Tree log Identification based on digital cross-section images of log ends using fingerprint and iris recognition methods

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WOOD LOG TRACKING

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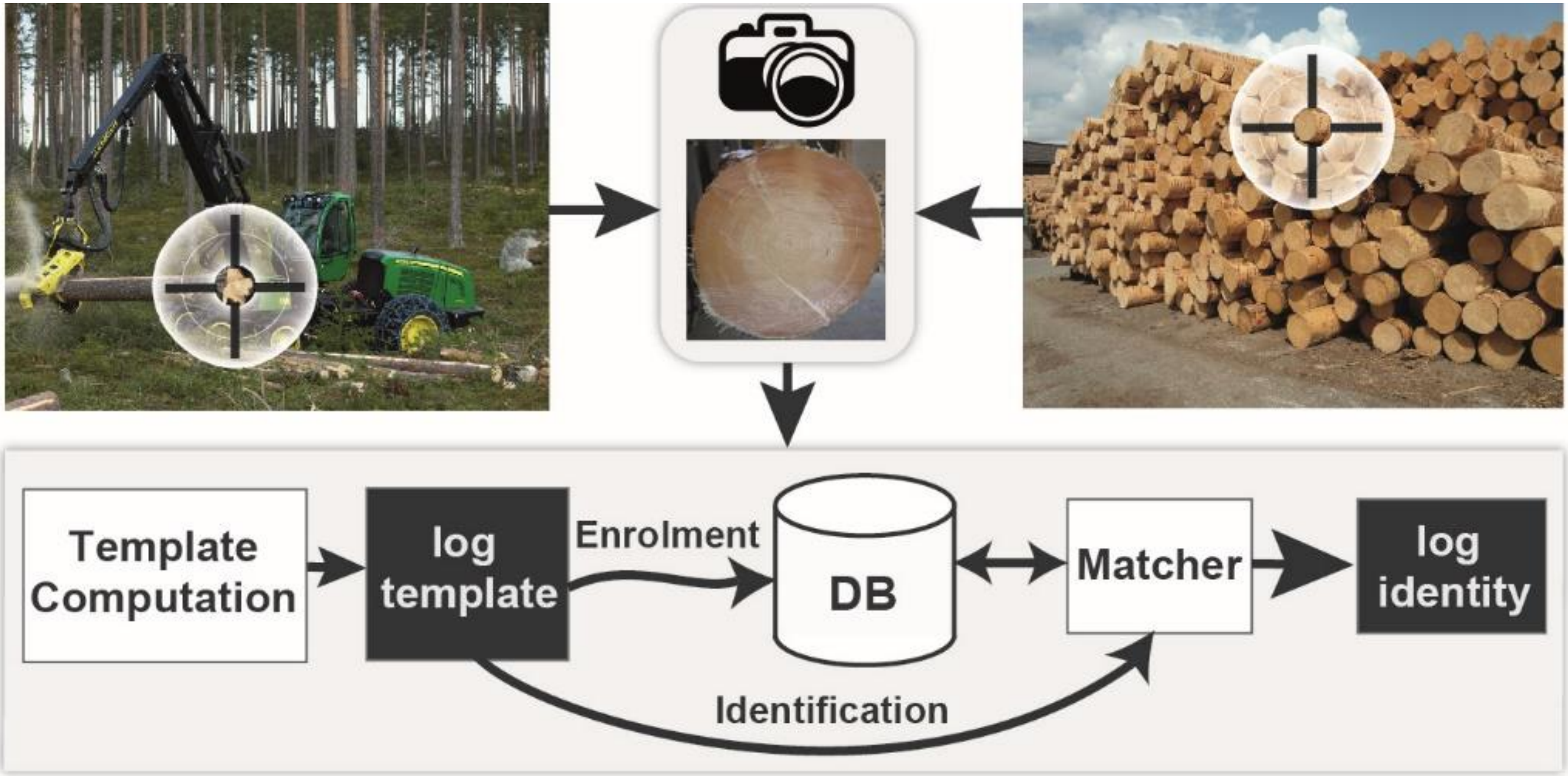
BIOMETRIC LOG IDENTIFICATION SYSTEM



Main Objectives

Assess

1. the identification performance for a set of tree logs,
2. the applicability of fingerprint- and iris-based methods,
3. the impact of enhancement.

