PITH ESTIMATION ON ROUGH LOG END IMAGES USING LOCAL FOURIER SPECTRUM ANALYSIS

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

1) INTRODUCTION

2) PITH ESTIMATION SCHEME

LOCAL FOURIER SPECTRUM ANALYSIS METHODS

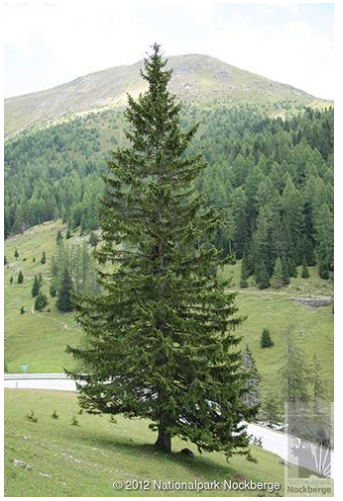
BLOCK SELECTION ALGORITHMS

3) EXPERIMENTS & RESULTS

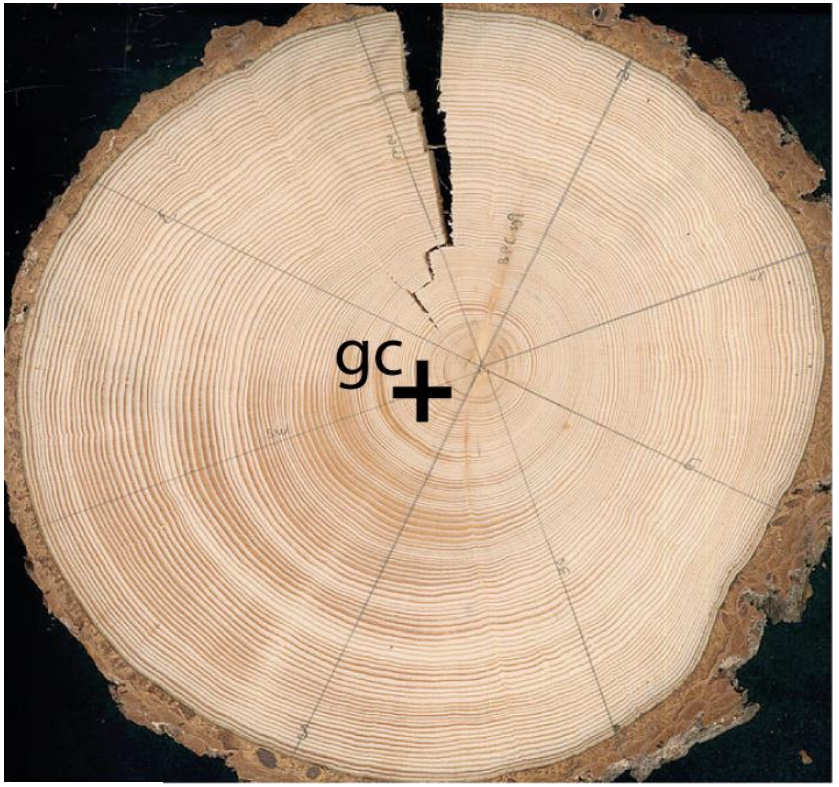
UNIVERSITÄT SALZBURG

Overview

PITH ?



- Growth center of a tree stem == innermost point
- Pith != geometric center



WHY ?

Single reference point on a cross section image

Timber Grading

Fingerprint Approach

Wood industry

- Annual ring measurements:
  → counting / average ring width
- Reaction wood estimation

Dendrochronology:

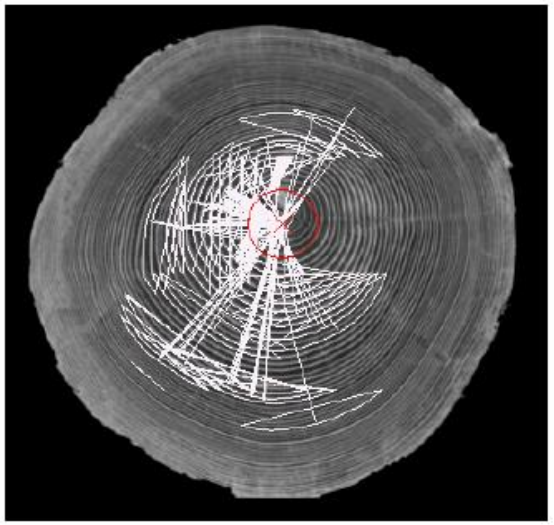
- Tree ring dating

RELATED LITERATURE

Annual Ring Analysis

F. Longuetaud, J.-M. Leban, F. Mothe, E. Kerrien, and M.-O. Berger, "**Automatic detection of pith on ct images of spruce logs**", 2004

K. Entacher, S. Hegenbart, J. Kerschbaumer, C. Lenz, D. Planitzer, M. Seidel, A. Uhl, and R. Weiglmaier, "**Pith detection on ct-cross-section images of logs: An experimental comparison**", 2008



Local Orientation Estimation

T. Hanning, R. Kickingereder, and D. Casasent, "**Determining the average annual ring width on the front side of Lumber**", 2003.

