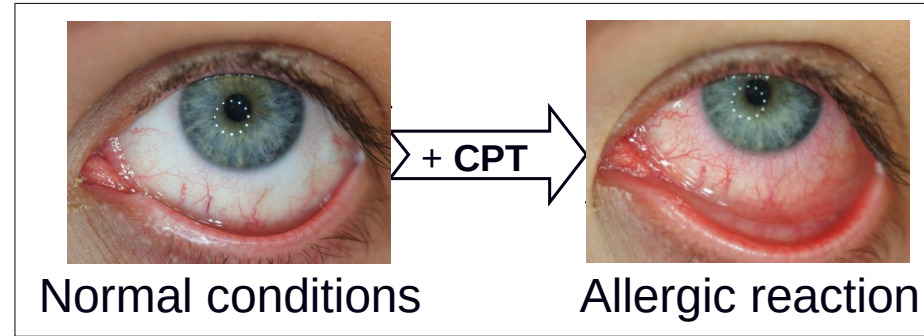
- **Introduction**
- Materials and methods
  - Image material
  - Image processing chain
  - Evaluation
- Results
- Summary and discussion



# Introduction

## ■ Conjunctival Provocation Test

- ▢ Apply allergen solution
- ▢ Evaluate response

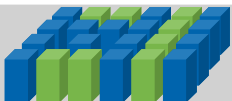


## ■ Application

- ▢ Allergy diagnosis in clinical trials

## ■ Aim

- ▢ Quantification of change in conjunctiva redness
- ▢ Fully automated image processing

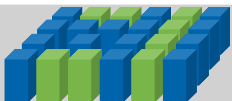




# Overview

---

- Introduction
- **Materials and methods**
  - Image material
  - Image processing
  - Evaluation
- Results
- Summary and discussion



# Image material

- Camera: Olympus PEN E-P1
- Macro Lens: Olympus M.Zuiko Digital ED 60mm f/2.8
- Light: Hama 12 LED-Macro-Light, DSLR
- Stand: Custom made at IMSIE, University Hospital Cologne



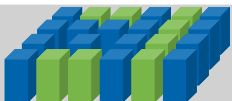
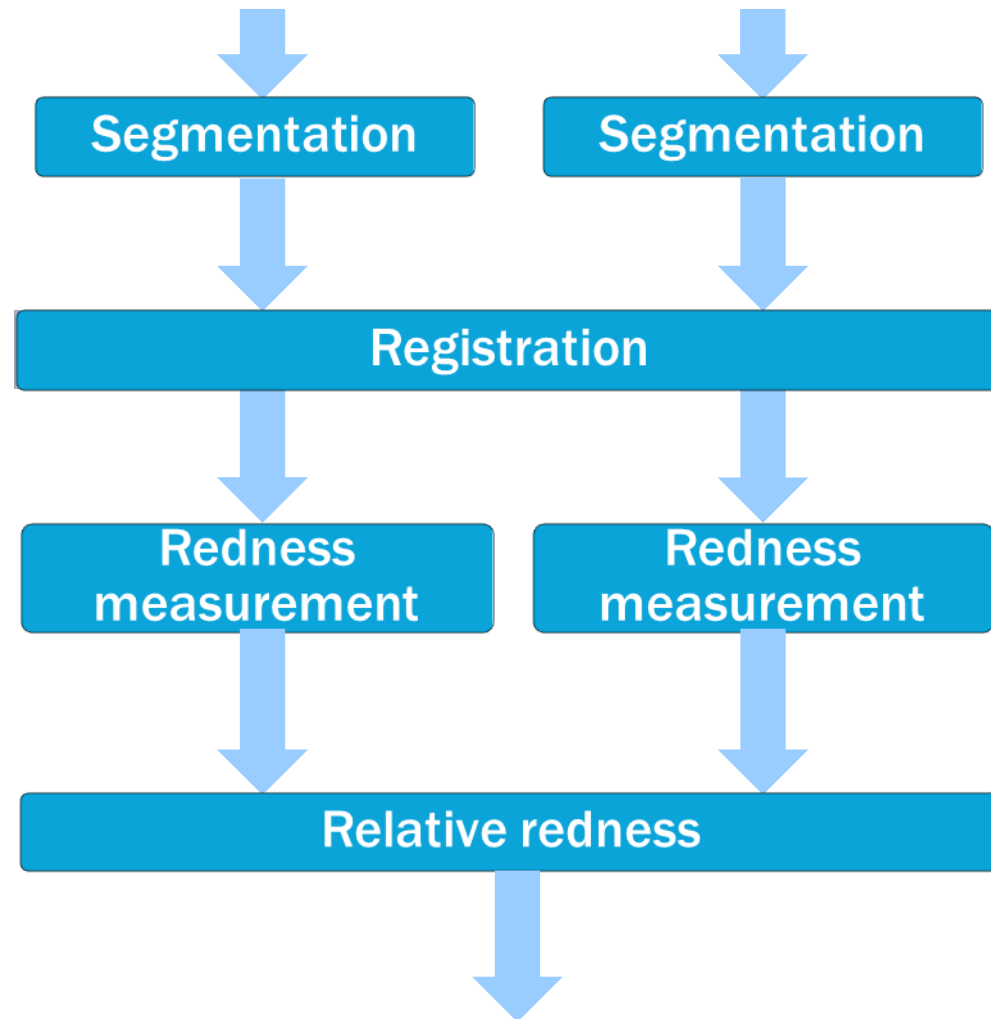
# Image processing