1. TESTSET – Identification Performance

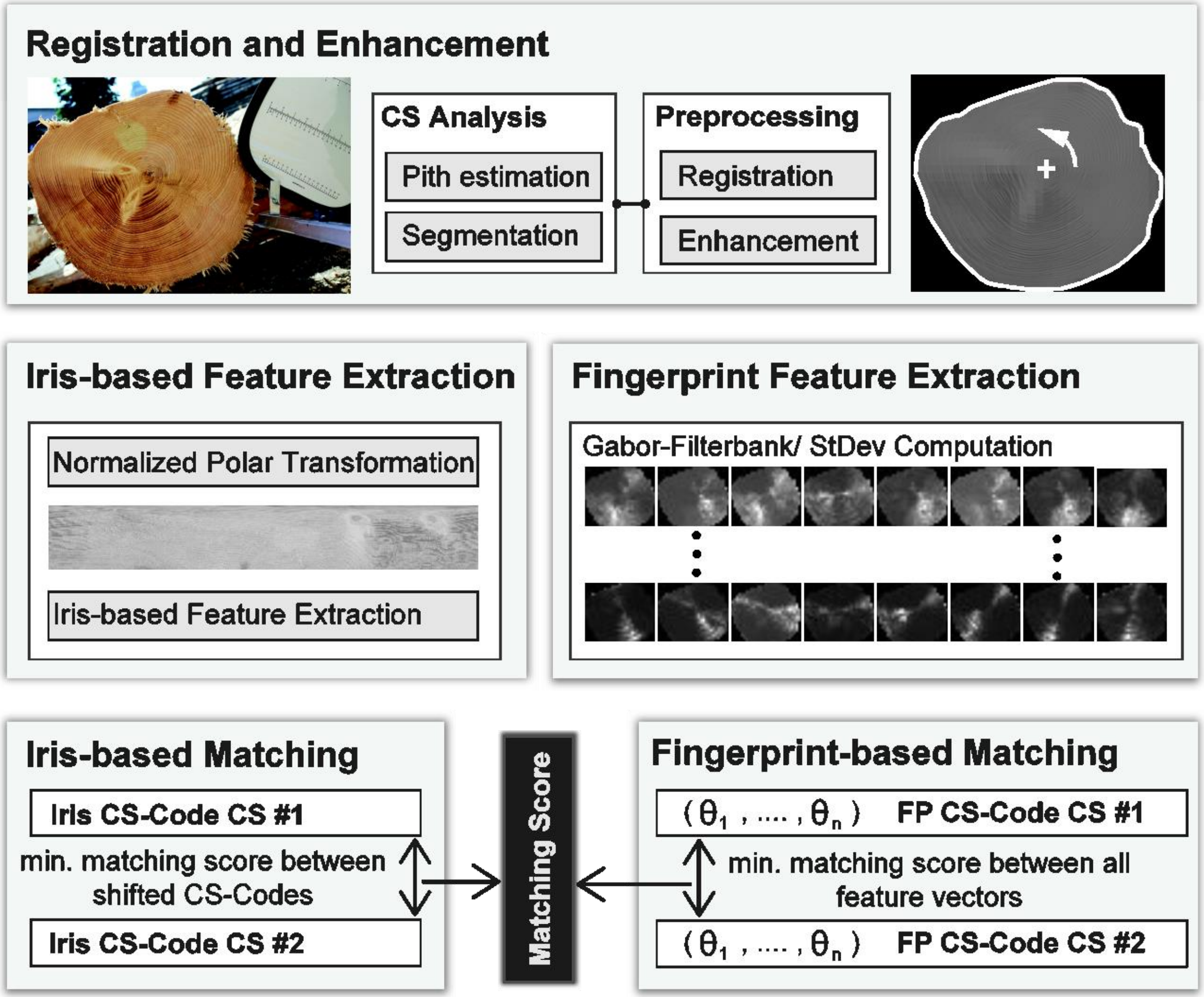
ENTACHER:

- 50 different logs
- 8 images per log (4 with and 4 without flash)
- 8 logs were cross-cut and again captured

Mayr-Melnhof:

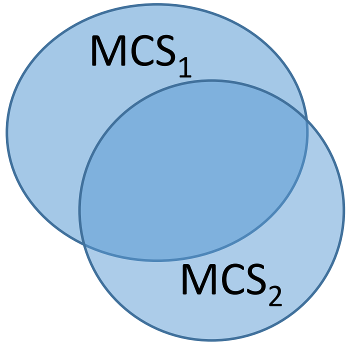
- 105 strongly bended logs
- 3 images per log

2. APPLICABILITY OF FINGERPRINT AND IRIS RECOGNITION BASED APPROACHES



2. FINGERPRINT-BASED APPROACH

Three different matching procedures: $$MS(CS_1, CS_2) = \frac{1}{M}\sum_{i=0}^{N} D(CS_1(i), CS_2(i))$$



MS_{AP}

$$D_{AP} = \begin{cases} |CS_1(i) - CS_2(i)| & \text{if } i \in MCS_1 \cap MCS_2 \\ 0 & \text{otherwise} \end{cases}$$

$MS_{AP\&S}$

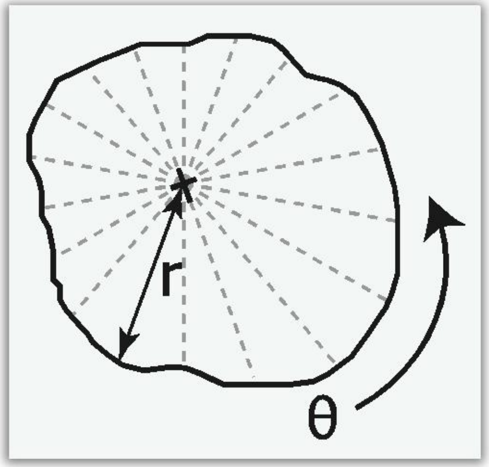
$$D_{AP\&S} = \begin{cases} |CS_1(i) - CS_2(i)| + & \text{if } i \in MCS_1 \triangle MCS_2 \\ P_{AP\&S} & \\ |CS_1(i) - CS_2(i)| & \text{if } i \in MCS_1 \cap MCS_2 \\ 0 & \text{otherwise} \end{cases}$$