P. Österberg, H. Ihalainen, and R. Ritala, "**Method for analyzing and classifying wood quality through local 2dspectrum of digital log end images**", 2004.

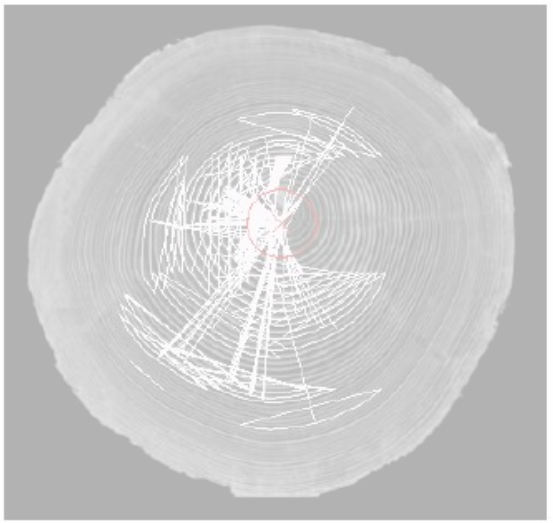
K. Norell and G. Borgefors, "**Estimation of pith position in untreated log ends in sawmill environments**", 2008.

RELATED LITERATURE

Annual Ring Analysis

F. Longuetaud, J.-M. Leban, F. Mothe, E. Kerrien, and M.-O. Berger, "**Automatic detection of pith on ct images of spruce logs**", 2004

K. Entacher, S. Hegenbart, J. Kerschbaumer, C. Lenz, D. Planitzer, M. Seidel, A. Uhl, and R. Weiglmaier, "**Pith detection on ct-cross-section images of logs: An experimental comparison**", 2008



Local Orientation Estimation

T. Hanning, R. Kickingereder, and D. Casasent, "**Determining the average annual ring width on the front side of Lumber**", 2003.

P. Österberg, H. Ihalainen, and R. Ritala, "**Method for analyzing and classifying wood quality through local 2dspectrum of digital log end images**", 2004.

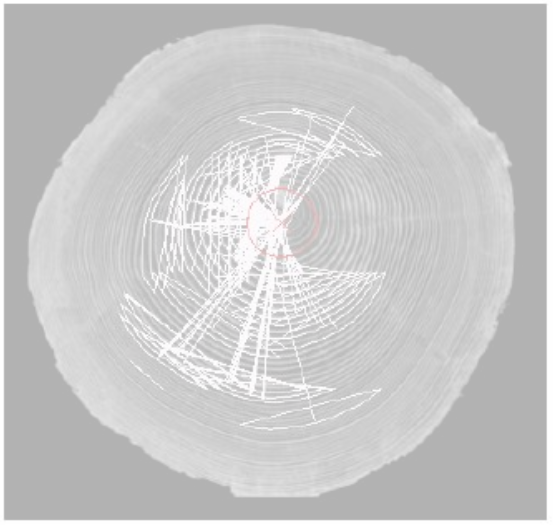
K. Norell and G. Borgefors, "**Estimation of pith position in untreated log ends in sawmill environments**", 2008.

RELATED LITERATURE

Annual Ring Analysis

F. Longuetaud, J.-M. Leban, F. Mothe, E. Kerrien, and M.-O. Berger, "**Automatic detection of pith on ct images of spruce logs**", 2004

K. Entacher, S. Hegenbart, J. Kerschbaumer, C. Lenz, D. Planitzer, M. Seidel, A. Uhl, and R. Weiglmaier, "**Pith detection on ct-cross-section images of logs: An experimental comparison**", 2008



Local Orientation Estimation

T. Hanning, R. Kickingereder, and D. Casasent, "**Determining the average annual ring width on the front side of Lumber**", 2003.

P. Österberg, H. Ihalainen, and R. Ritala, "**Method for analyzing and classifying wood quality through local 2dspectrum of digital log end images**", 2004.

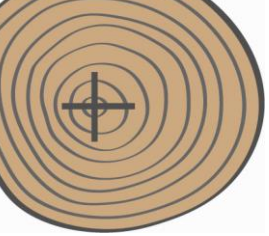
K. Norell and G. Borgefors, "**Estimation of pith position in untreated log ends in sawmill environments**", 2008.

→ **First work treating rough log end images**

→ **Local orientation estimation using**
- **Laplacian pyramids and linear symmetry**
- **Quadrature filters**

???

