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FÜR INFORMATIK  
Faculty of Informatics



# Superpixel applied to 3D medical data

SSIP 2011, Szeged  
Student Lecture Talk

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# Overview

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- The khresmoi-Project
  - About the project
  - Usecase radiology
  - Image processing projects
- Master thesis
  - State of the Art
  - Method example
- Summary

# Khresmoi - about

- Name: **Χρησμοί**

*Khresmoi in greek letters meaning:  
oracles*

- Goal: Khresmoi aims to develop a multi-lingual multi-modal search and access system for biomedical information and documents.

## Facts:

**Start:** 1 September 2010

**End:** 31 August 2014

**Duration:** 48 months

**Budget (total):** approx. €10 Million

**EC contribution:** approx. €8 Million

**Partners:** 12 (from 9 countries)

**Project Number:** FP7 – 257528





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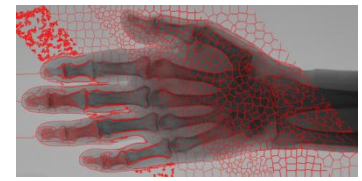
**Project Number:** FP7 – 257528



- Gather Information about hospital Workflow
  - Radiology Survey
  - Getting in Touch with radiologies
  - Eye-Tracking: [demo](#)
- Some relevant projects at CIR
  - Pathology detection:
    - based on BoW, k-means and diffusion distance
    - based on 3D Particle Filters and RF-classifier
  - Semi-supervised annotation of medical data (RF, MRF)



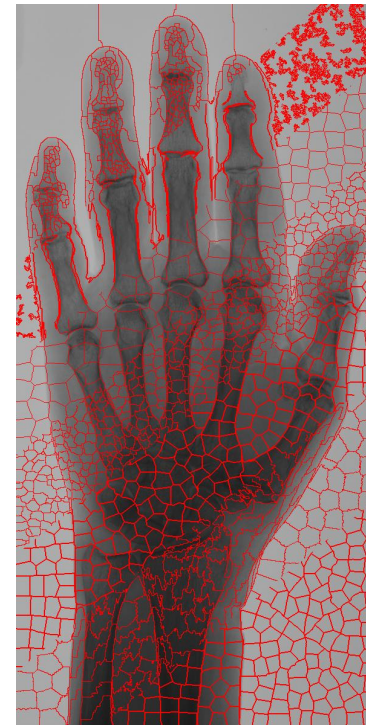
# Master's thesis – 3D Superpixel



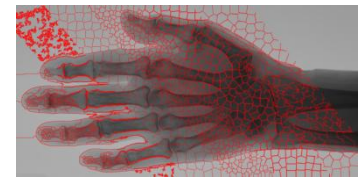
- Preprocessing with reduction of dimensionality, while preserving object relevant information



Pixel



Superpixel

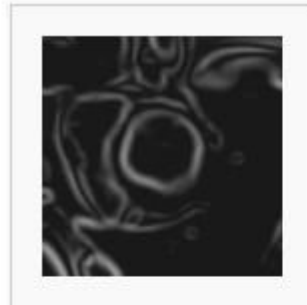
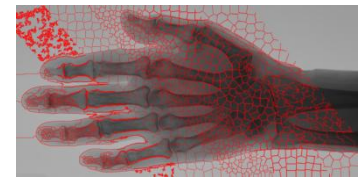


# 3D Superpixel

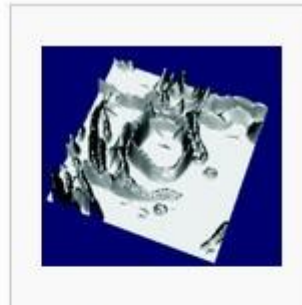
- Basic oversegmentation using Watershed (Luc et.al. 1991)
- Synonym „superpixel“ introduced 2003 by Ren et. al. In Normalized Cuts
- Superpixel algorithms:
  - Malik 01 (Textons, ncut)
  - Felzenswalb 04 (graph-based)
  - Levinshtein 09 (Turbopixel, gradient based)
  - Moore 10 (Lattice cut, gradient based)
- All in 2D