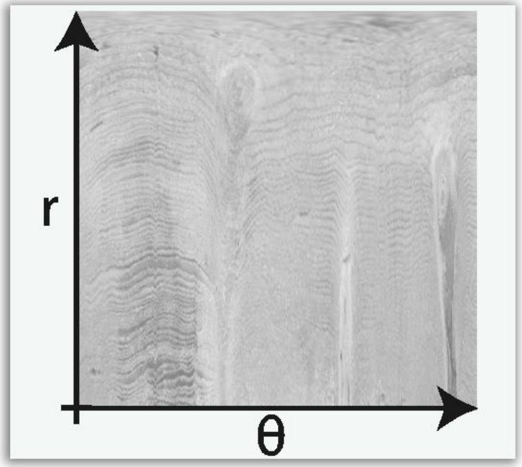
$MS_{AP,F}$

$$\mathrm{F} = \frac{MCS_1 \triangle MCS_2}{\min(|MCS_1|, |MCS_2|)}, \quad MS_{AP,F} = MS_{AP} \cdot \sigma_{AP} + F \cdot \sigma_F$$

2. IRIS-BASED APPROACHES

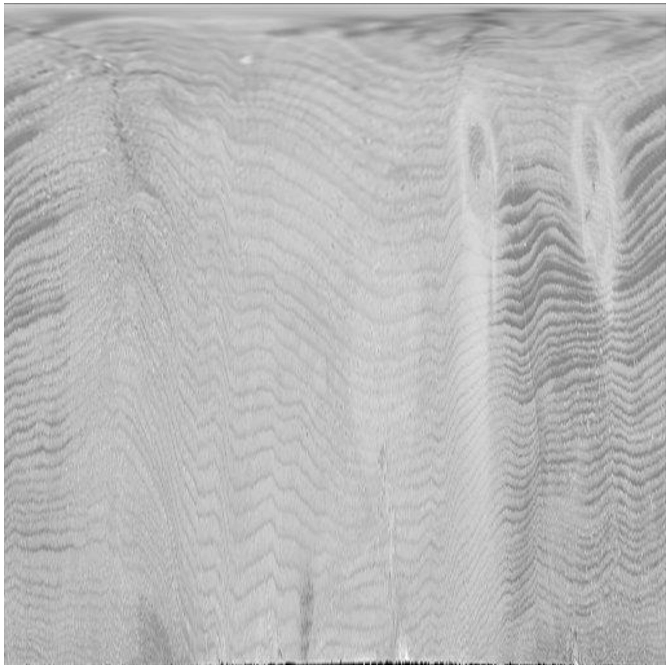
- Normalized polar transformation using the pith position (bi-cubic)

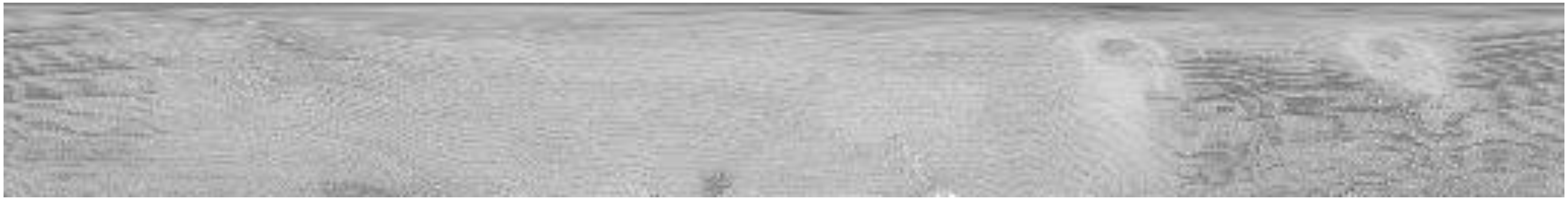




2. IRIS-BASED APPROACHES

- Normalized polar transformation using the pith position (bi-cubic)
- Two formats: **512x64** and **512x512**





2. IRIS-BASED APPROACHES

- Normalized polar transformation using the pith position (bi-cubic)
- Two formats: **512x64** and **512x512**
- Different feature extractors/ comparators - **USIT** (University of Salzburg Iris Toolkit):
  - **lg** – Masek (2003)
  - **cr** – Rathgeb (2010c)
  - **qsw** – Ma (2004a)

  Hamming distance

  - **ko** – Ko (2007) has its own comparator (koc)

