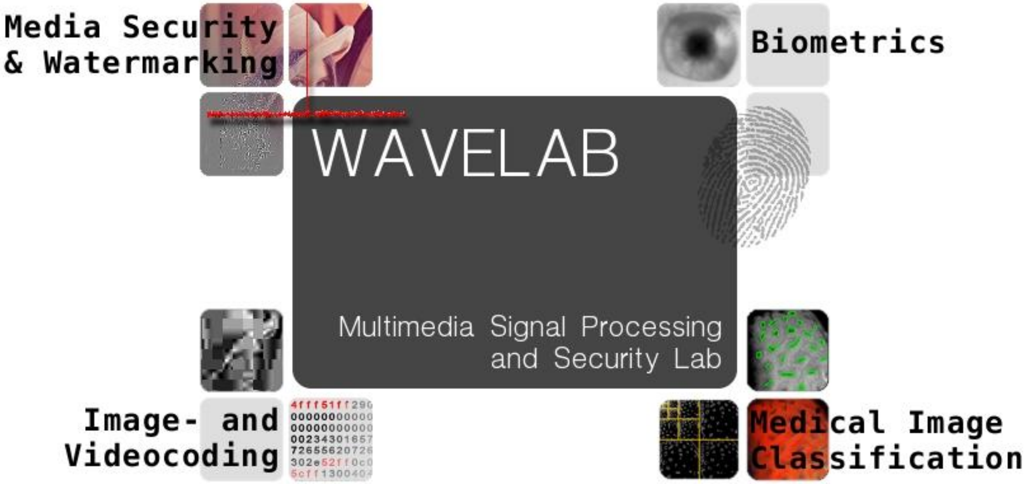
SIMILARITY BASED CROSS-SECTION SEGMENTATION IN ROUGH LOG END IMAGES

Andreas Uhl, Rudolf Schraml {uhl,rschraml}@cosy.sbg.ac.at
Department of Computer Sciences
University of Salzburg



I. MOTIVATION

II. MAIN OBJECTIVES

III. APPROACH OUTLINE

IV. RESULTS - DISCUSSION

UNIVERSITÄT SALZBURG

MOTIVATION/APPLICATIONS

I. AUTOMATED LOG GRADING

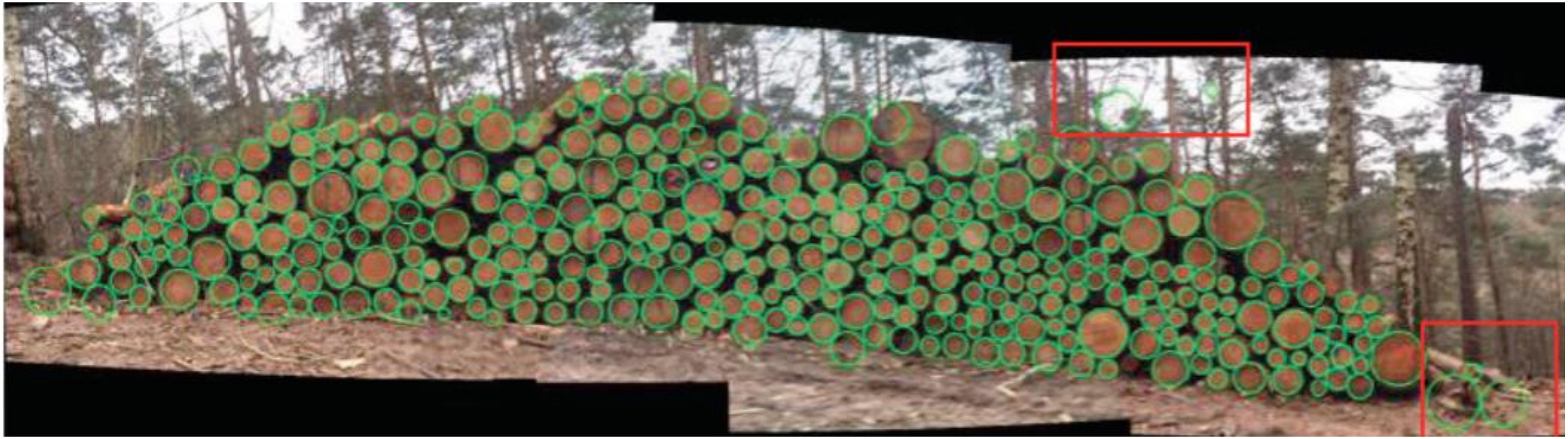
- Pith Estimation
- Annual Ring Measurements:
  - Counting / Average Ring Width
- Reaction Wood Estimation
- Knot Detection
- Dendrochronology/ Tree Ring Dating

K. Norell
Automatic counting of annual rings on Pinus sylvestris end faces in sawmill industry,
Computers and Electronics in Agriculture, Volume 75, Issue 2, February 2011, Pages 231-237