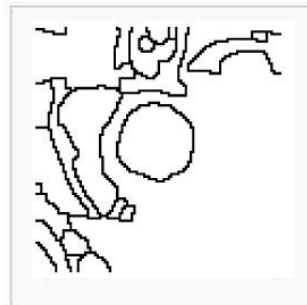
# 3D Superpixel - Watershed



Gradient image



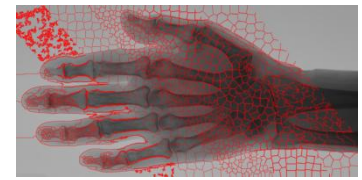
Relief of the gradient



Watershed of the gradient



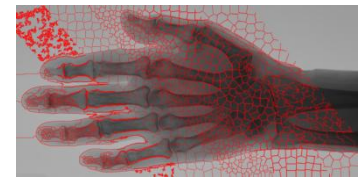
Watershed of the gradient  
(relief)



# 3D Superpixel

- Basic oversegmentation using Watershed (Luc et.al. 1991)
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# 3D Superpixel



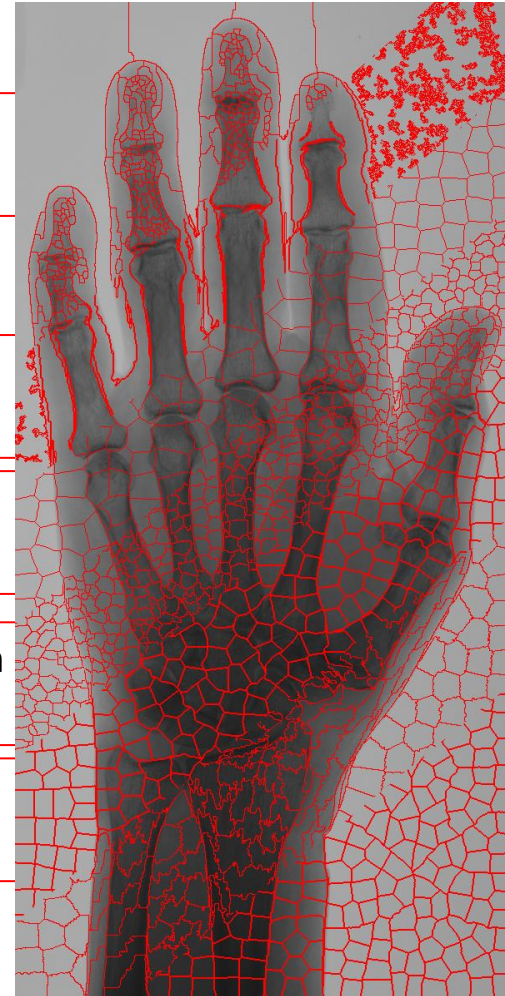
Medial Features for Superpixel Segmentation, Engel 2009

Efficient Graph-Based Image Segmentation, Felzenswalb 2004

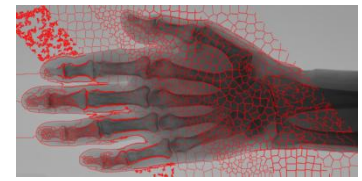
Faste Superpixels Using Geometric Flows, Levinstein 2009

Superpixel in an Energy Optimization Framework, Olga, 2010

Contour and texture analysis for image segmentation, Malik 2001

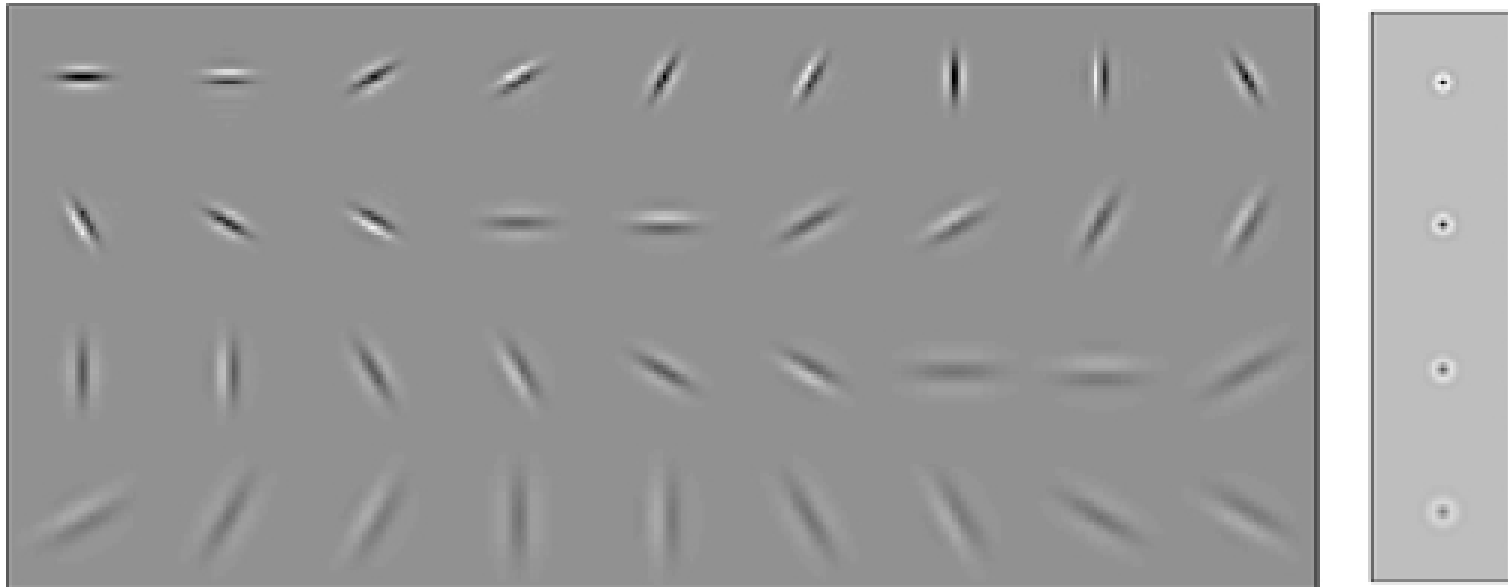
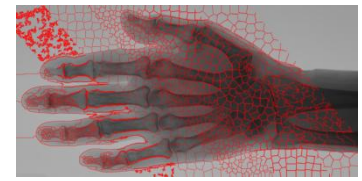