*Photo without allergen*



*Photo with allergen*

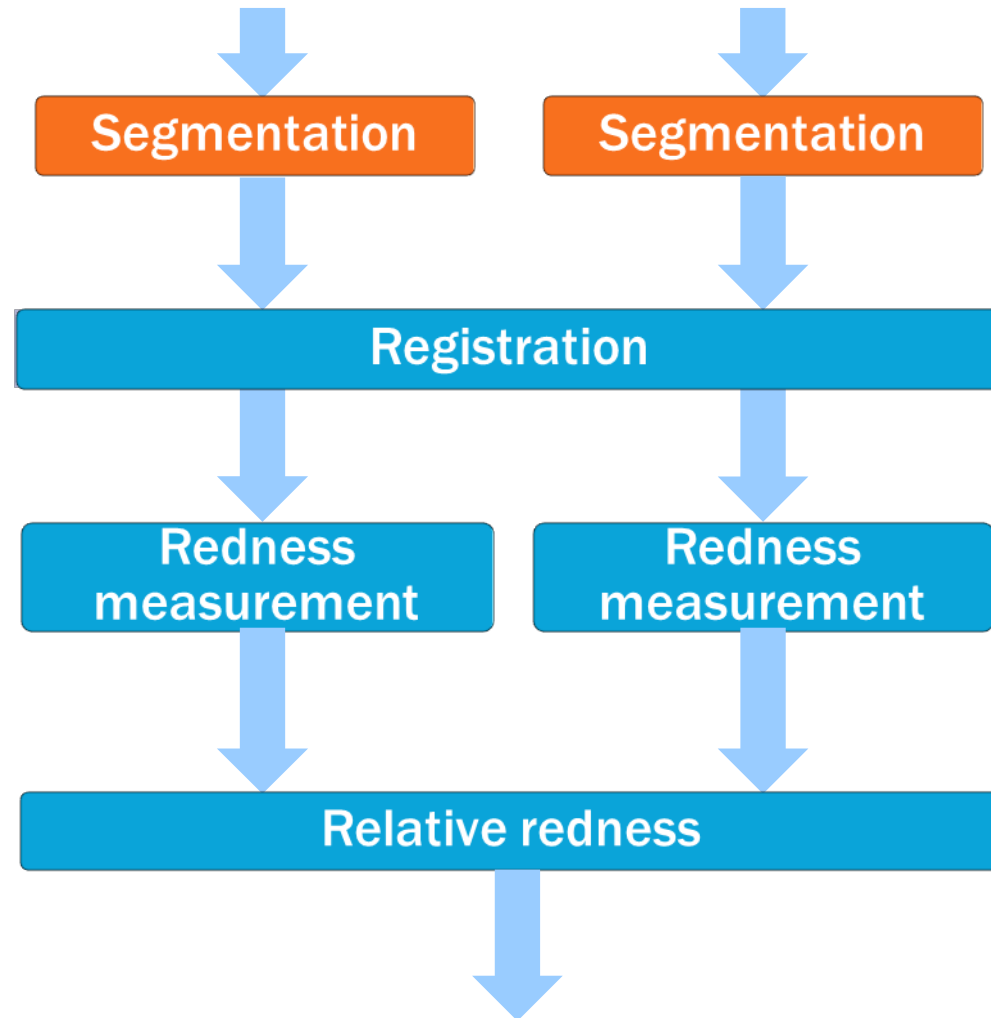


# Image processing



*Photo without allergen*

*Photo with allergen*



# Segmentation

## Steps

- Binarize
  - ◆ Threshold in YUV color space
  - ◆ Edge-based correction
- Find components
- Select conjunctiva
- Smooth ROI

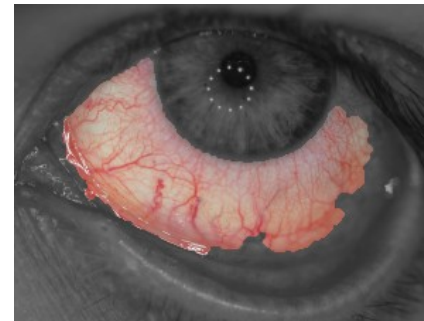
## Example



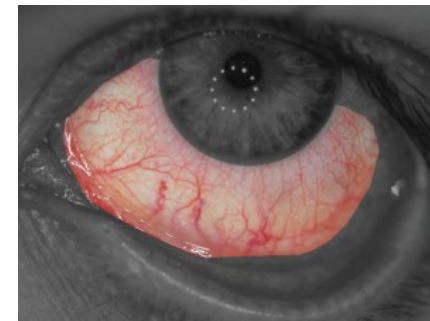
Original



Binarized (color/gray)