MOTIVATION

I. AUTOMATED TIMBER GRADING

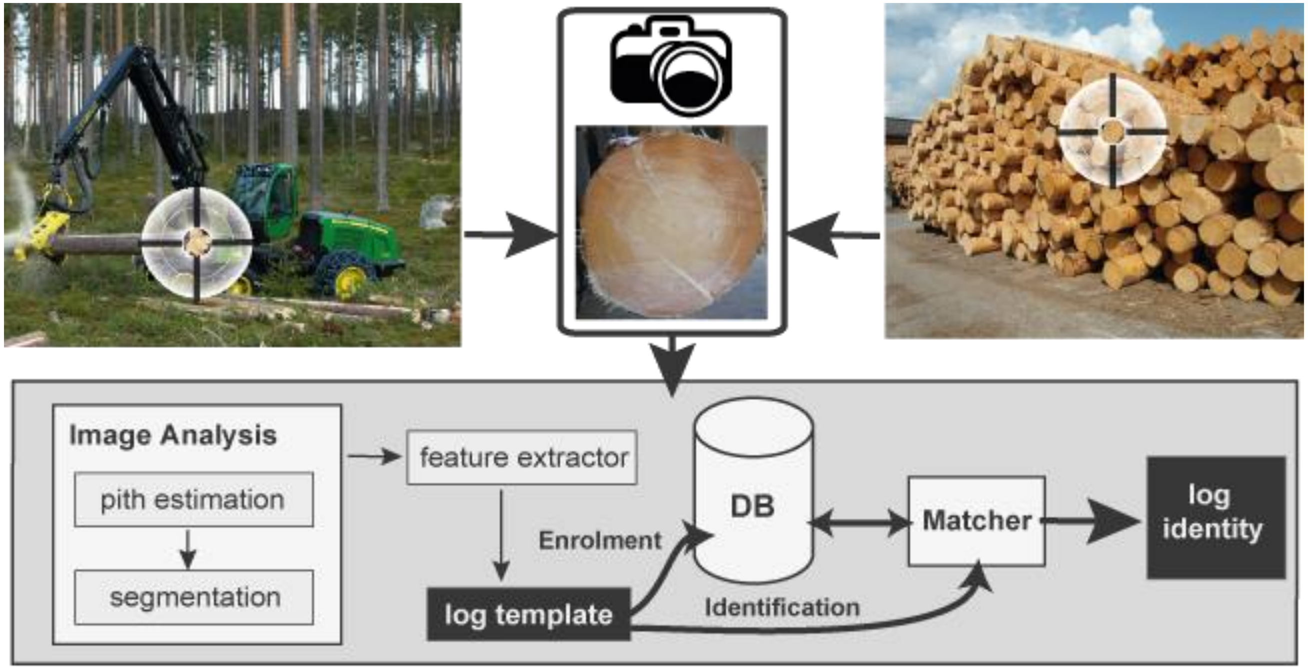
II. **PHOTO-OPTICAL TIMBER STACK MEASUREMENT**



Ch. Herbon, K. Tönnies and Bernd Stock
Detection and Segmentation of Clustered Objects by Using Iterative Classification, Segmentation, and Gaussian Mixture Models and Application to Wood Log Detection, GCPR'14, Münster (GER)