# [Malik 2001]



- Texture similarity  $W_{ij}^{TX}$ 
  - Clustering and Textons histograms
- Contour,  $W_{ij}^{IC}$ 
  - Orientation Energy [Morrone et al 1987]
- Combine Weights to  $W_{ij}$
- Normalized Cut on  $W_{ij}$  -> Segmentation
- Update weights and cut again

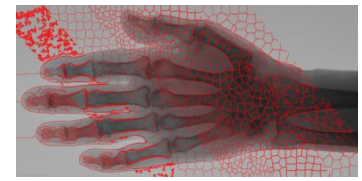
# [Malik 2001] Texton Filterbank



- 2 phases (even and odd symmetric), 3 scales, 6 orientations
- Difference of Gaussians (DOG)

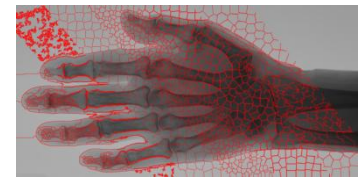


# [Malik 2001] Textons 1/2

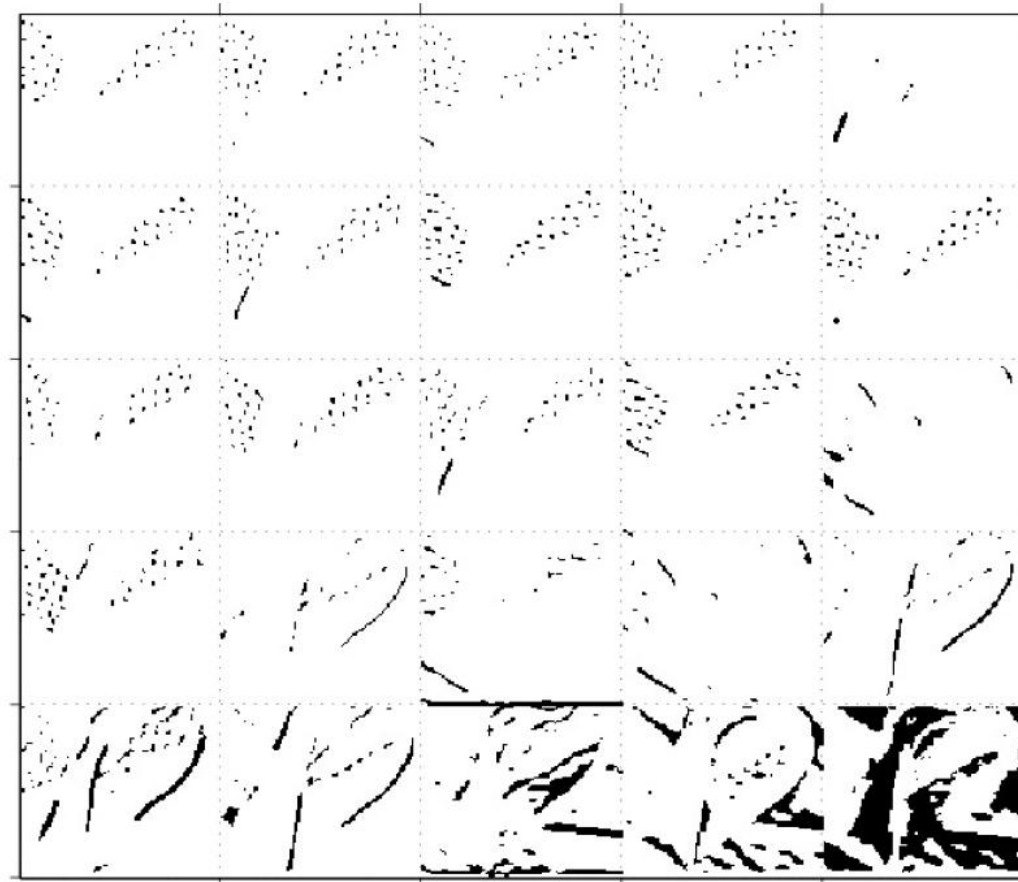
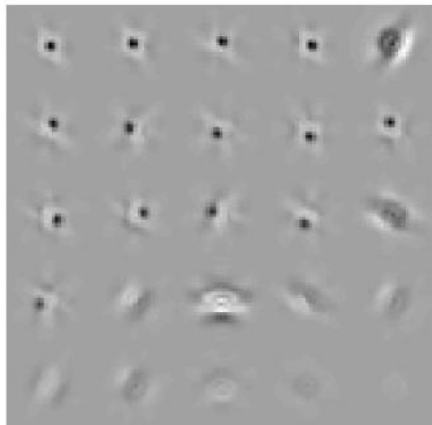