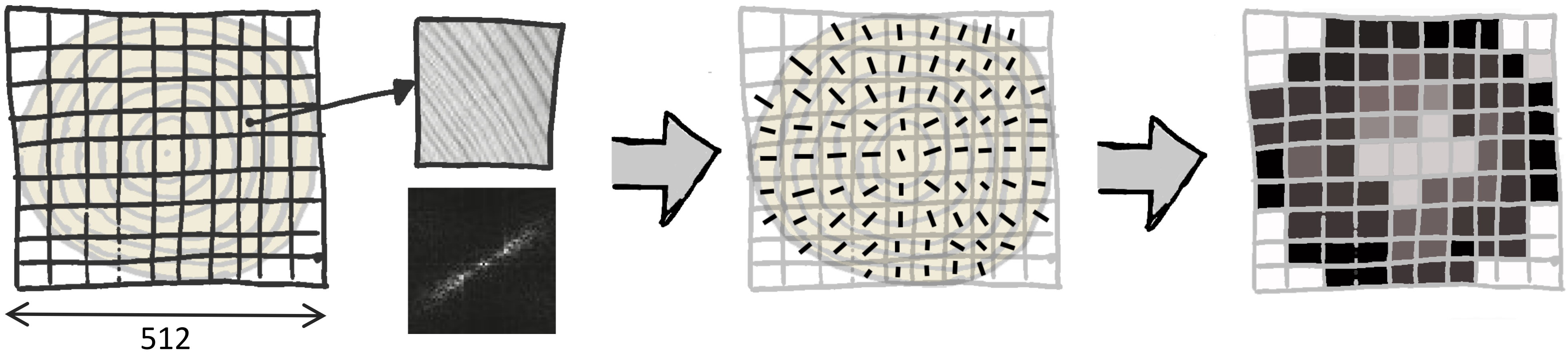
2. IRIS-BASED APPROACHES

- Normalized polar transformation using the pith position (bi-cubic)
- Two formats: **512x64** and **512x512**
- Different feature extractors/ comparators
- **lg** and **ko** were extended to work with bigger textures:

ROI = #rows x row-height:

- different configurations for #rows (r) and row-height (h_r)

3. ENHANCEMENT



Input image

- Image registration
- Subdivide into blocks

Orientation image

- Local orientation estimation
- Smooth orientation field

Frequency image

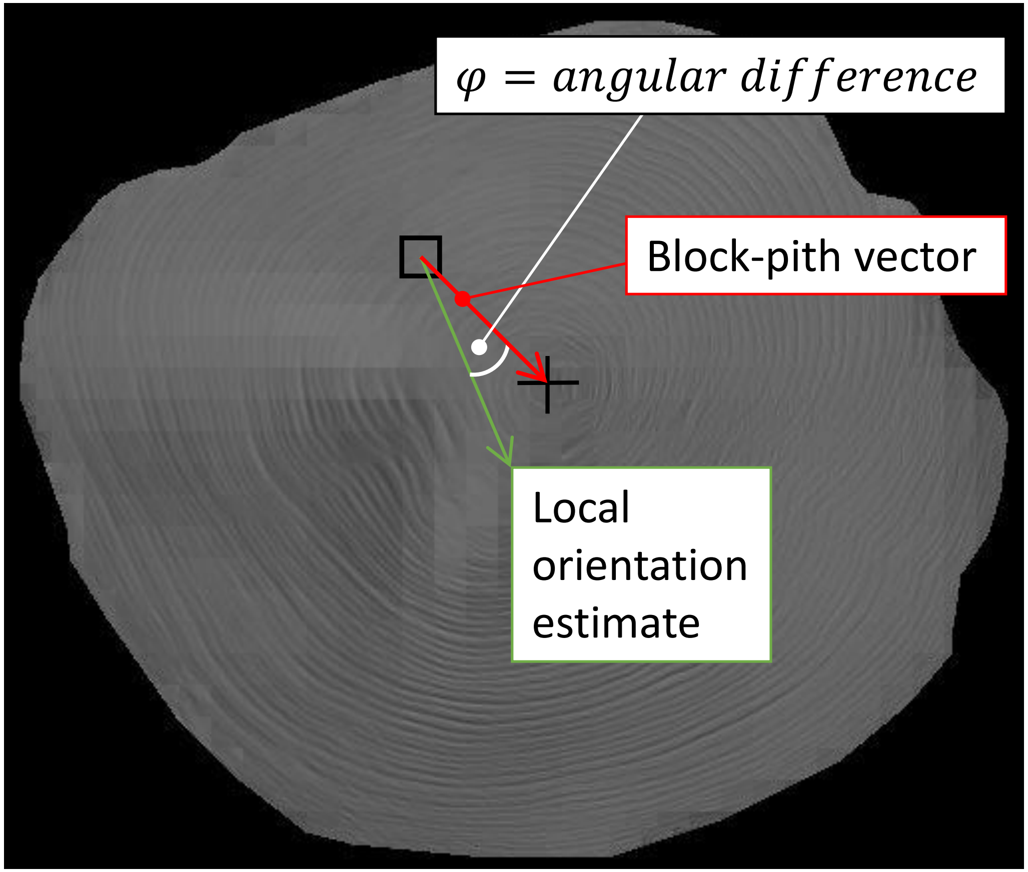
Adaptive FFT-filtering using Log-Gabor filters