Conjunctiva

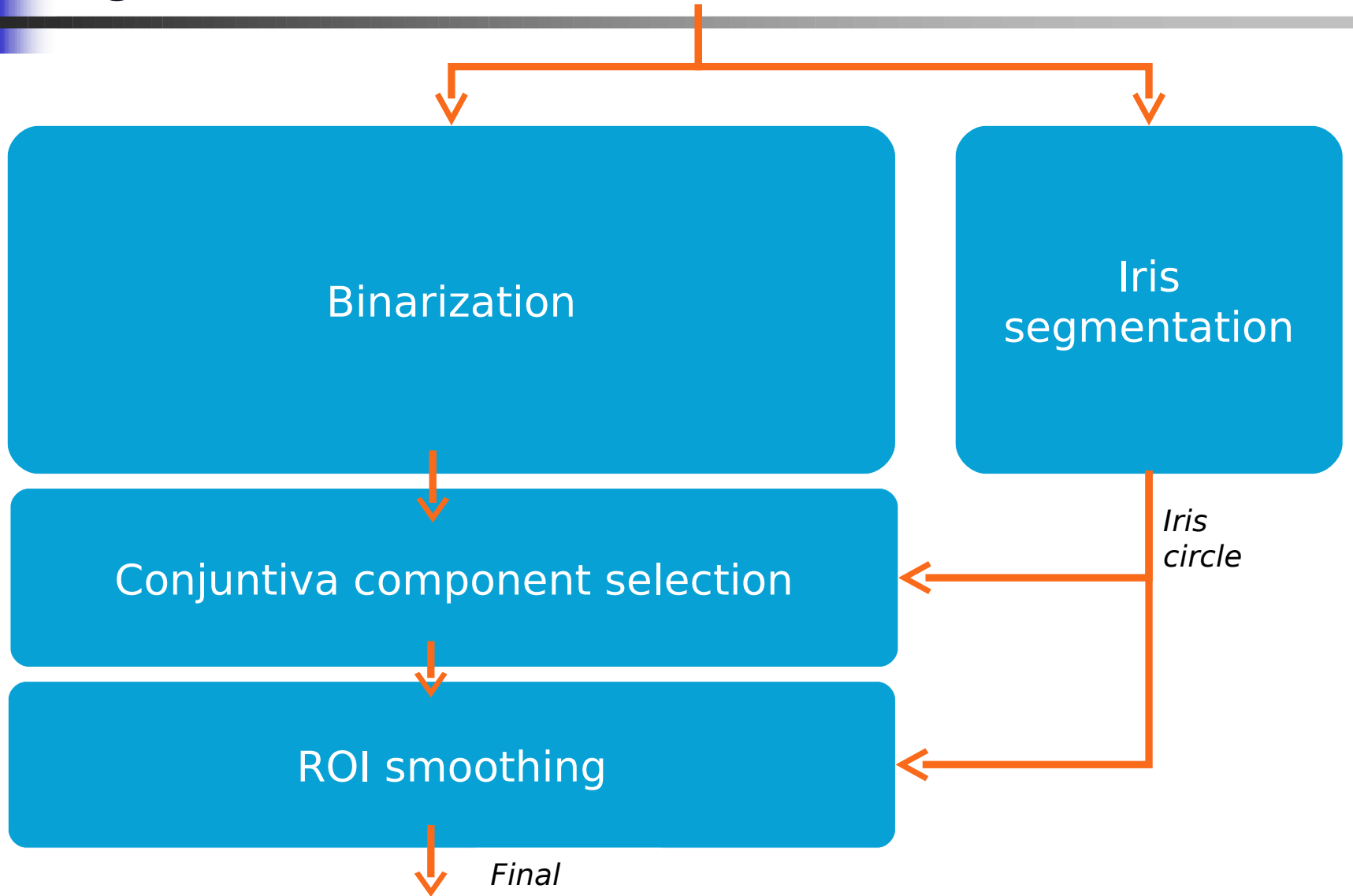


Smoothed ROI

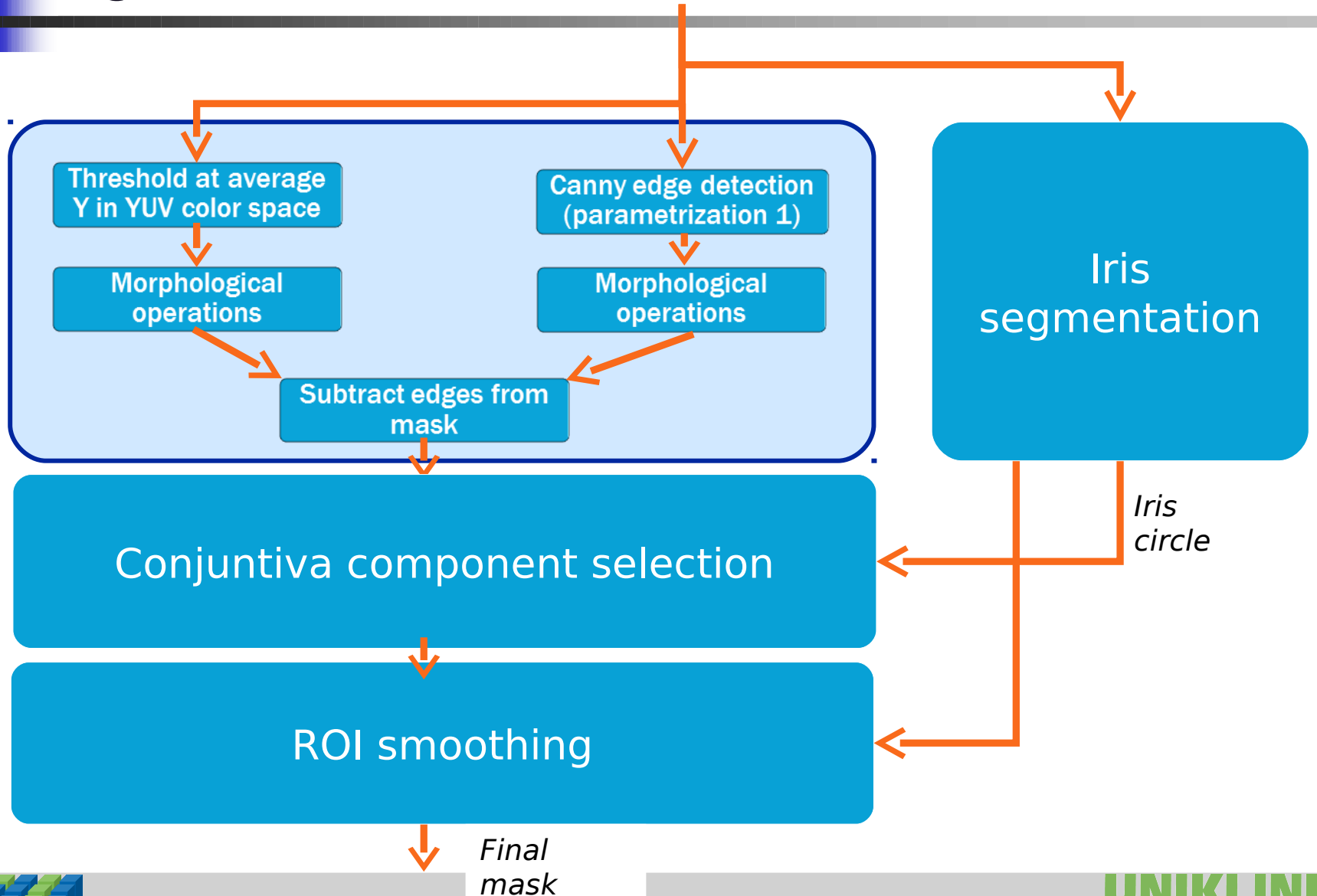




# Segmentation



# Segmentation



# Segmentation (edge-based correction)

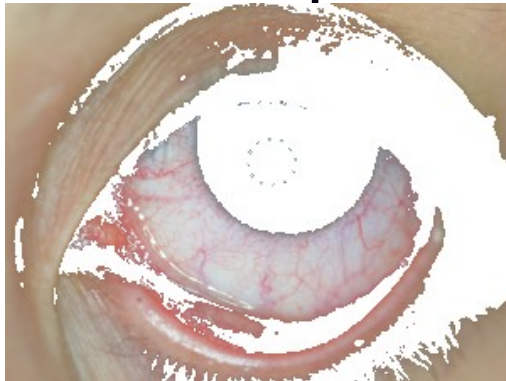
- Goal

- Remove artefacts (bridges from thresholding)

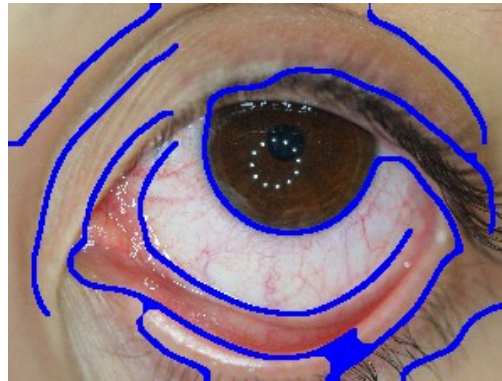
- Steps

- Canny edge map & morphological optimization
- Subtract from the mask before connected components