- $N_{fil}$  filter responses for each pixel  
( $N_{fil}=40$ )
- Produces a lot of information
  - Some distinct filter responses
  - All others are noisy variations
- How to reduce Information?

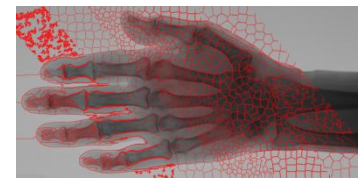
# [Malik 2001] Textons 2/2



## Using K-Means clustering



# [Malik 2001] Estimating Texturedness

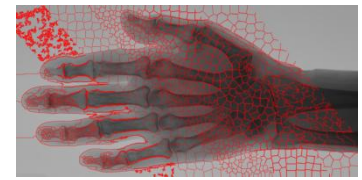


- For each pixel:
  - Compare texton distribution on either side relative to its dominant orientation

$$\chi^2(h_L, h_R) = \frac{1}{2} \sum_{k=1}^K \frac{[h_L(k) - h_R(k)]^2}{h_L(k) + h_R(k)}$$

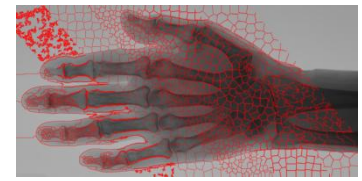
texturedness  $p_{texture} = 1 - \frac{1}{1 + \exp[-(\chi_{LR}^2 - \tau)/\beta]}$