3. ENHANCEMENT – TWO VARIATIONS

- ENH-1: smoothed orientation and frequency field
- ENH-2: corrects the orientation and frequency field for each block

  if $\varphi > t, t = \lambda * \log(pith\ distance)$

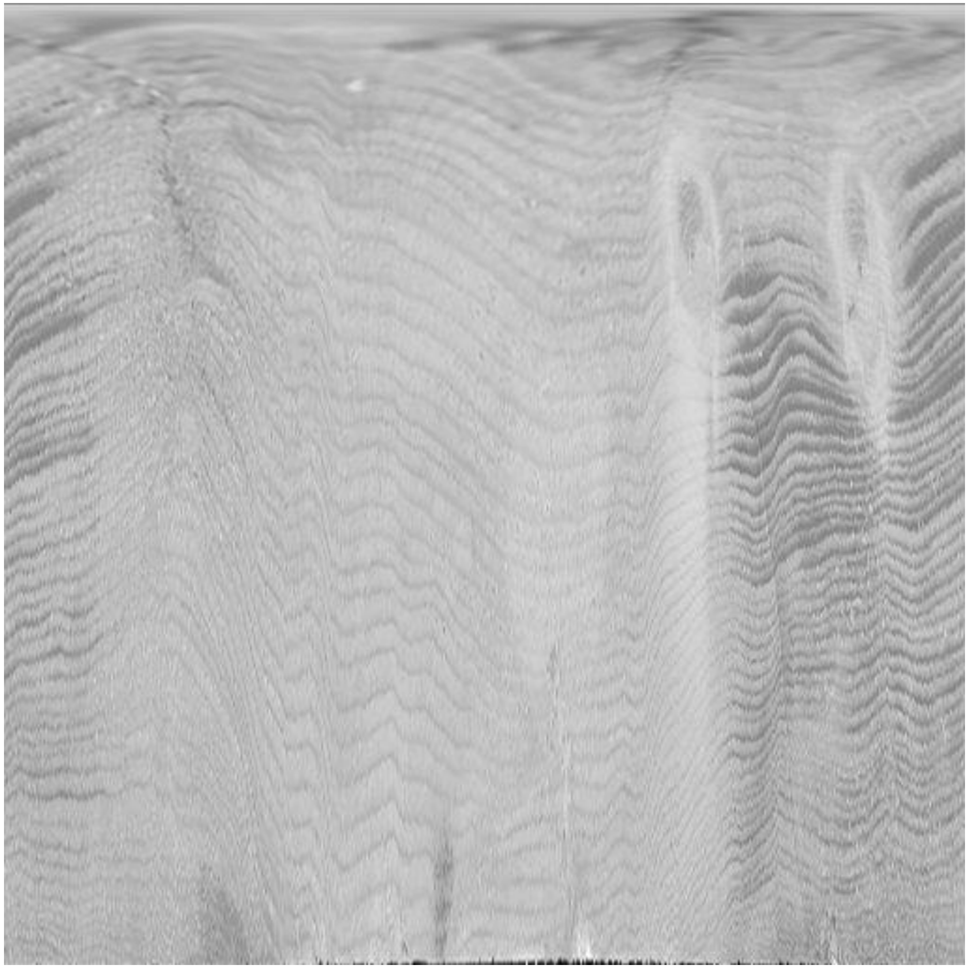
ENH-NO



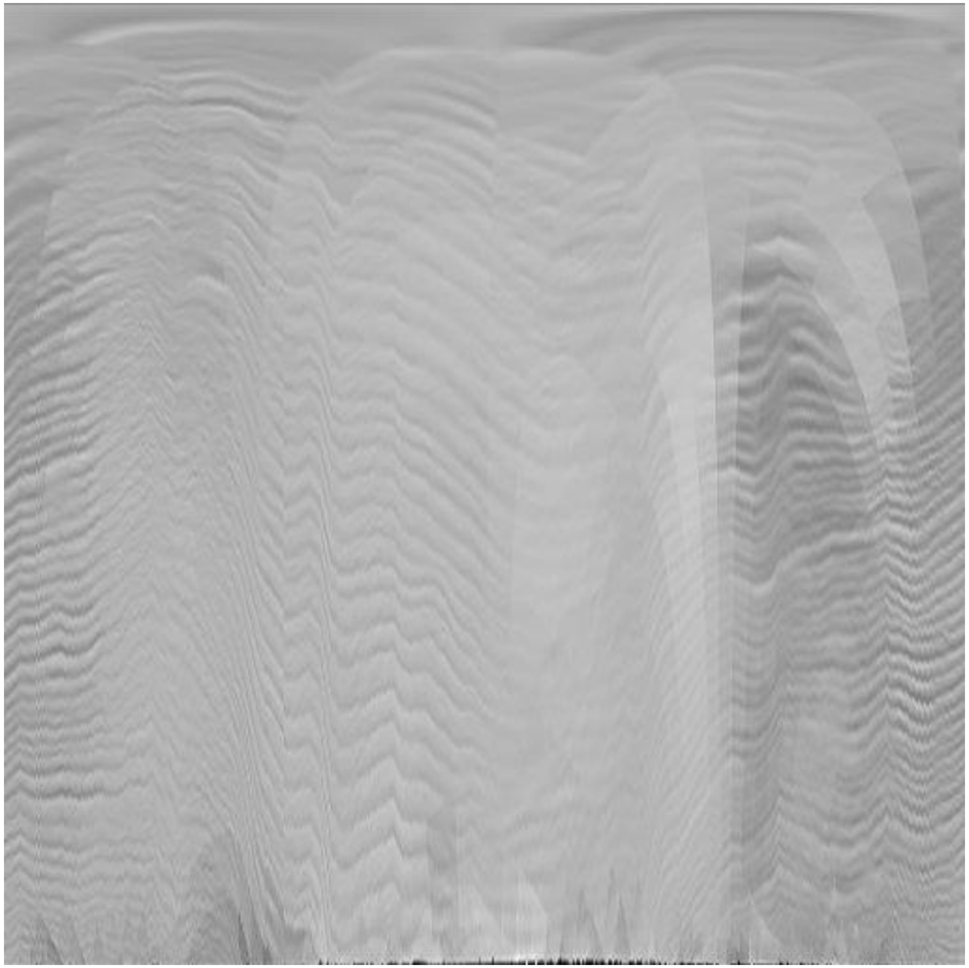
ENH-2

3. ENHANCEMENT – TWO VARIATIONS

- ISSUE: ENH-1 & ENH-2: introduce block artefacts



ENH-NO



ENH-2

EXPERIMENTS – VERIFICATION PERFORMANCE

- Applicability of the fingerprint and iris-based configurations and the impact of enhancement:

		Configuration	ENH_{NO}	ENH_1	ENH_2
FP		MS_{AP}	15.7	1.7	0.9
		$MS_{AP\&S}$	1.85	0.74	0.68
		$MS_{AP,F}$	1.53	0.37	0.17