Pith estimation scheme **Experiments**



Contributions

→ Large image set captured at an Austrian sawmill yard

→ Comparative experiments (ct-images and rough log end images)

- 109 images log rough spruce log ends ↔ (Norell, 2008)
- 29 ct-image slices of a single log ↔ (Entacher, 2008)

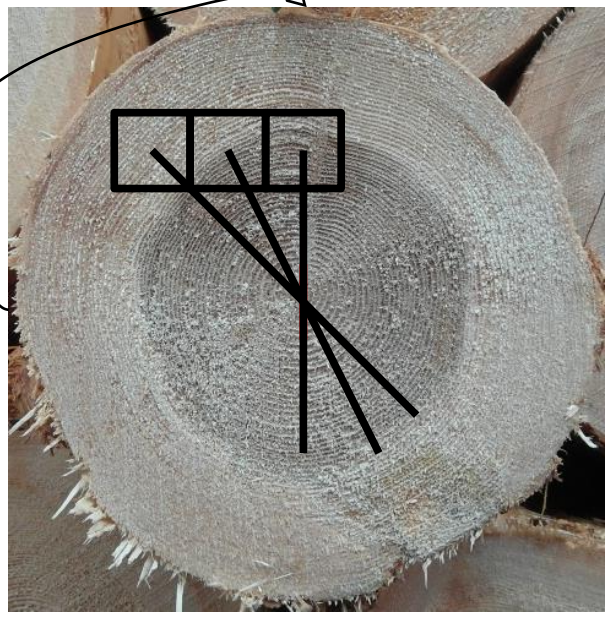
→ Simple Fourier Spectrum Analysis methods

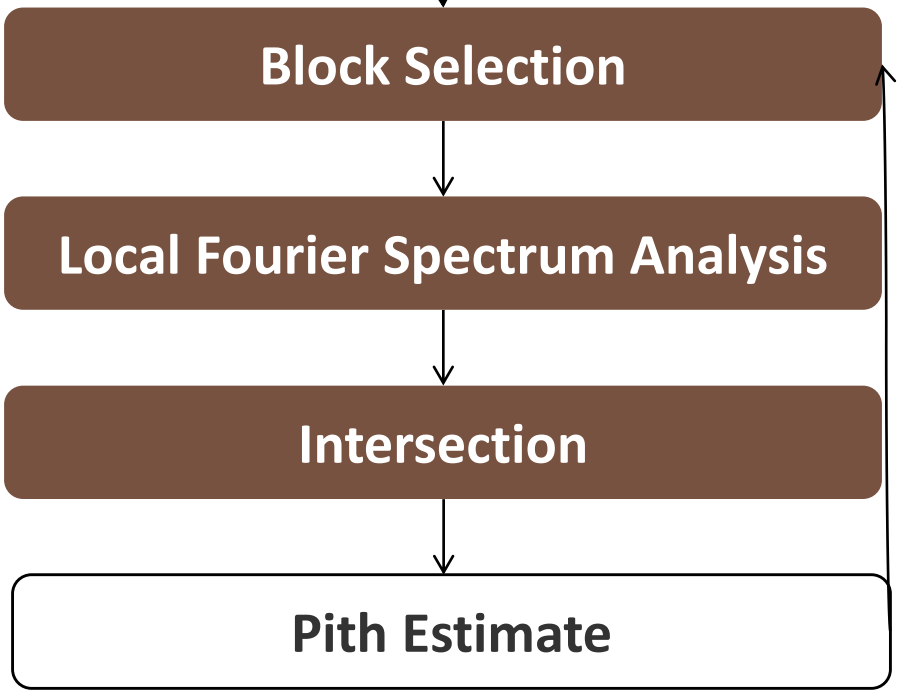
- considerations about Fourier Spectra of annual ring sections

→ Pith estimation accuracy and timing performance:

- Block selection (size and distribution)