# [Malik 2001] Estimating Texturedness

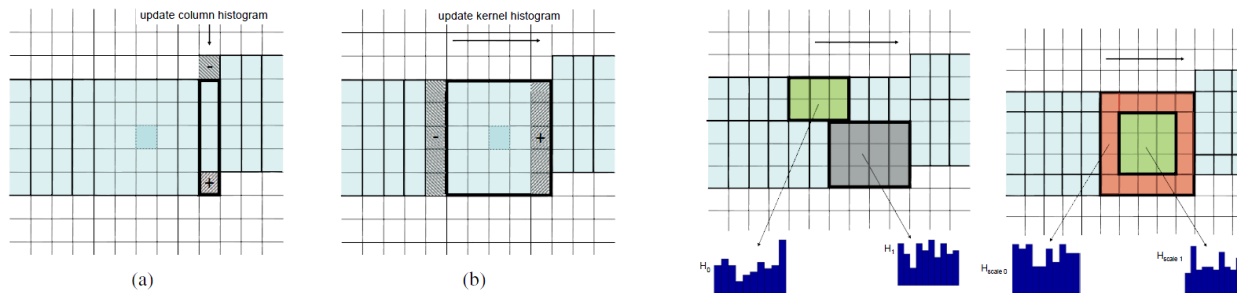


texturedness

# Histogram Calculation

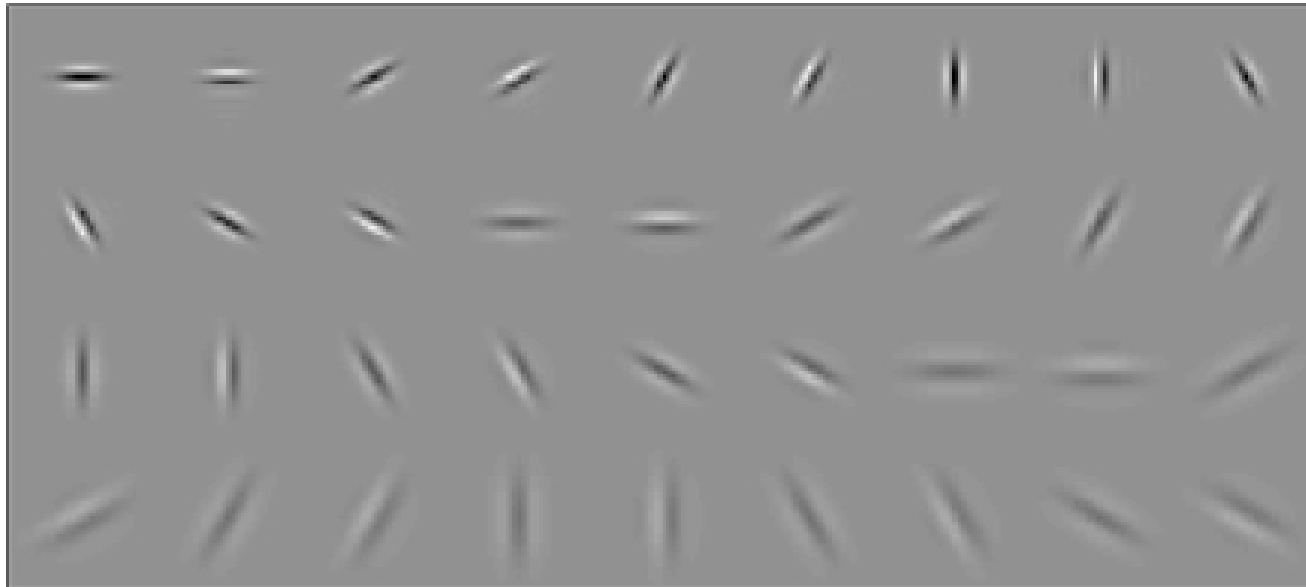
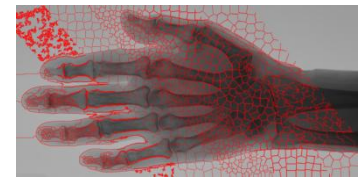


- Kernel depends on orientation and texture scale of pixel
- Integral Images
  - Not working efficiently for non-rectangular shapes
- Histogram based search [Sizintsev et al 2008]



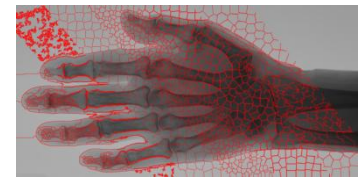


# [Malik 2001] Contour Filterbank



- 2 phases (even and odd symmetric),  
3 scales, 6 orientation

# [Malik 2001] Orientation Energy 1/2



- Orientation Energy at  $0^\circ$

$$OE_{0^\circ} = (I * f_1)^2 + (I * f_2)^2$$

- For each pixel

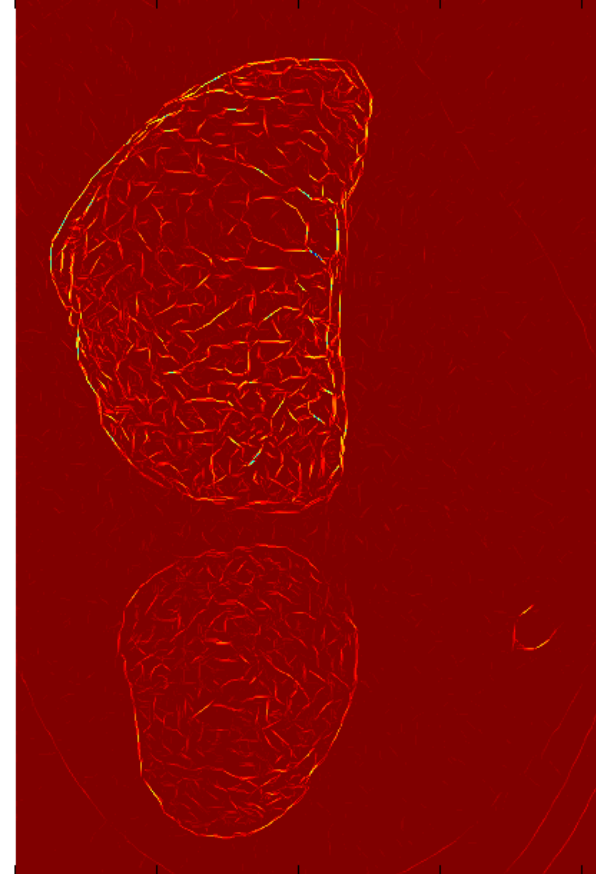
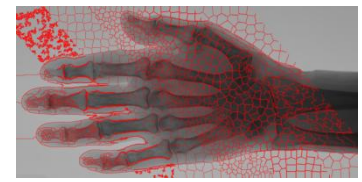
- Various orientations and scales
- => find dominant orientation and energy  $OE^*$