MOTIVATION

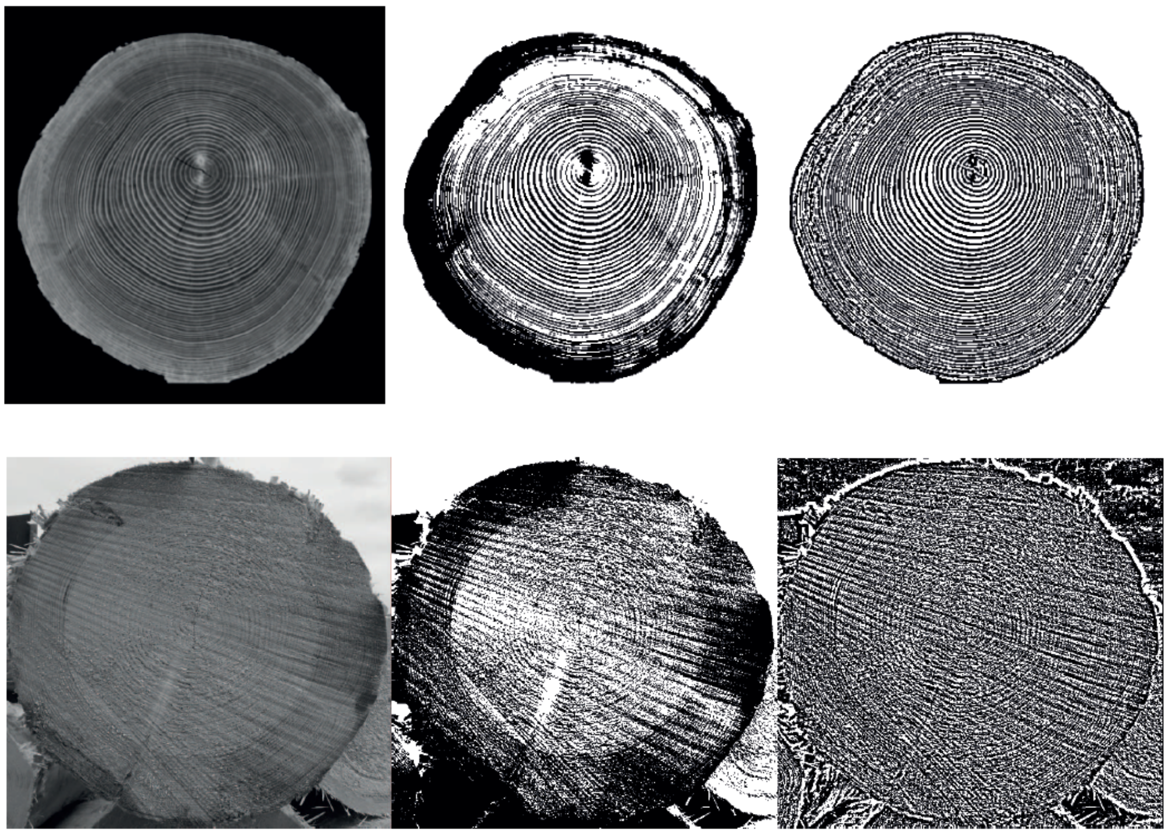
I. AUTOMATED TIMBER GRADING
II. PHOTO-OPTICAL TIMBER STACK MEASUREMENT
III. BIOMETRIC LOG RECOGNITION



R. Schraml, J. Charwat-Pessler and A. Uhl
Temporal and longitudinal variances in wood log cross-section image analysis,
ICIP'14, PARIS (FR)

MOTIVATION/ RESEARCH GAP

I. AUTOMATED TIMBER GRADING
II. PHOTO-OPTICAL TIMBER STACK MEASUREMENT
III. BIOMETRIC LOG RECOGNITION



Computed tomography cross-section images

SEGMENTATION DIFFICULTY

Rough log end images:

- Saw cut
- Cracks, Knots
- Discolourations
- Muck/Dirt
- Background

OBJECTIVES / REQUIREMENTS

I. ACCURACY
II. TIMING

- Cross-section segmention in rough log end images is a typical task for region-based segmentation approaches:

- T. Chan and L. Vese,
An Active Contour Model without Edges,
IEEE Transactions on Image Processing (2001)

- T. Chan et al.,
Histogram Based Segmentation Using the Wasserstein Distance,
SSVM (2007)

- Jung et al.,
Texture segmentation via non-local nonparametric active contours,
EMMCVPR (2011)

APPROACH OUTLINE:

SIMILARITY BASED – REGION GROWING

- Inspired by the EMD-region-based level set formulation
- Based on similarity of adjacent image sections
- Utilize ease and fast computeable texture features
- Different metrics to compute distances between feature histograms
- Subdivided into three consecutive stages:

CLUSTER INITIALISATION | CLUSTER GROWING | SHAPE ESTIMATION

APPROACH OUTLINE:

CLUSTER INITIALISATION | CLUSTER GROWING | SHAPE ESTIMATION

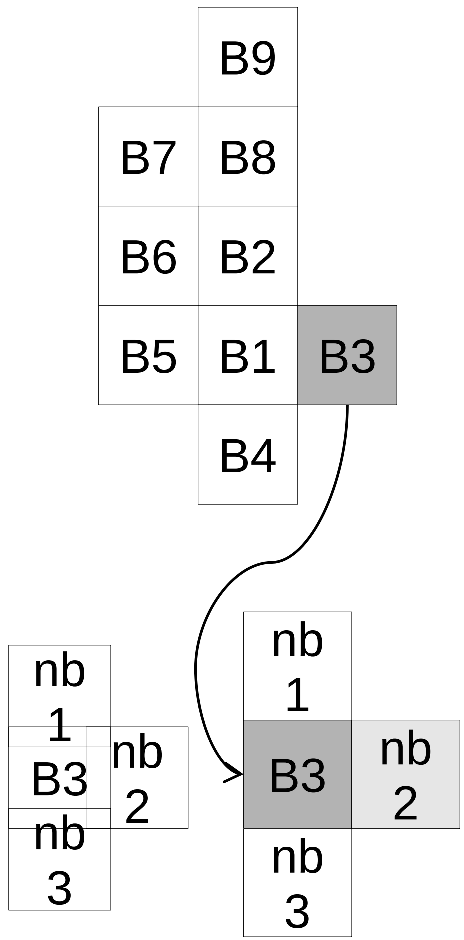
1. Utilize the **pith position**
2. Select a number of seed blocks equally distributed close to the pith
3. Initialise a cluster for each seed block using its adjacent neighbours