- Example



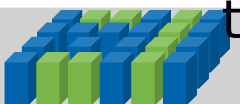
Regions above  
threshold



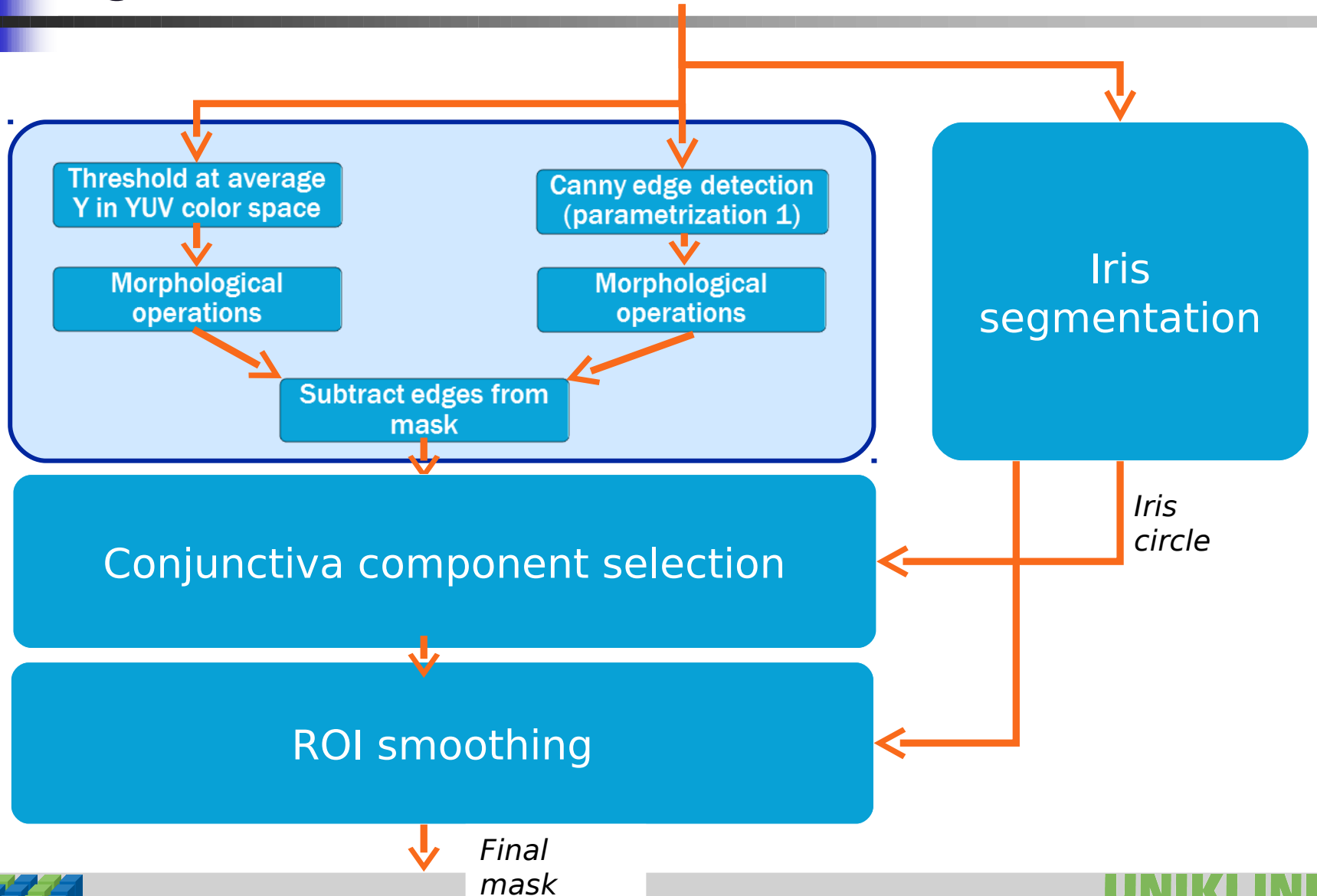
Canny edges



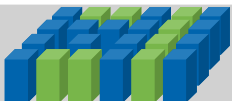
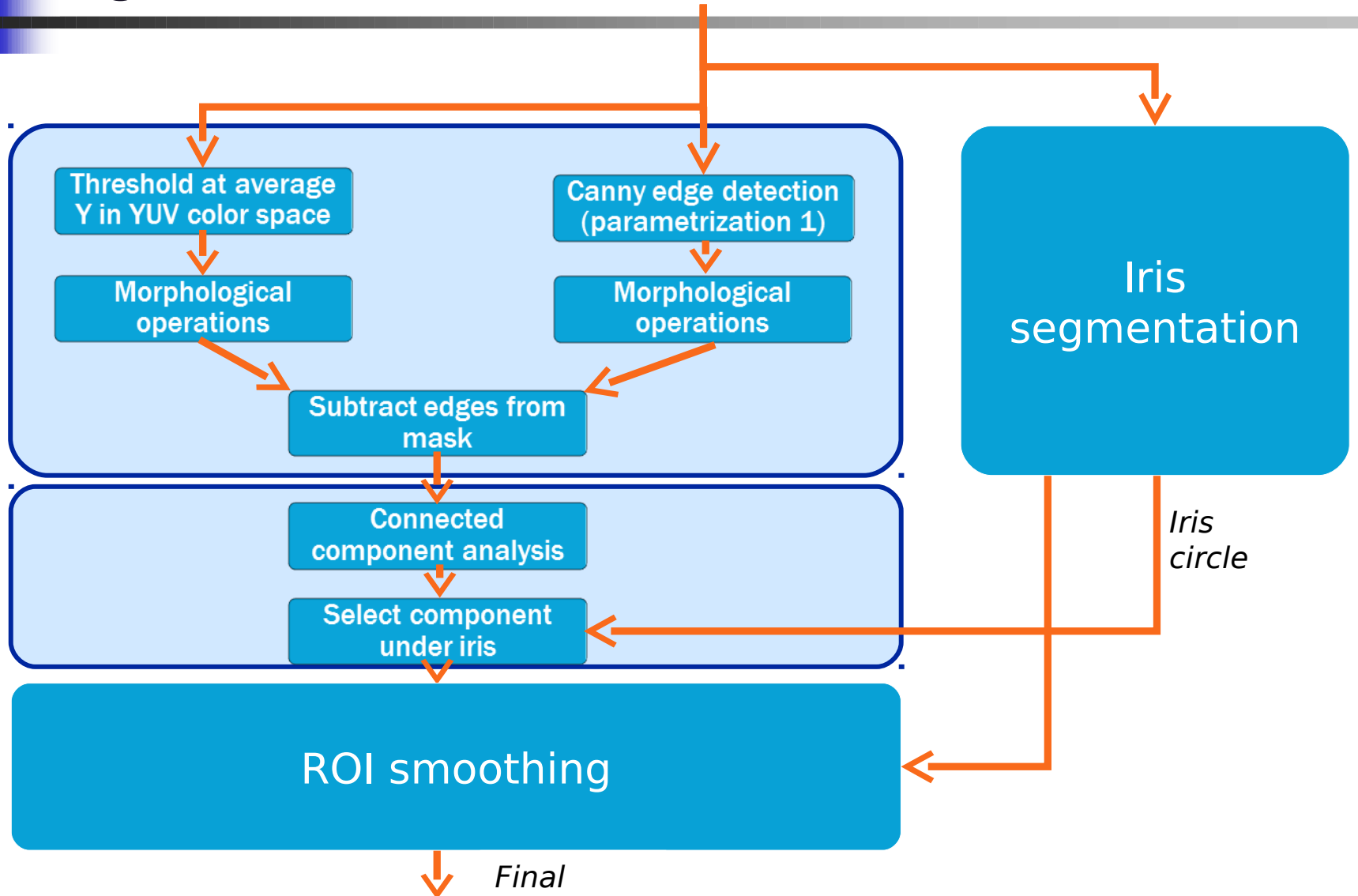
Final mask



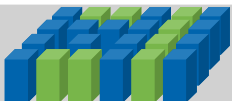
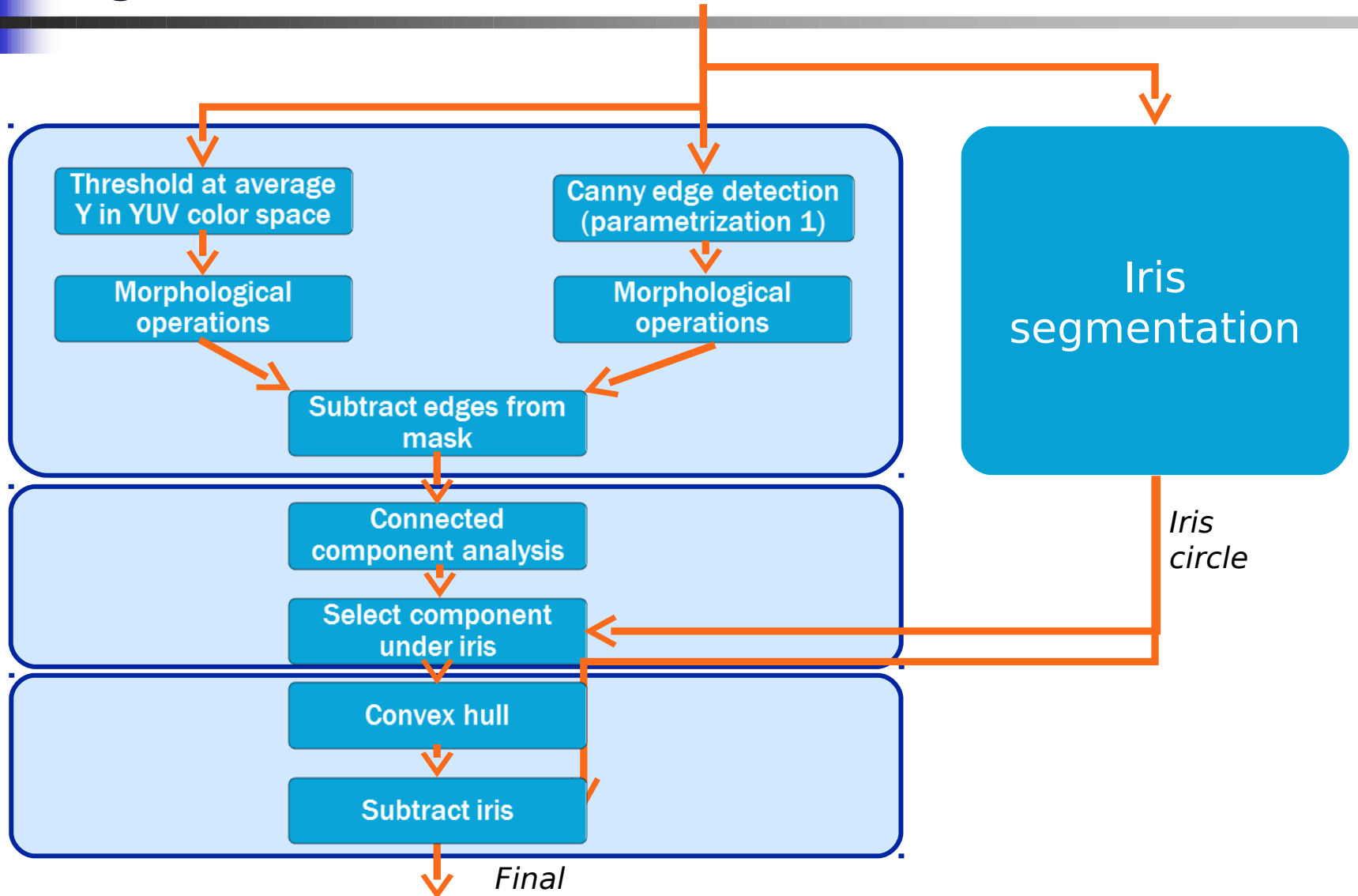
# Segmentation