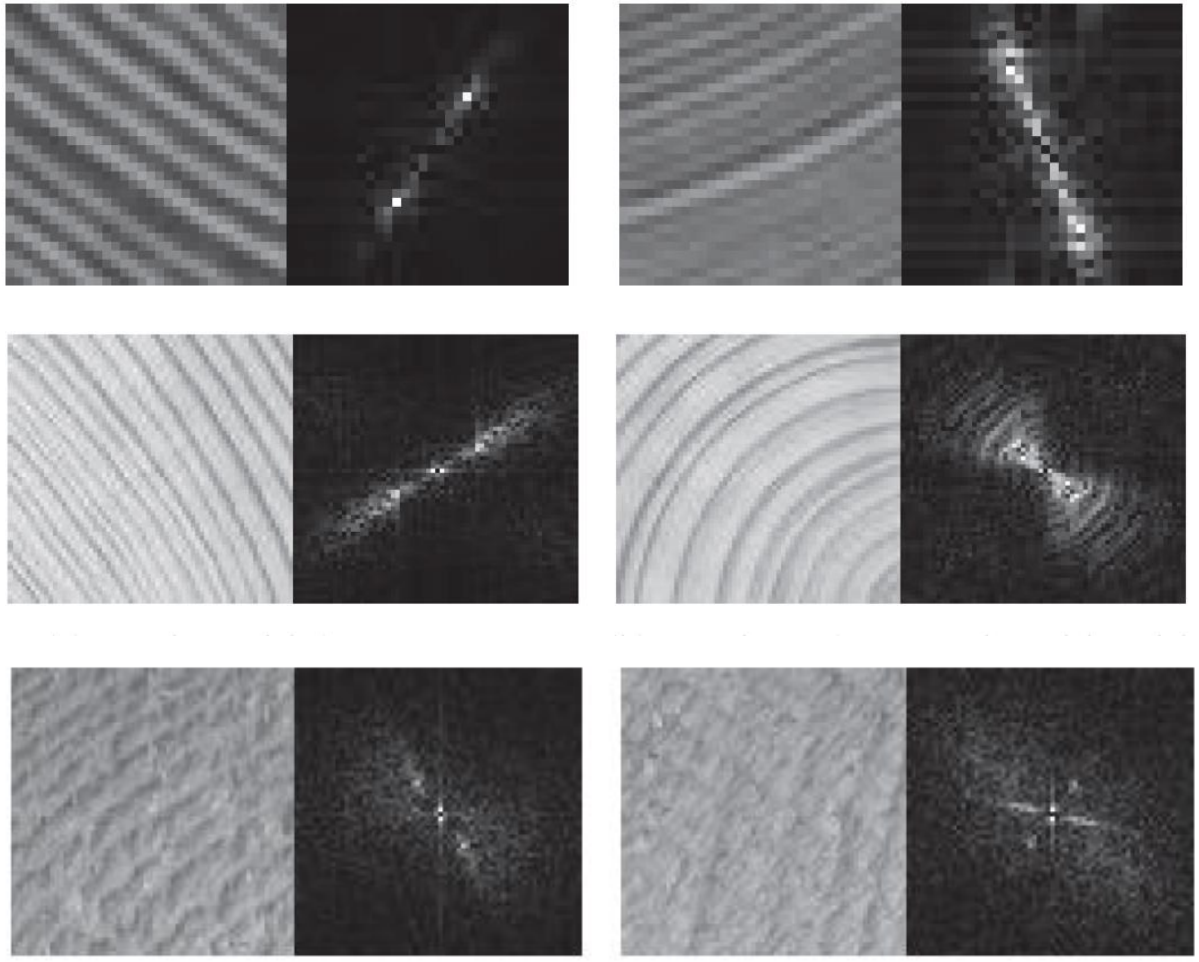
Pith estimation scheme





Pith estimation scheme

Local Fourier Spectrum Analysis

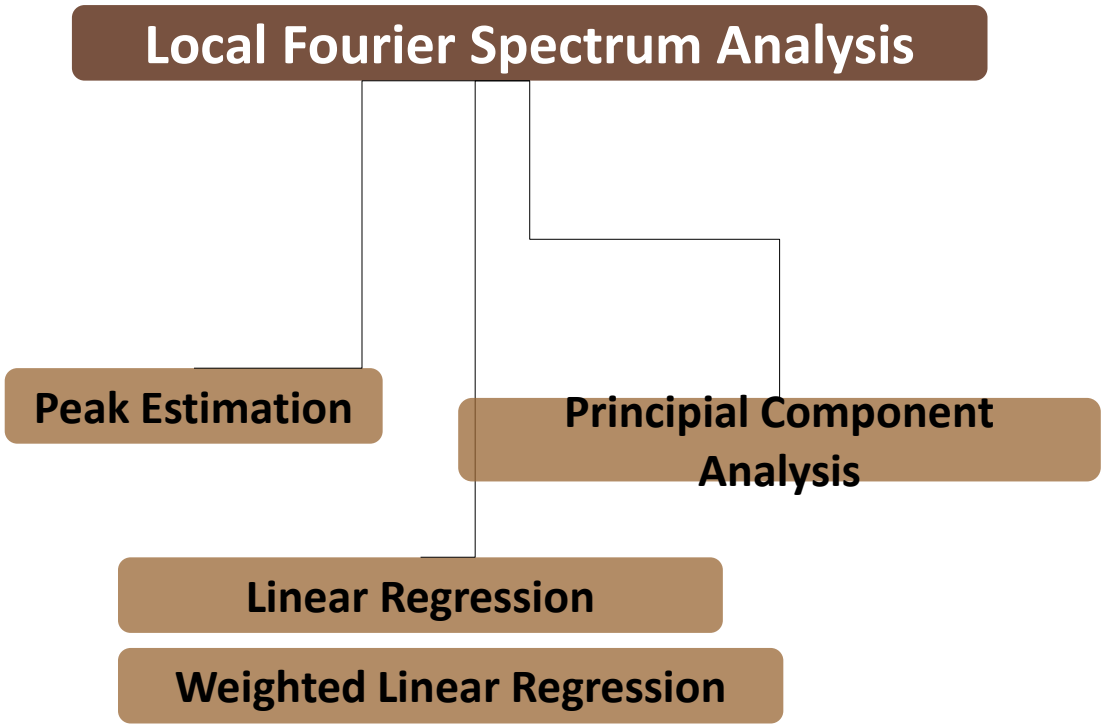


→ **ct-image**
varying ring width

→ **sanded cross section**
ring curvature

→ **rough cross section**
sawing disturbances

Pith estimation scheme



Pith estimation scheme

Local Fourier Spectrum Analysis

Simple Preprocessing

→ **Bandpass filter**

remove low and high frequencies

→ **Threshold**

T = max. Peak * [0.6, 0.9]