Cluster intitialisation:

- Mean gray value/ variance
- Mean entropy/ variance
- Mean intensity or LBP histogram distance/ variance

APPROACH OUTLINE:

CLUSTER INITIALISATION | **CLUSTER GROWING** | SHAPE ESTIMATION



→ mean gray value / var

→ mean entropy / var

→ mean histogram distances / var

CLUSTER

DECISION

→ nb2 mean gray value

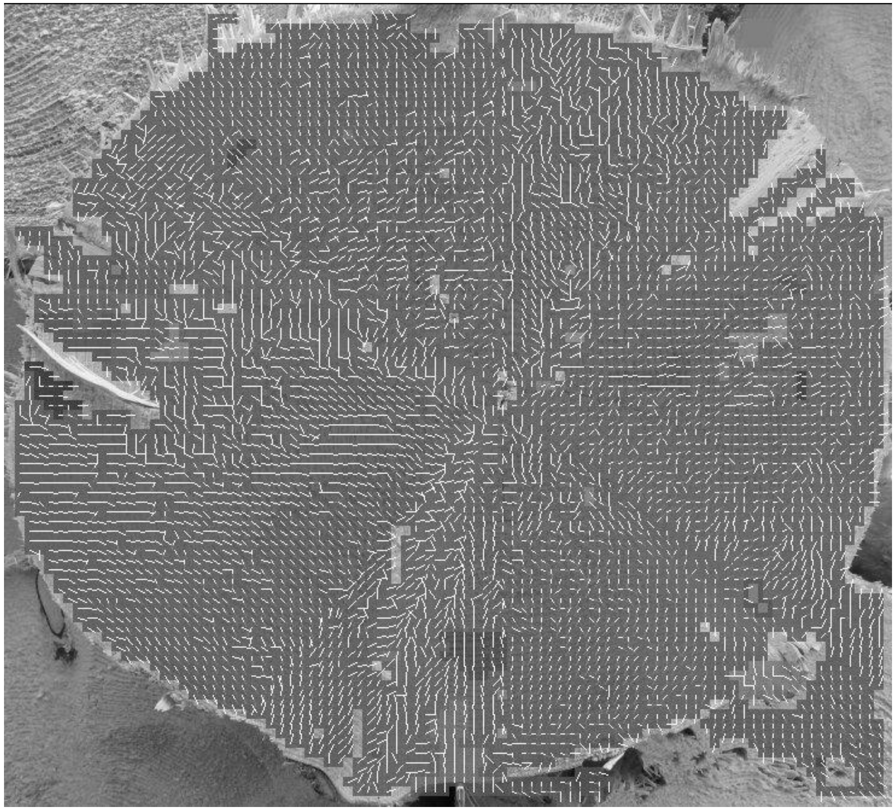
→ nb2 entropy

→ histogram distance B3 ↔ nb2

BLOCK

APPROACH OUTLINE:

CLUSTER INITIALISATION | **CLUSTER GROWING** | SHAPE ESTIMATION

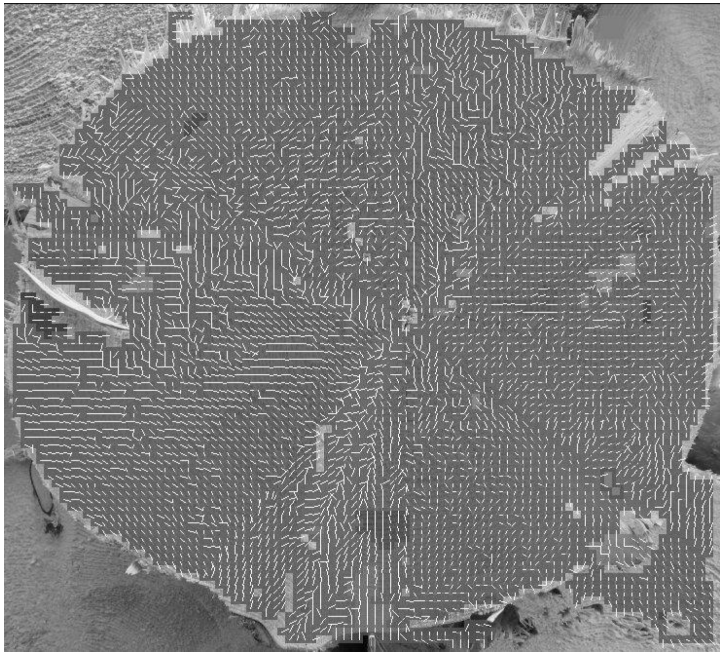


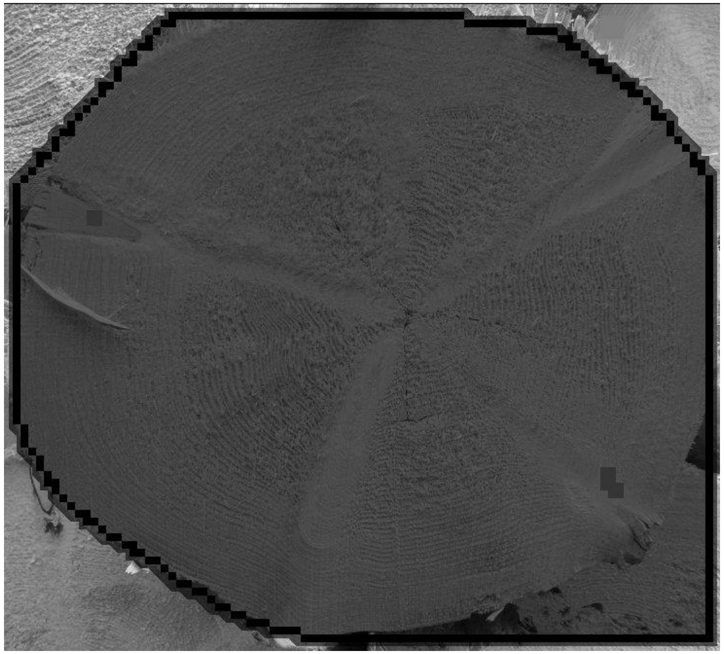
Merge all clusters - intermediate result

APPROACH OUTLINE:

CLUSTER INITIALISATION | CLUSTER GROWING | **SHAPE ESTIMATION**

- Estimate the cross-section boundary
- Convex hull is no solution → Concave hull

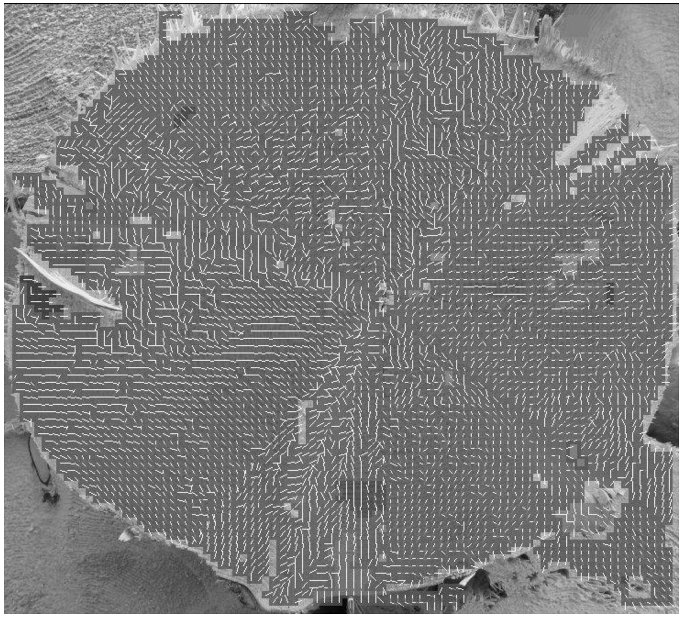


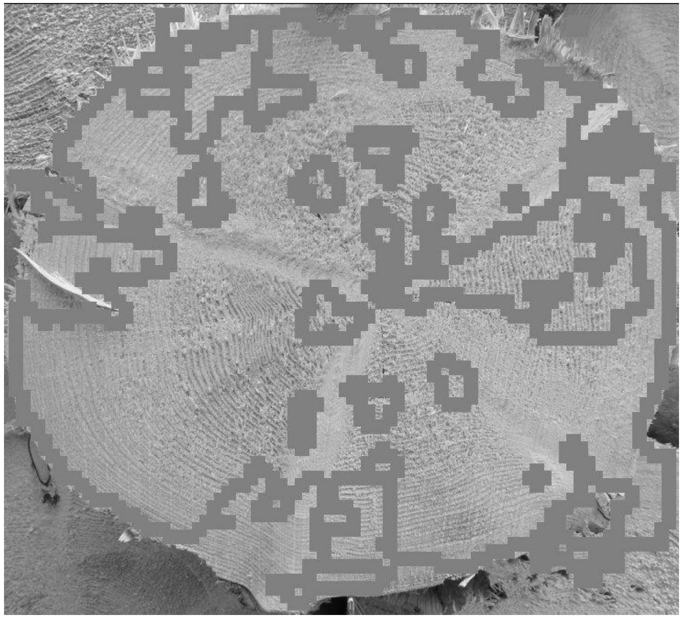


APPROACH OUTLINE:

SEED BLOCK SELECTION | CLUSTER GROWING | **SHAPE ESTIMATION**

1. Determine boundary blocks

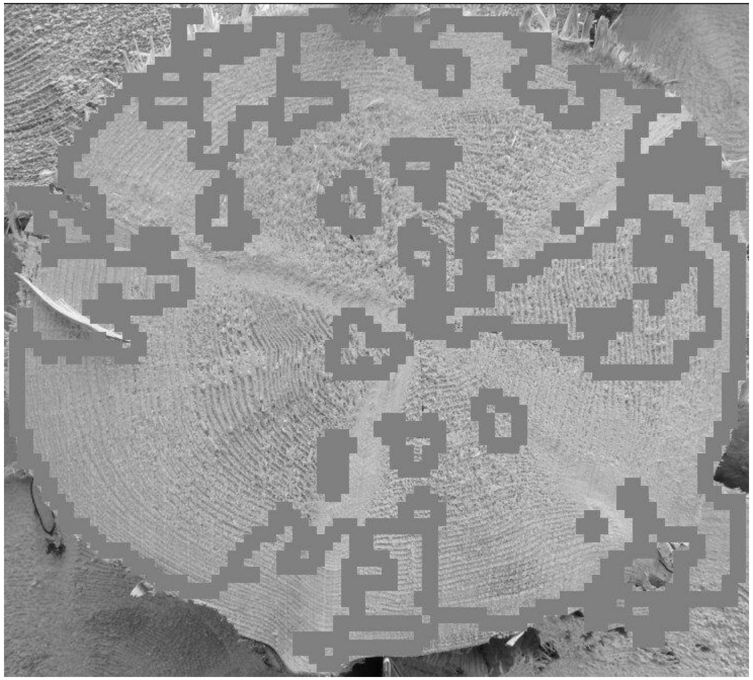


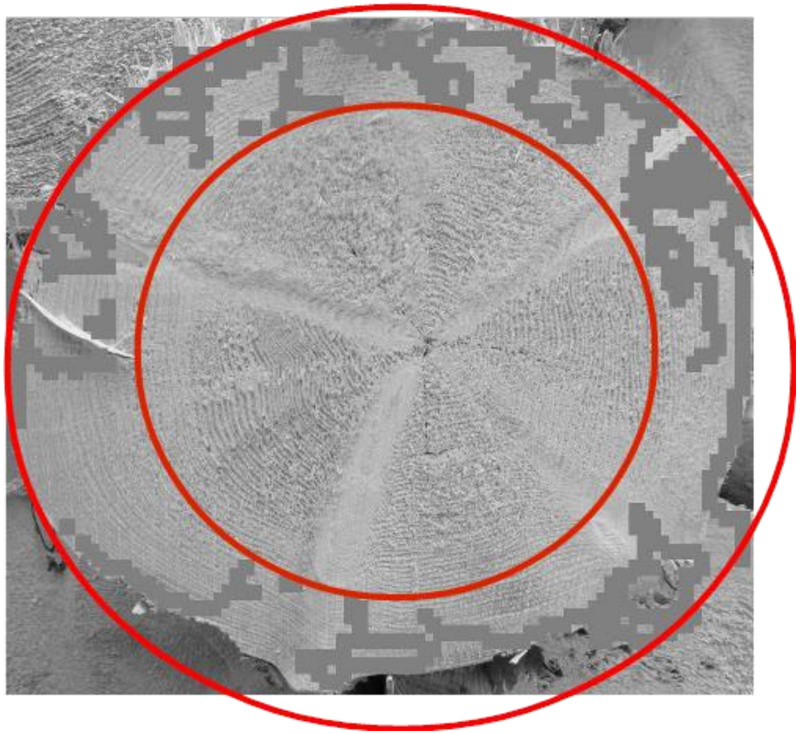


APPROACH OUTLINE:

SEED BLOCK SELECTION | CLUSTER GROWING | **SHAPE ESTIMATION**

1. Determine boundary blocks
2. Eliminate outliers: Circle/Ellipse fitting

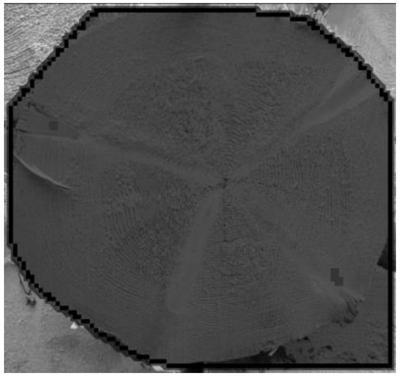


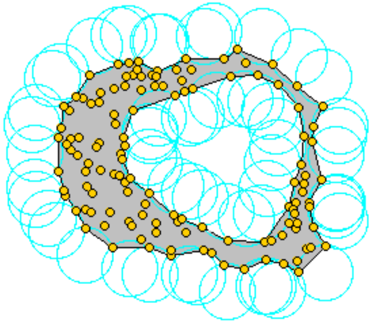


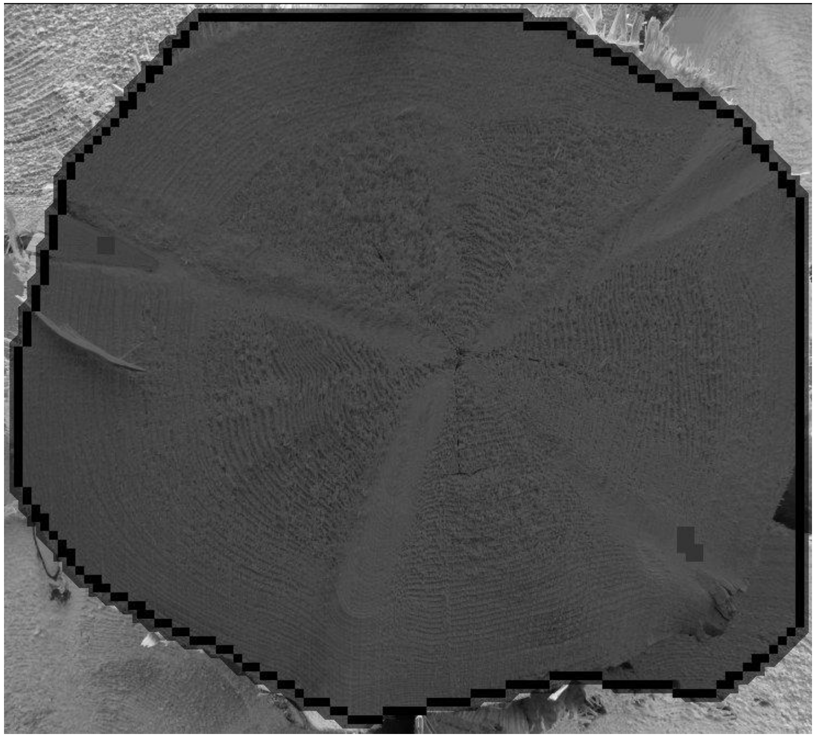
APPROACH OUTLINE:

SEED BLOCK SELECTION | CLUSTER GROWING | **SHAPE ESTIMATION**

1. Determine boundary blocks
2. Eliminate outliers: Circle/Ellipse fitting
3. Compute the Alpha shape (Concave hull)







EXPERIMENTS

- #108 spruce log end images (1024x768 pixels)
- Different configurations:
  - Blocksizes: 16x16 and 32x32 pixels (non- and halfoverlapping)
  - Cluster growing: texure features, histogram distances, variance factors

- Four experiments:
  - Experiment #1: **Intensity histograms as texture features**
  - Experiment #2: **LBP histograms as texture features**
  - Experiment #3: **Circle/Ellipse fitting**
  - Experiment #4: **Timing performance evaluation**






EXPERIMENTS - EVALUATION

- Average timing performance [ms]
- Segmentation accuracy = segmentation error in %
  - **Mean** [%], **StDev** [%] and **R** = span between min. and max. segmentation error

Groundtruth

Result

$$\boldsymbol{Accuracy}[\%] = \frac{|\{\boldsymbol{Groundtruth}\,\Delta\,\boldsymbol{Result}\}|}{|\boldsymbol{pixels}|}$$

EXPERIMENT #1: **Intensity histograms**

Blocksize 16x16					
H_d	V_f	Mean	StDev	R	[ms]
non-overlapping					
L_1	0.9	7.29	3.74	17.0	312
L_2	1.0	7.97	3.4	15.0	310
H	0.9	7.72	4.16	17.0	312
X^2	0.6	8.55	4.27	17.0	310
EMD	**0.5**	**6.45**	**3.41**	**17.0**	**304**
half-overlapping					
L_1	−0.5	10.04	5.64	20.0	2135
L_2	−0.4	10.52	4.68	20	2175
H	−0.3	11.11	5.99	21.0	2278
X^2	−0.9	6.71	4.14	19.0	2000
EMD	**−0.1**	**5.53**	**3.3**	**14.0**	**1867**

Blocksize 32x32					
H_d	V_f	Mean	StDev	R	[ms]
non-overlapping					
L_1	1.3	10.05	3.46	18.0	258
L_2	1.7	11.13	3.87	17.0	261
H	1.0	9.45	3.81	18.0	267
X^2	0.6	10.88	4.11	19.0	260
EMD	**1.2**	**9.34**	**3.49**	**16.0**	**262**
half-overlapping					
L_1	−0.3	8.03	3.03	14.0	1103
L_2	−0.2	8.44	3.12	15.0	1090
H	**−0.3**	**7.13**	**3.16**	**14.0**	**1078**
X^2	−0.6	8.12	3.05	15.0	1064
EMD	0.4	8.35	3.57	17.0	1043

- For three of four configurations the EMD shows the best results
- Smaller blocksizes increase the accuracy but the timing performance decreases
- Half-overlapping blocks enable a more accurate segmentation