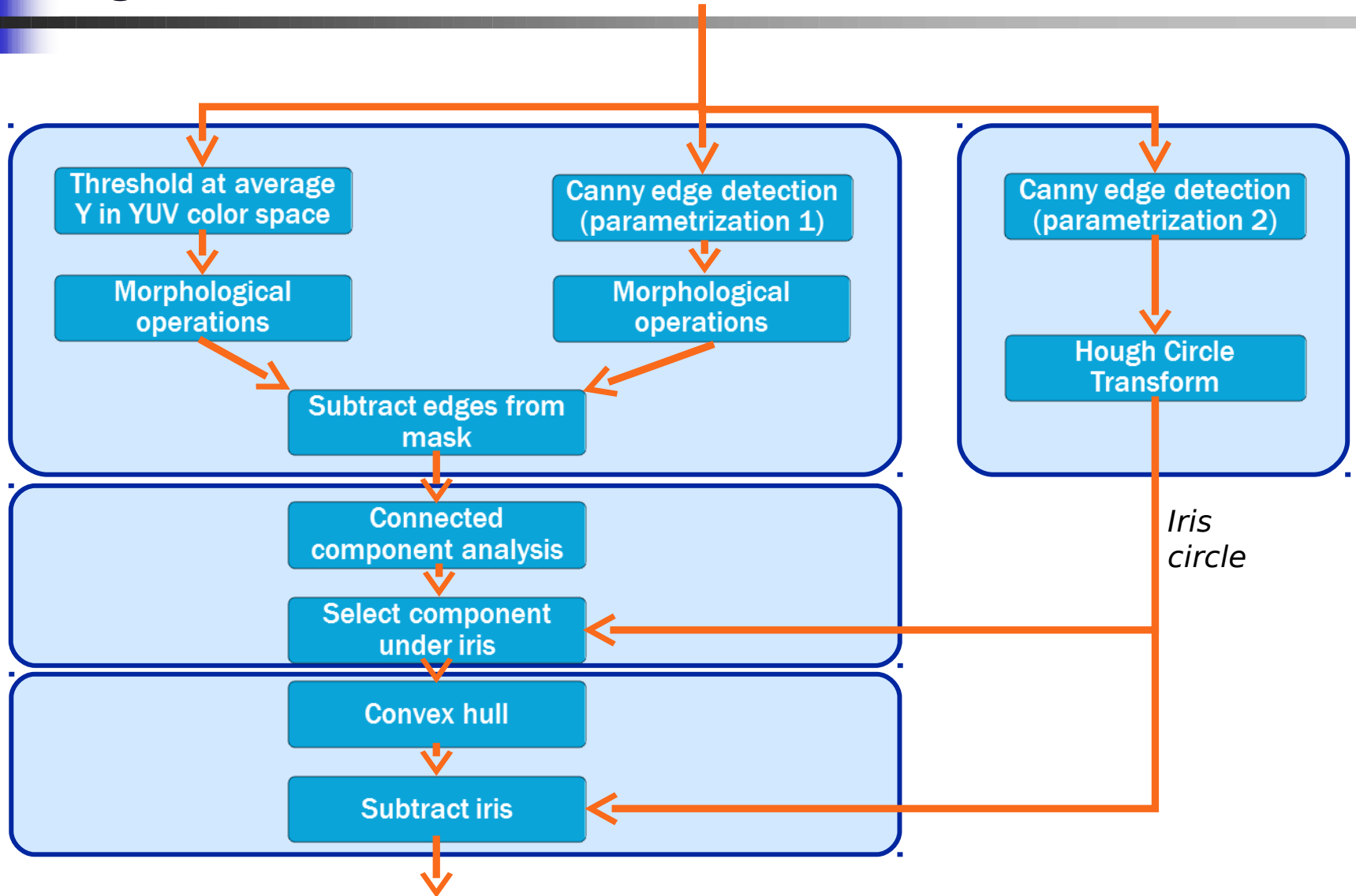
# Segmentation



# Segmentation



# Segmentation



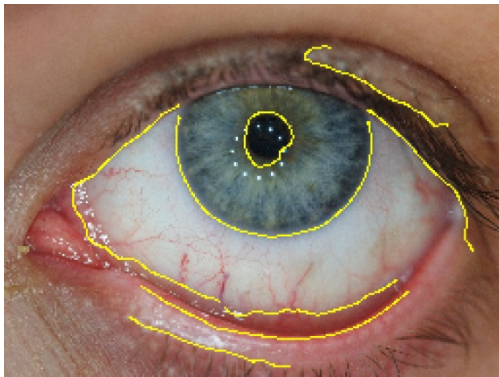
# Iris segmentation

- Steps

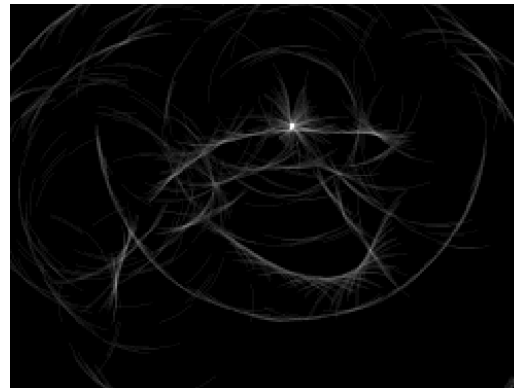
- Canny edge detection

- Gradient-based Hough Circle Transform

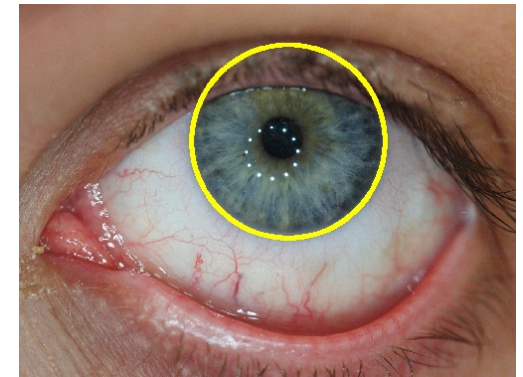
- Example



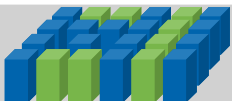
Canny  
edges



Hough space  
(sliced at  $r$  of global maximum)