IRIS	512x512	lg, hd(16/32)	0.21	0.68	0.82
		lg, hd(50/10)	0.16	0.72	0.32
		lg, hd(64/08)	0.16	0.76	0.51
		ko, koc	2.73	4.88	4.24
IRIS	512x64	cr, hd	5.27	3.41	4.97
		lg, hd	1.34	3.64	5.42
		qsw, hd	3.44	5.73	8.33
		ko, koc	4.95	8.09	7.35

Table 1: EERs [%] for the FP and iris configurations

FP:
- Enhancement improves the EERs
- Shape information is beneficial

IRIS:
- Bigger textures achieve better results
- Enhancement detoriates the EERs
- lg shows the lowest EERs
- lg(50/10) ignores 12 pixel of each image the EER is the same as for lg(64/08)

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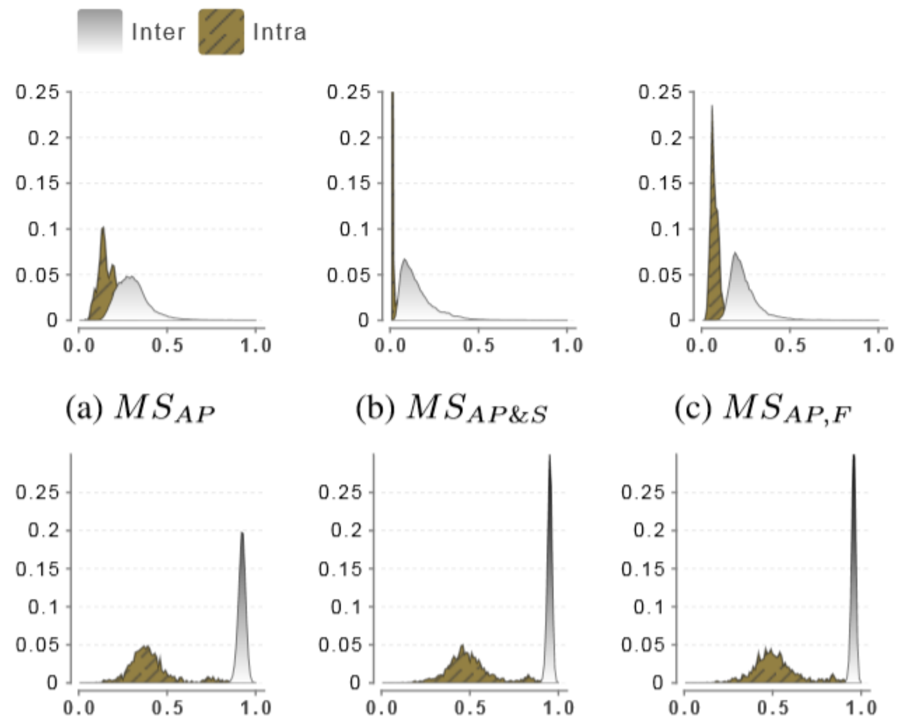
shape information