- Non-maxima suppression

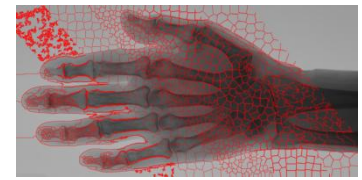
- Inspect neighboring values perpendicular to the maxima orientation
- Keep  $OE^*$  if the others are smaller
- Otherwise set to zero

# [Malik 2001] Orientation Energy

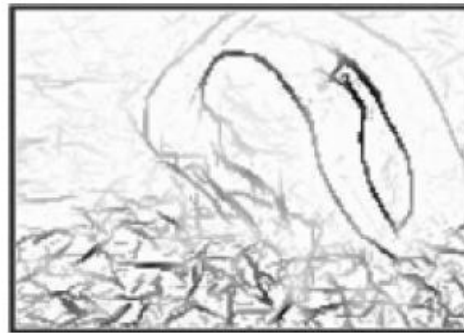
## 2/2



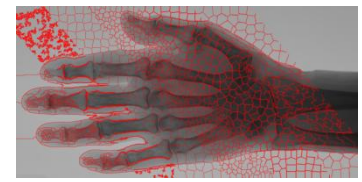
# [Malik 2001] Combine to Contour Energy



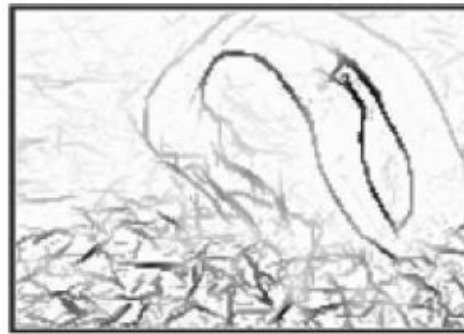
orientation energy



# [Malik 2001] Combine to Contour Energy



orientation energy



texturedness

Product: soft edge detector that does not fire on textured regions



$p_B(x)$

$$W_{ij}^{IC} = 1 - \max_{x \in M_{ij}} p_B(x)$$

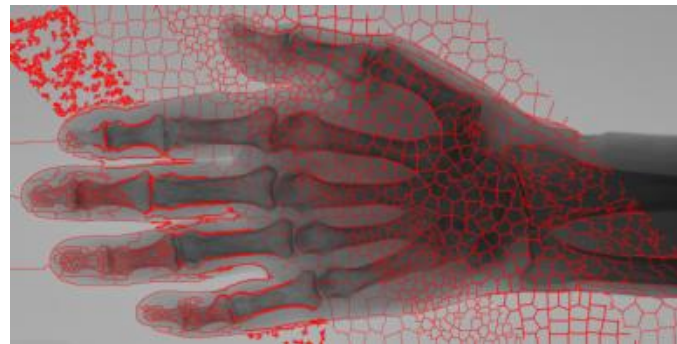


# Summary

## ■ The khresmoi-Project



## ■ Master thesis





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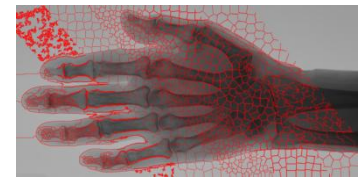
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# Khresmoi - people



## Coordinators:

Henning Müller  
(Project Coordinator)



University of Applied Sciences  
Western Switzerland

Allan Hanbury  
(Scientific Coordinator)