Most voted circle





# Image processing

*Photo without allergen*

*Photo with allergen*

Segmentation

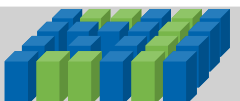
Segmentation

Registration

Redness  
measurement

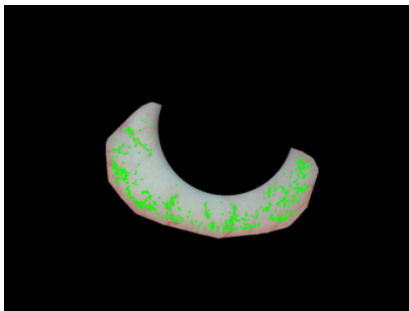
Redness  
measurement

Relative redness

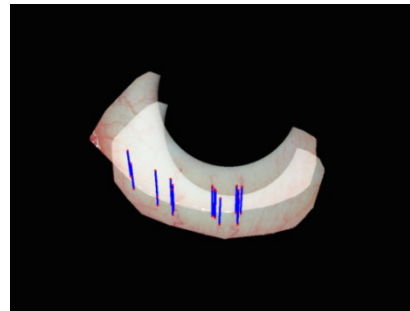


# Registration

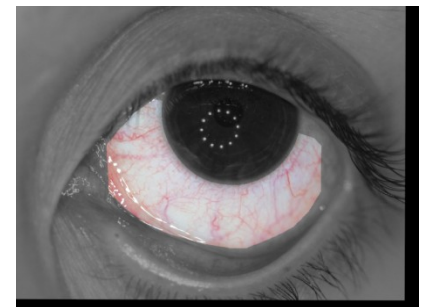
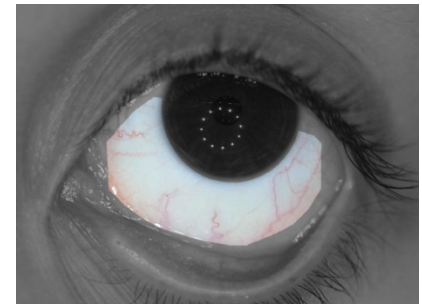
- Goal
  - measure same region
- Steps
  - Register the images (similarity transform with SIFT algorithm)
  - Intersect ROIs
- Example



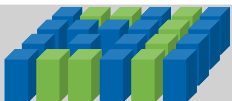
Detected features



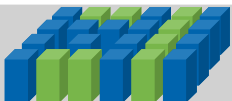
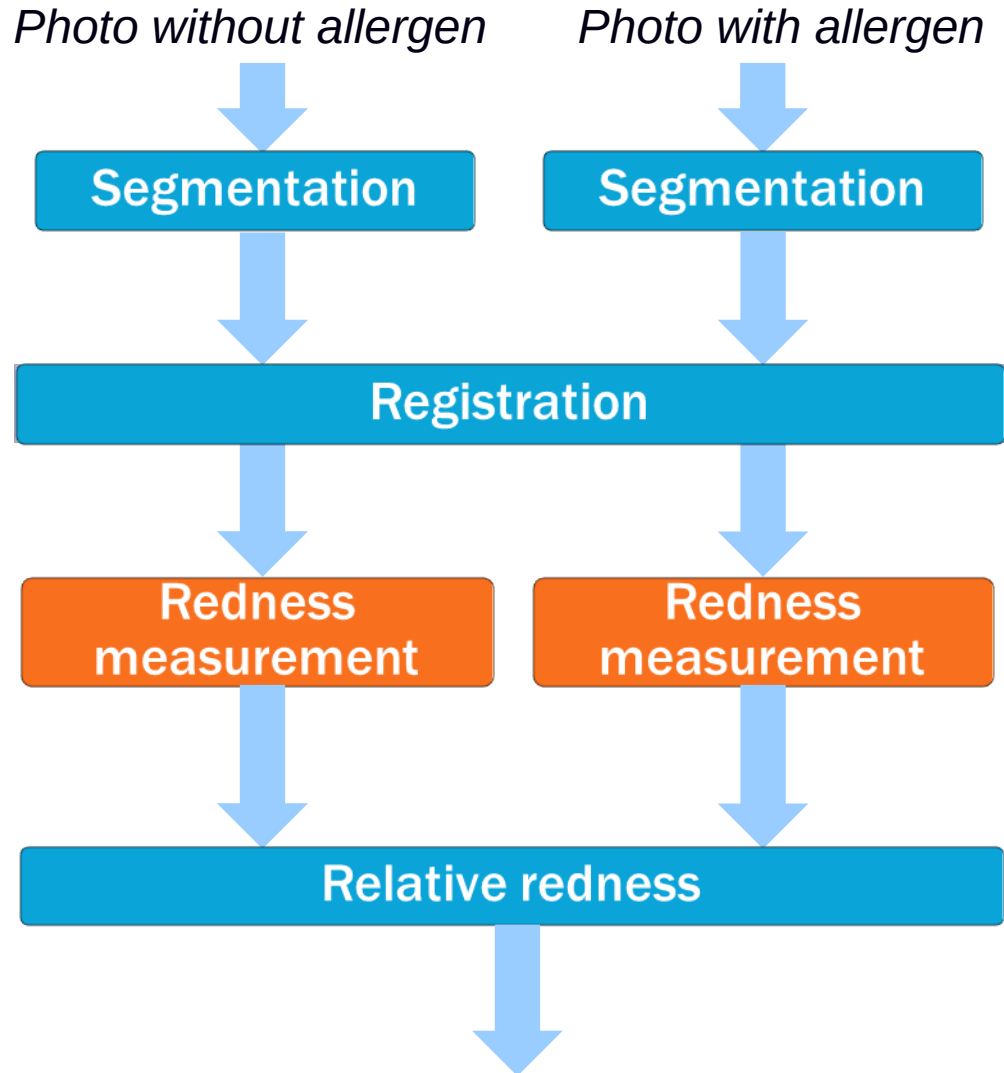
Detected matches



Registered images



# Image processing



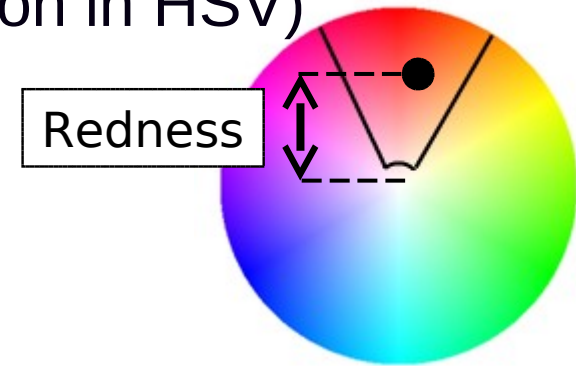
# Redness measurement

## ■ Steps

- ▢ Select red pixels (thresholding in HSV space)
- ▢ Calculate per pixel redness (projection in HSV)