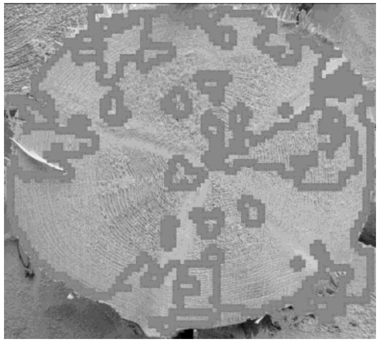
EXPERIMENT #2: **LBP histograms**

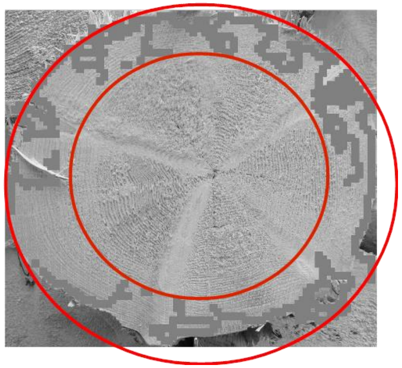
LBP histograms							
Config.		H_d	V_f	Mean	StDev	R	[ms]
3x3 LBPs							
16x16	no	L_2	0.9	9.85	4.75	20.0	772
32x32	ho	L_2	−0.2	8.88	3.83	25.0	3273
3x3 uniform LBPs							
16x16	ho	X^2	−0.4	8.57	2.91	14.0	6636
32x32	no	L_2	0.5	9.66	3.64	14.0	711
3x3 multiscale LBP							
16x16	no	L_2	0.0	9.37	7.31	73	1294
32x32	ho	L_2	0.3	7.53	3.45	14.0	5084
3x3 multiscale & uniform LBPs							
16x16	no	L_1	0.9	8.89	4.29	16.0	1250
32x32	ho	L_2	0.1	7.5	3.41	15.0	5206

- Best results are achieved using the euclidean distance
- Smaller blocksizes do not increase the accuracy
- LBP extensions improve the accuracy
- **Strongly varying results!**

EXPERIMENT #3: **Circle/Ellipse fitting**

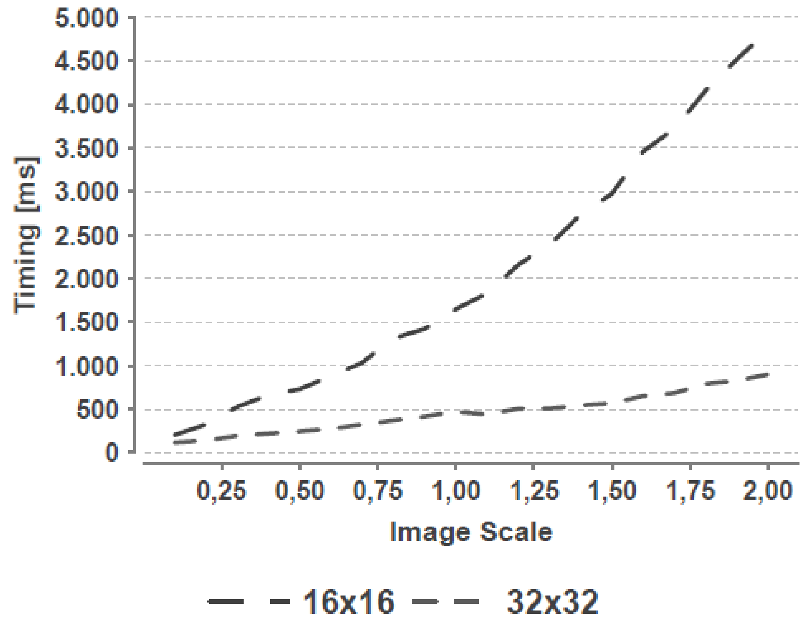
Intensity histograms						
16x16	H_d	V_f	Mean	StDev	R	[ms]
no	EMD	0.4	5.99	2.83	12.0	610
ho	EMD	-0.1	5.1	2.85	13.0	2597





- Best configurations are recomputed including circle/ ellipse fitting
    - **Improvement of the segmentation accuracy**
    - **Time consuming**

EXPERIMENT #4: **Timing performance**



- Testset images were scaled in a range from $\{0.1, 0.2, \ldots, 2\}$
- Intensity histograms and half-overlapping blocks are utilized
- Timings for 32x32 blocks increase roughly linearly
- For 16x16 blocks the number of points considered for the Alpha shape computation increases rapidly: O (n logn)

CONCLUSIONS

- Ease and fast computable approach
- Intensity histograms and EMD:
  - Accurate and Robust
- LBP histograms:
  - Less accurate and irregular results
- Evalutation forms a solid basis for further research
- Active contour approaches are probably more robust to similar textured cross-sections in the background

CONCLUSIONS

- Ease and fast computable approach
- Intensity histograms and EMD:
  - Accurate and Robust
- LBP histograms:
  - Less accurate and irregular results
- Evalutation forms a solid basis for further research
- Active contour approaches are probably more robust to similar textured cross-sections in the background

QUESTIONS?