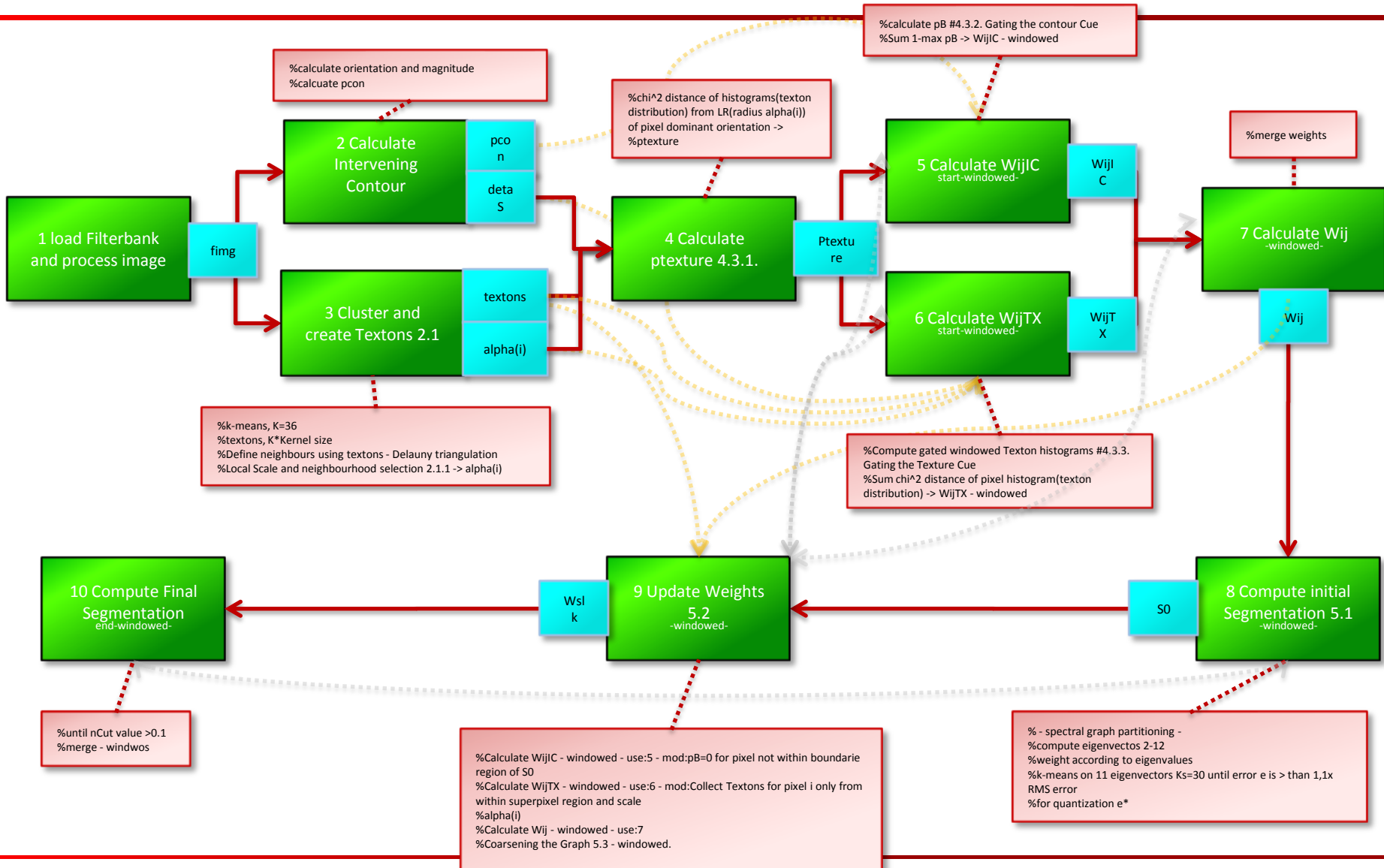
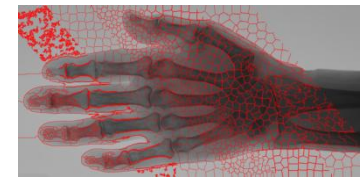