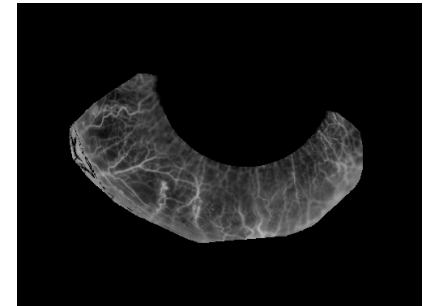
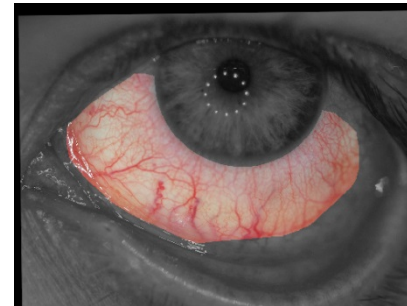
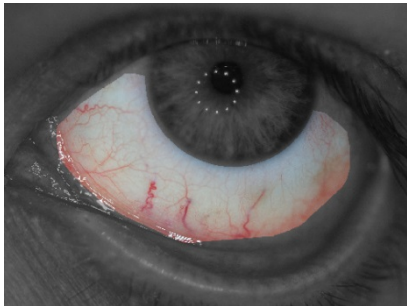
$$\text{redness} = \text{saturation} \cdot \cos(\text{hue})$$

- ▢ Return mean redness of red pixels

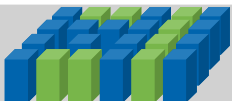
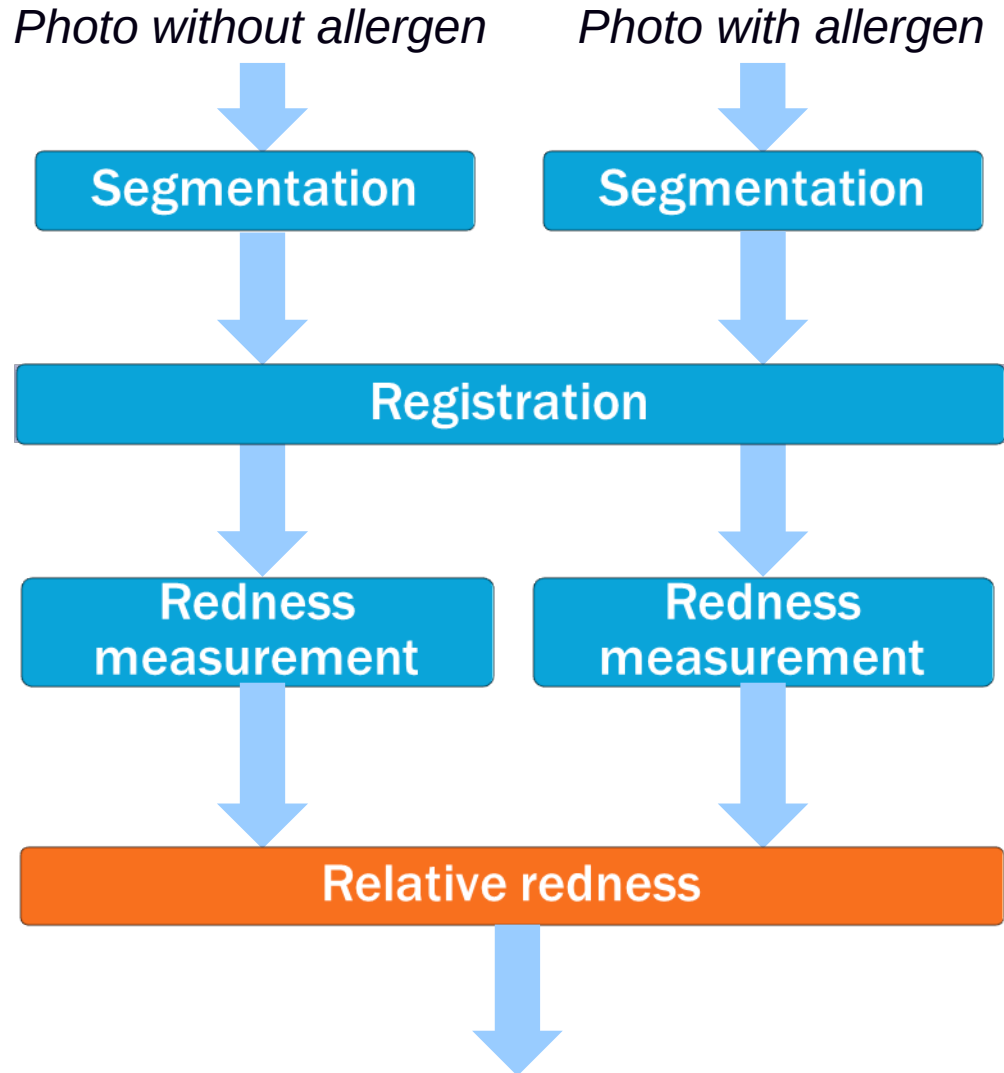


## ■ Examples

- ▢ Gray scale represents the redness



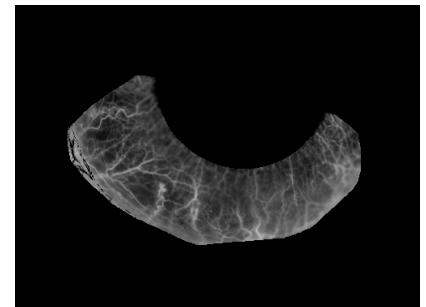
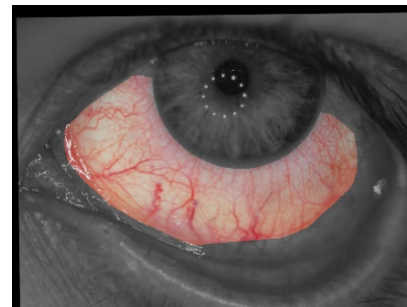
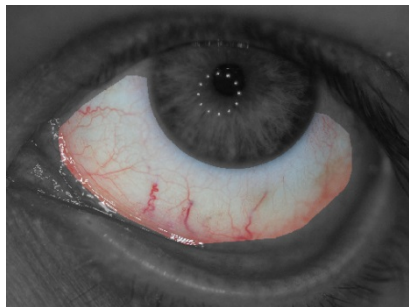
# Image processing



# Relative redness index

- Goal: measure redness change
- Relative redness

$$\frac{\text{redness after allergen}}{\text{redness before allergen}}$$

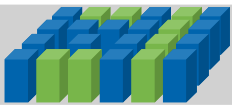




# Overview

---

- Introduction
- Materials and methods
  - Image material
  - Image processing chain
  - **Evaluation**
- Results
- Summary and discussion

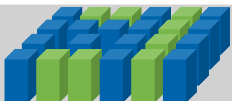




# Evaluation

---

- Observational diagnostic study (Wiesbaden)
  - Goal: assess test-retest reliability of CPT
  - Patients: 23 allergic patients
  - Procedure:
    - ◆ Test 1: Take photo before and after application of allergen (dose individually predetermined)
    - ◆ Test 2: After a couple of weeks, repeat test with the same dose
    - ◆ No therapy between tests
  - Expectation: correlation between Test 1 and Test 2 relative redness measure