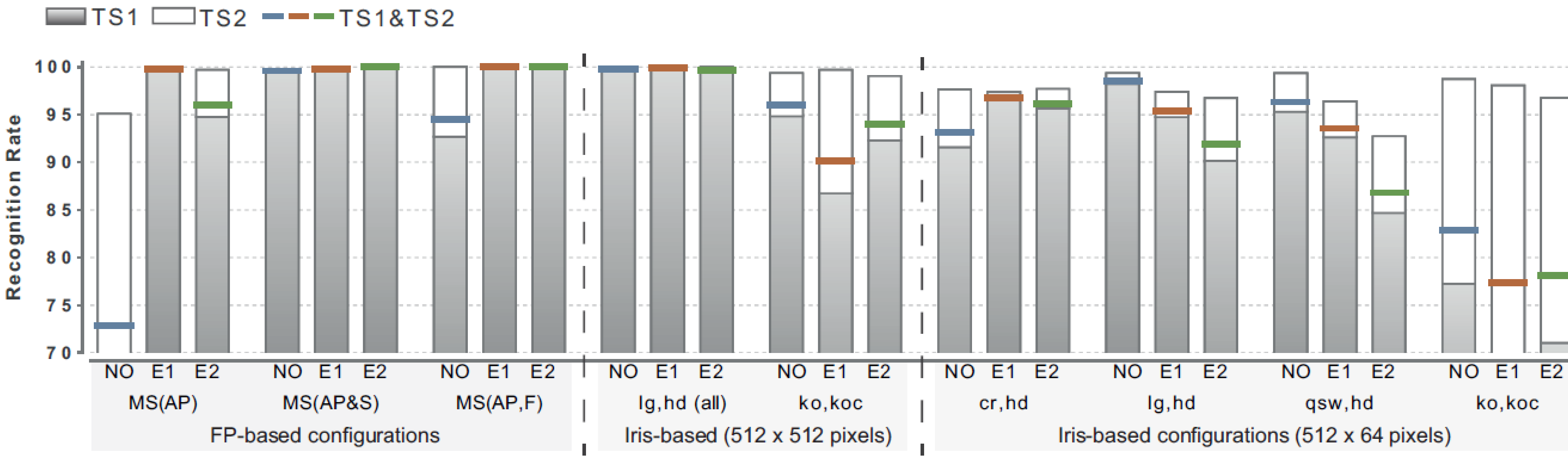


(a) MS_{AP} (b) $MS_{AP\&S}$ (c) $MS_{AP,F}$

(d) $lg(16/32)$ (e) $lg(50/10)$ (f) $lg(64/08)$

smaller grid = increasing feature vector size

EXPERIMENTS – IDENTIFICATION PERFORMANCE

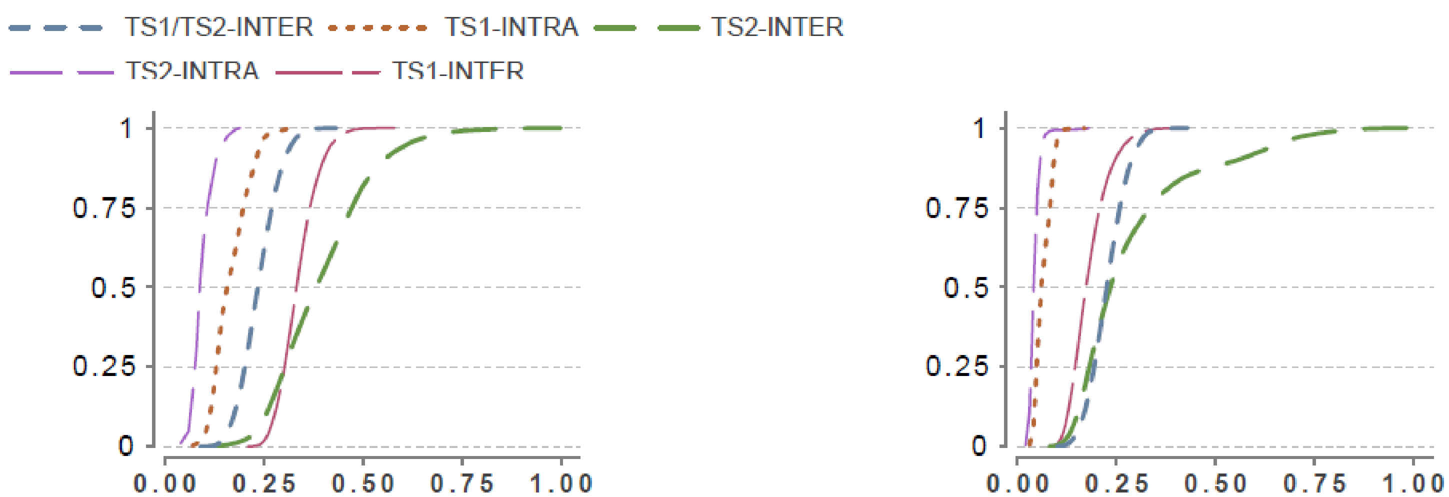


- Rank 1 – Detection rates
  - Rates for TS1 are lower than for TS2
  - Iris configurations achieve 100% recognition rates without enhancement

    -> Implict use of shape information

EXPERIMENTS – SUBSET ANALYSIS

- Cumulative distribution functions for the different intra- and interclass score distribution subsets:



(a) MS_{AP}/ ENH$_{NO}$ (b) MS_{AP}/ ENH$_2$

  - Scores of TS1 are inferior than those from TS2
  - Enhancement improves the separability