Peak Estimation

Principial Component Analysis

Linear Regression

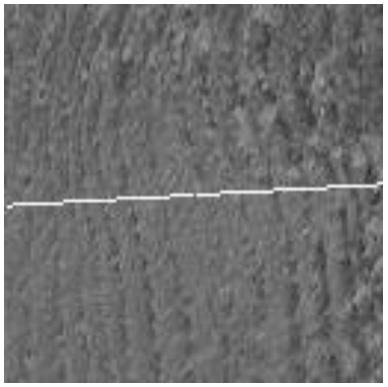
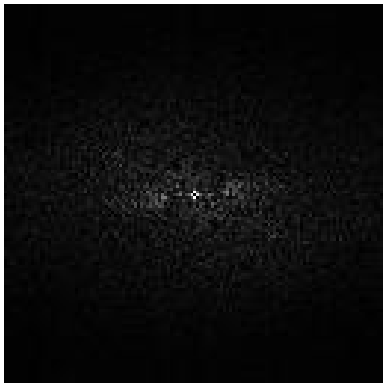
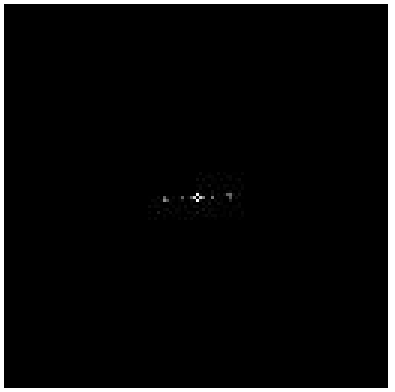
Weighted Linear Regression

Pith estimation scheme

Local Fourier Spectrum Analysis

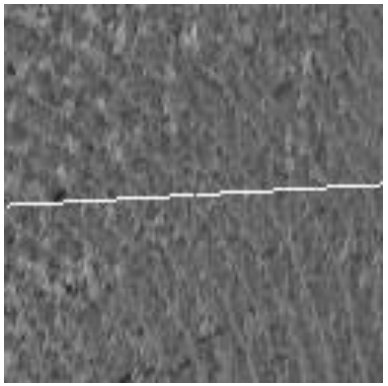
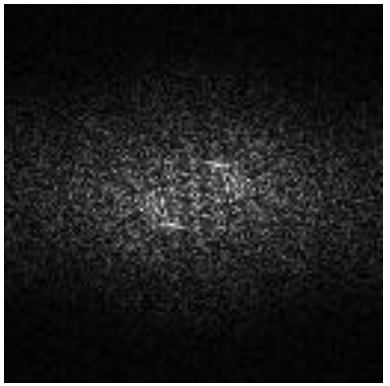
PCA

T = max. Peak* 0.6

Certainty Value:

0,995

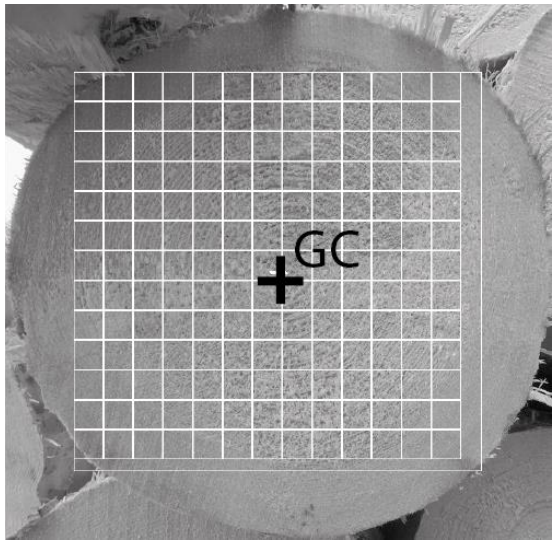

0,769

Pith estimation scheme

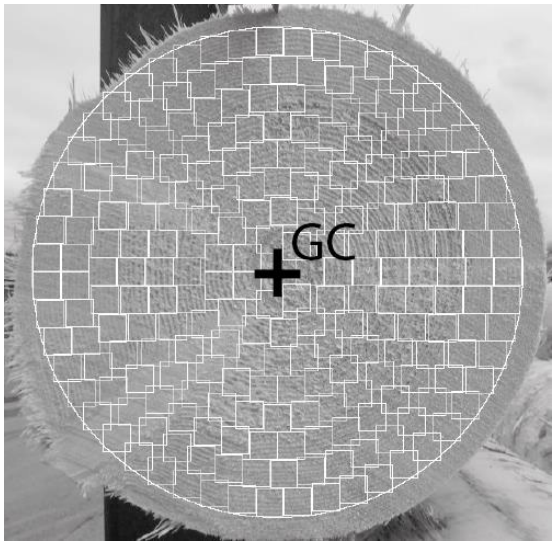
Block Selection Algorithms

Block Area Selection

Rectangular

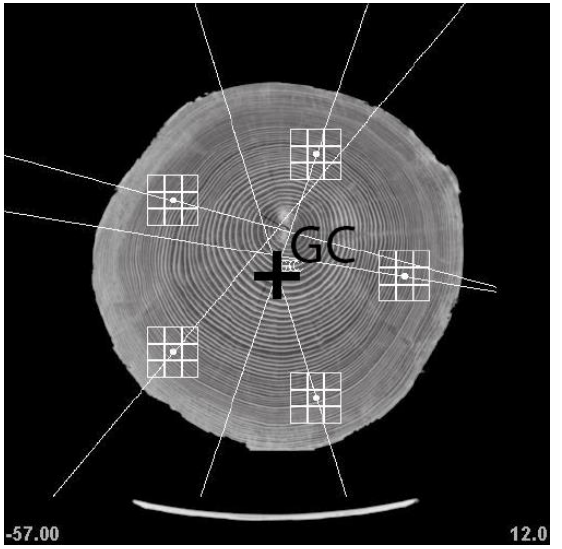


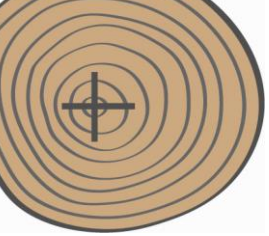
Circular



Pointwise Block Selection

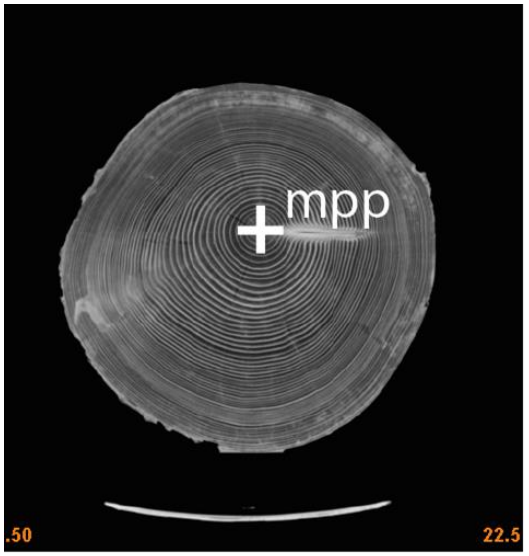
(Österberg, 2004)

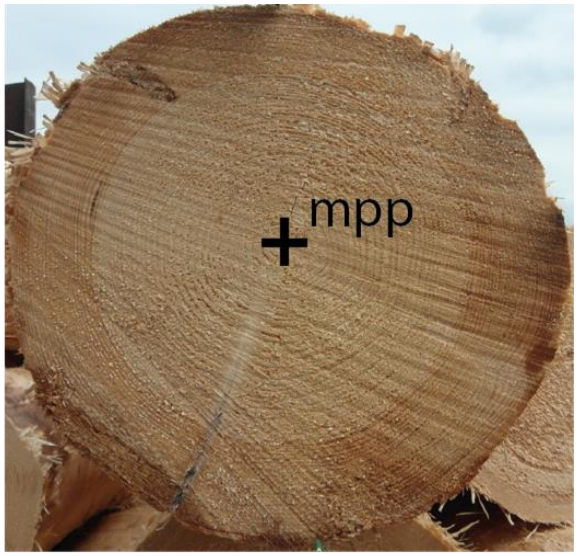




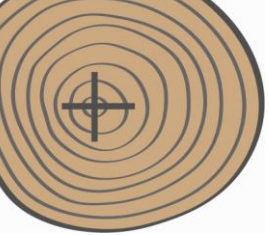
Experiments

→ Two image sets





→ 36 ct – image slices (512x512)
→ 109 rough log end images (1024x768)



Experiments

→ Two image sets

→ Different configurations:

- Two block selection algorithms with different settings

Block Area Selection	Pointwise Block Selection
- Circular and rectangular - Blocksize 8x8 to 32x32 - non- and halfoverlapping - different selection areas	- Blocksize 8x8 to 32x32 - Cluster size - Amount of clusters - Termination criterias

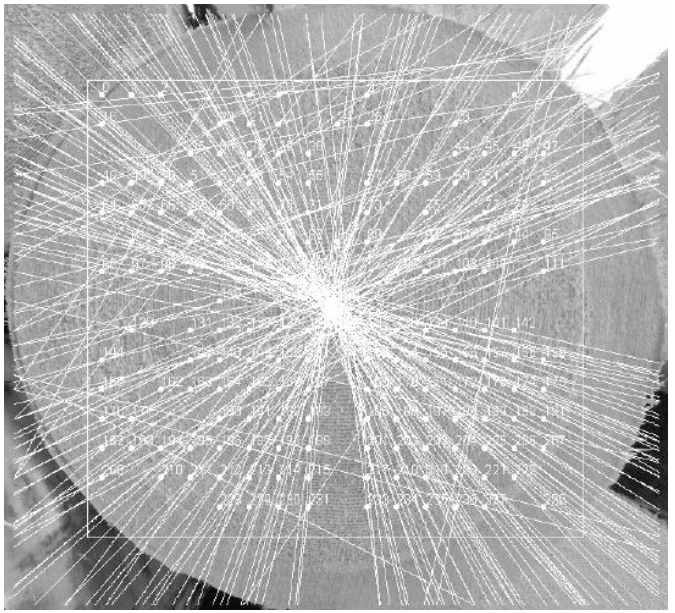
Experiments

→ Two image sets

→ Different configurations:

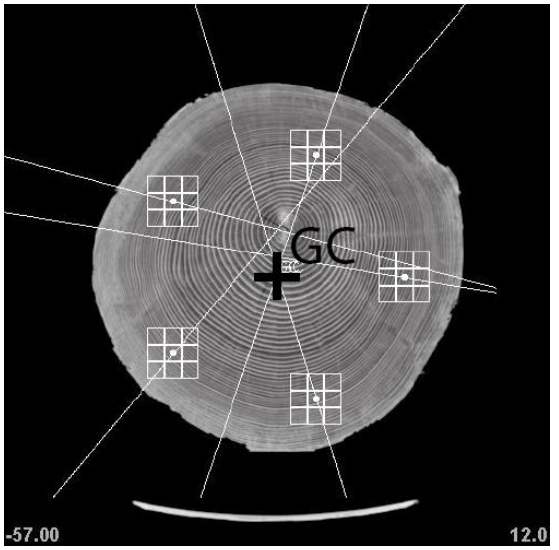
- Two block selection algorithms with different settings

→ Different certainty value thresholds for the intersection step



Experiments

Config.	Method	C	Mean	StDev	#B	R	[ms]
CT-BAS-C1	PA	-	4.65	1.12	249	6	211
	LSR	0.9	4.86	1.3	234	7	196
	WLSR	0.9	4.78	1.25	243	7	202
	PCA	0.9	4.78	1.19	230	7	199
CT-BAS-C2	PA	-	3.08	1.68	346	7	303
	LSR	0.5	2.27	1.0	330	4	307
	WLSR	0.9	2.41	1.1	339	5	304
	PCA	0.7	2.46	1.35	335	6	303
CT-PBS-C3	PA	-	6.54	8.55	117	45	21
	LSR	0.9	2.16	1.75	118	8	22
	WLSR	0.9	1.86	1.3	114	5	21
	PCA	0.7	1.49	1.06	111	4	21



→CT-BAS-C1 (16x16 blocksize, non-overlapping)
→CT-BAS-C2 (8x8 blocksize, non-overlapping) – 80x80
→CT-BAS-C3
(16x16 blocksize, 5 clusters – 2x2 blocks,
max. 5 iterations, termination criteria: 2 pixel)

Experiments

Config.	Method	C	Mean	StDev	#B	R	[ms]
CT-BAS-C1	PA	-	4.65	1.12	249	6	211
	LSR	0.9	4.86	1.3	234	7	196
	WLSR	0.9	4.78	1.25	243	7	202
	PCA	0.9	4.78	1.19	230	7	199
CT-BAS-C2	PA	-	3.08	1.68	346	7	303
	LSR	0.5	2.27	1.0	330	4	307
	WLSR	0.9	2.41	1.1	339	5	304
	PCA	0.7	2.46	1.35	335	6	303
CT-PBS-C3	PA	-	6.54	8.55	117	45	21
	LSR	0.9	2.16	1.75	118	8	22
	WLSR	0.9	1.86	1.3	114	5	21
	PCA	0.7	1.49	1.06	111	4	21

METHOD	AVG. TIME
Circle Equation (ring tracing - CErt)	1.25
Circle Equation (equal gradients - CEeg)	16.64
Gradient Method (intersection - GMi)	6.17
Gradient Method (radial length - GMrl)	3.16
Curvature (Cur)	1.40
Poincaré Index (Poi)	1.04

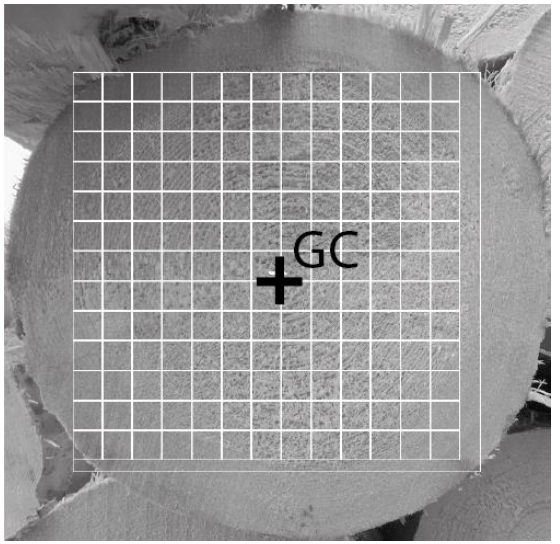
Mean - 2.8 pixel

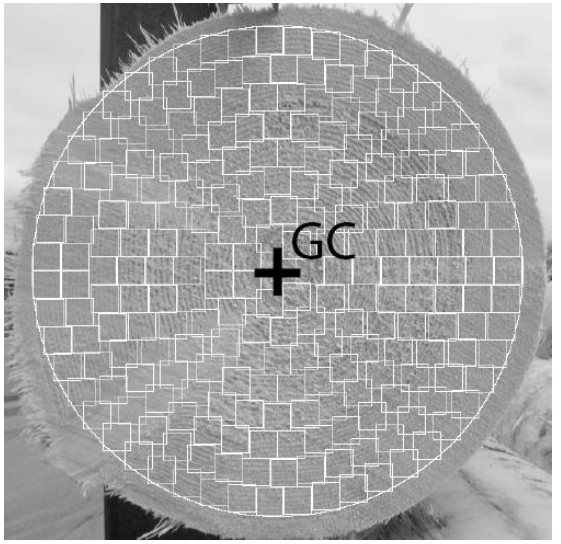
(Entacher,2008)