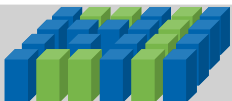




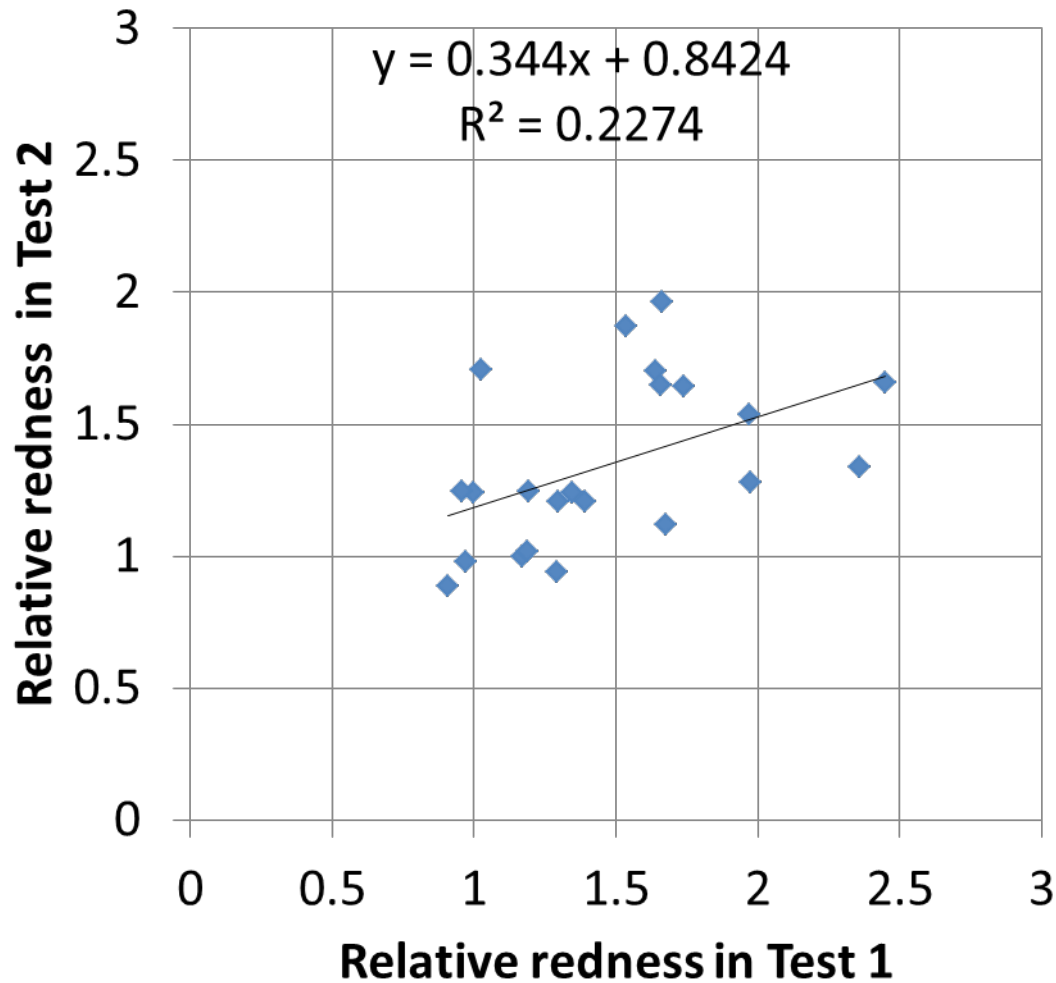
# Overview

---

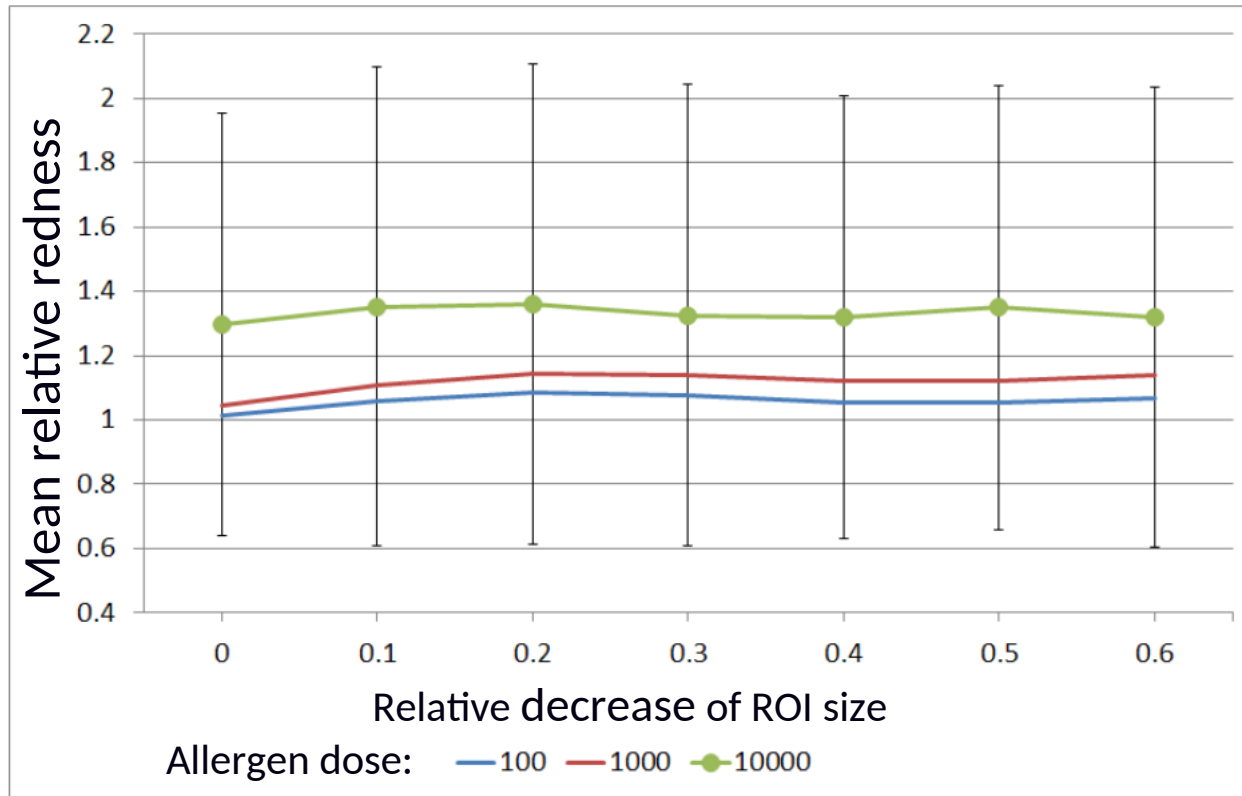
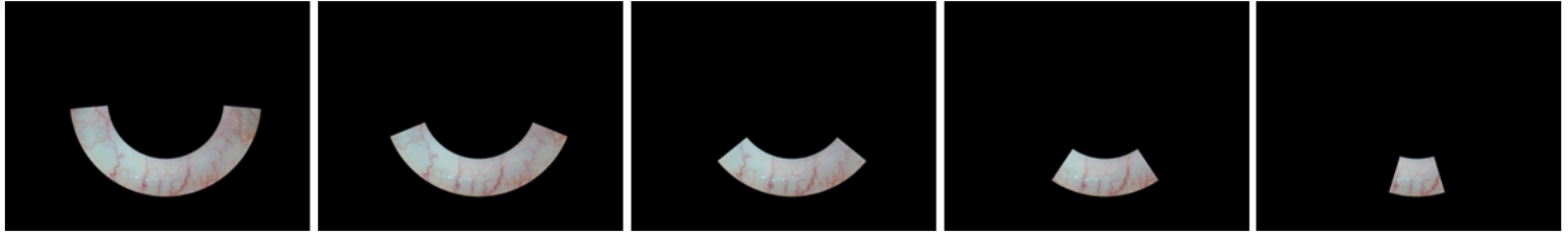
- Introduction
- Materials and methods
  - Image material
  - Image processing chain
  - Evaluation
- **Results**
- Summary and discussion



# Results: Test-retest reliability



# Results: Algorithm robustness



# Discussion and summary

- Image processing chain for automatic quantitative CPT evaluation
- Assessed
  - Test-retest reliability
  - Measurement robustness
- Future work: integration into web-based clinical system