Vienna University of Technology,  
Austria

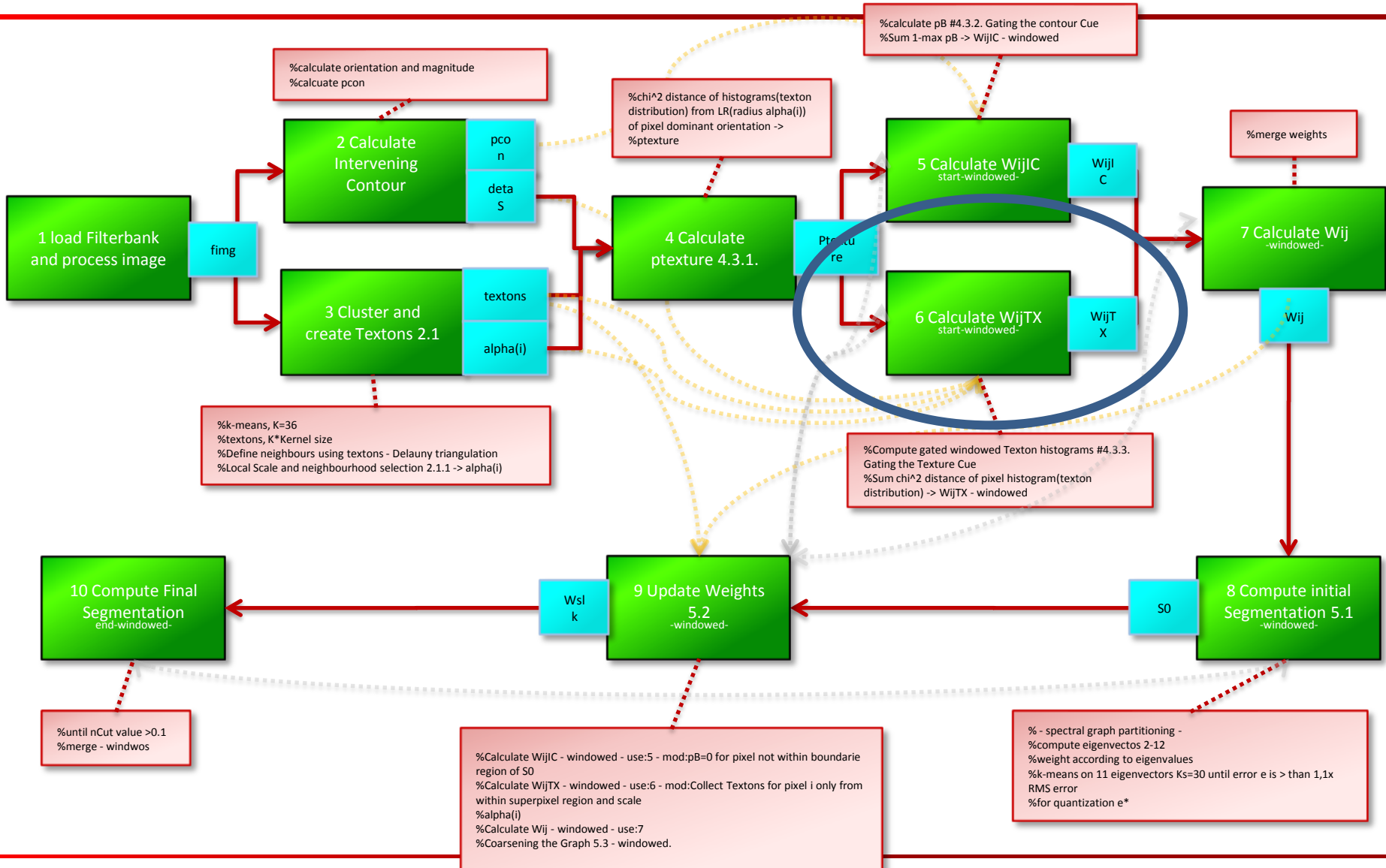
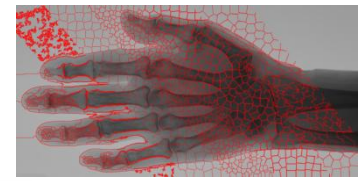
## From the CIR-lab:

Georg Langs  
René Donner  
Andreas Burner  
Markus Holzer  
Erich Birngruber

# [Malik 2001] Workflow

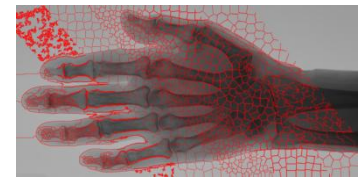


# [Malik 2001] Workflow





# Progress and timeline



2do:

- Finish coding framework (June)
- Apply to 3D (July)
- Improve performance of implementation and exploit domain specific properties (August)
- Finish document (September)

# Superpixel applied to 3D medical data

Master Thesis Specification Talk

Markus Holzer

Supervisor: Ao.Univ.Prof.Dipl.-Ing. Dr. techn. Robert Sablatnig

Co-Supervision: René Donner