Experiments

16x16 pixel blocks

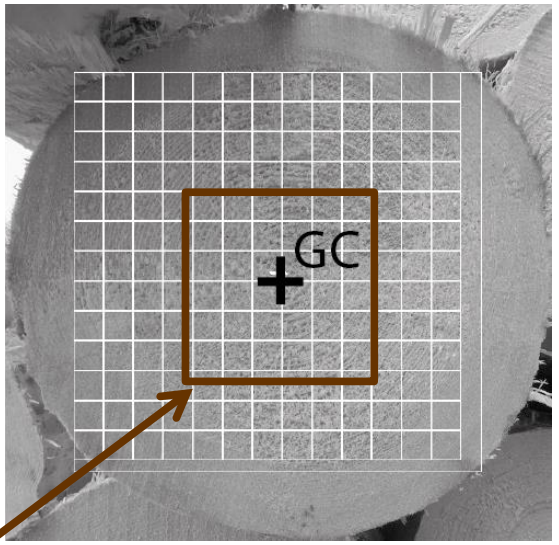
Config		Method	C	Mean	StDev	#B	R	[ms]
Rectangular BAS-1	non	PA	-	5.56	4.43	710	25	1048
	over-	LSR	0.9	6.45	5.08	643	27	1008
	lap-	WLSR	0.9	6.49	5.09	689	31	1032
	ping	PCA	0.5	5.75	4.3	660	25	1036
	half	PA	-	3.49	2.53	2789	13	2453
	over-	LSR	0.9	4.36	4.01	2528	24	2306
	lap-	WLSR	0.9	4.2	3.81	2709	25	2357
	ping	PCA	0.9	4.03	3.23	1697	15	2003
Circular BAS	non	PA	-	6.57	4.55	798	22	1053
	over-	LSR	0.9	6.0	4.7	720	27	960
	lap-	WLSR	0.9	6.43	5.56	481	34	858
	ping	PCA	0.9	6.02	5.25	310	33	818
	half	PA	-	3.73	3.15	2118	20	1969
	over-	LSR	0.9	4.43	4.39	1923	30	1888
	lap-	WLSR	0.5	4.19	4.25	2097	30	1962
	ping	PCA	0.9	4.39	3.77	1296	25	1650
	non	PA	-	4.67	3.05	321	17	768



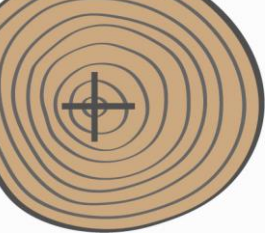


Experiments

Config		Method	C	Mean	StDev	#B	R	[ms]
Rectangular BAS-1	non over-lap-ping	PA	-	5.56	4.43	710	25	1048
		LSR	0.9	6.45	5.08	643	27	1008
		WLSR	0.9	6.49	5.09	689	31	1032
		PCA	0.5	5.75	4.3	660	25	1036
	half over-lap-ping	PA	-	3.49	2.53	2789	13	2453
		LSR	0.9	4.36	4.01	2528	24	2306
		WLSR	0.9	4.2	3.81	2709	25	2357
		PCA	0.9	4.03	3.23	1697	15	2003
Rectangular BAS-2	non over-lap-ping	PA	-	4.67	3.05	321	17	768
		LSR	0.9	5.91	5.1	295	33	761
		WLSR	0.5	6.46	6.7	319	45	771
		PCA	0.7	5.45	4.2	262	21	749
	half over-lap-ping	PA	-	3.04	2.43	1284	13	1393
		LSR	0.9	3.38	3.37	1178	19	1355
		WLSR	0.3	3.01	2.49	1279	15	1396
		PCA	0.9	3.1	2.34	785	11	1193
PBS	20 - Clus-ter	PA	0.9	6.87	7.38	417	65	150
		LSR	0.7	8.19	9.1	390	50	178
		WLSR	0.7	8.37	9.53	402	48	184
		PCA	0.9	6.23	7.22	299	54	229



300x300 pixel



Conclusions

→ Fourier Spectrum Analysis methods: fast, robust → accurate pith estimation

→ different image sets require different configurations

- difficulties due to disturbances

→ Peak analysis is very simple and effective

→ PCA shows a good reliability for determining valid orientation certainty values

→ annual rings close to the pith are more circular

→ Blocksize, distribution, amount of blocks and Fourier Spectrum preprocessing are very important for accurate pith estimation