EXPERIMENTS – TS1 ANALYSIS

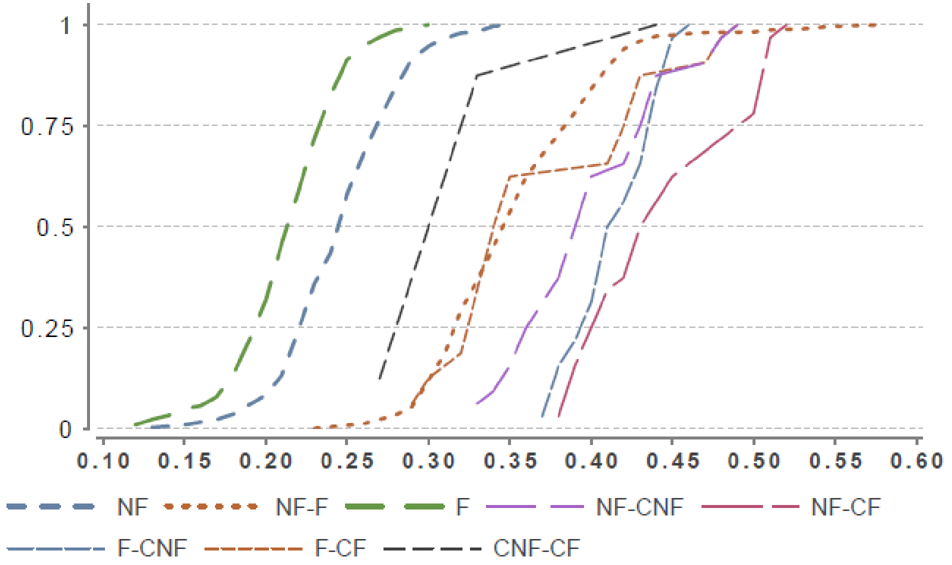


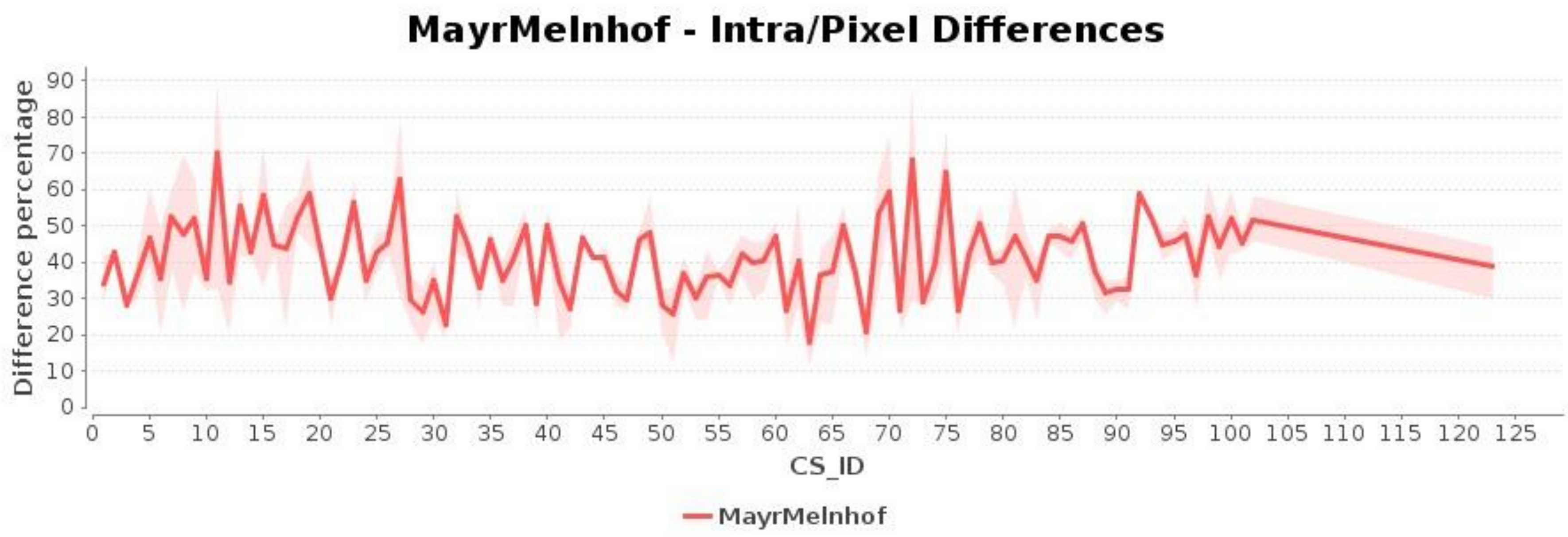
Fig. 10: Intraclass SD Subset Analysis for TS_1. NF = No Flash, F = Flash, CNF = Cut No Flash, CF = Cut Flash. [X-Axis: Matching Score, Y-Axis: Probability]

- CS-Images captured with flash (F) are more similar to each other than those without (NF).
- Scores for CS-Images without flash to those with flash are inferior (NF-F)
- Cross-cutting detoriates the similarity (F-CF, F-CNF, NF-CF, NF-CNF)

CONCLUSIONS

- Fingerprint and iris recognition based approaches can be successfully transfered to the field of wood log tracking
- **Fingerprint-based:**
    - Enhancement significantly improves the performance
    - Explicit use of shape information in the matching procedure achieves the best results
- **Iris-based:**
    - lg performs best – Gabor features are well suited
    - Larger format is better suited
    - Increasing number of rows increases the performance
    - Implicit use of shape information

Appendix 1


MayrMelnhof - Intra/Pixel Differences
Difference percentage
0
10
20
30
40
50
60
70
80
90
0
5
10
15
20
25
30
35
40
45
50
55
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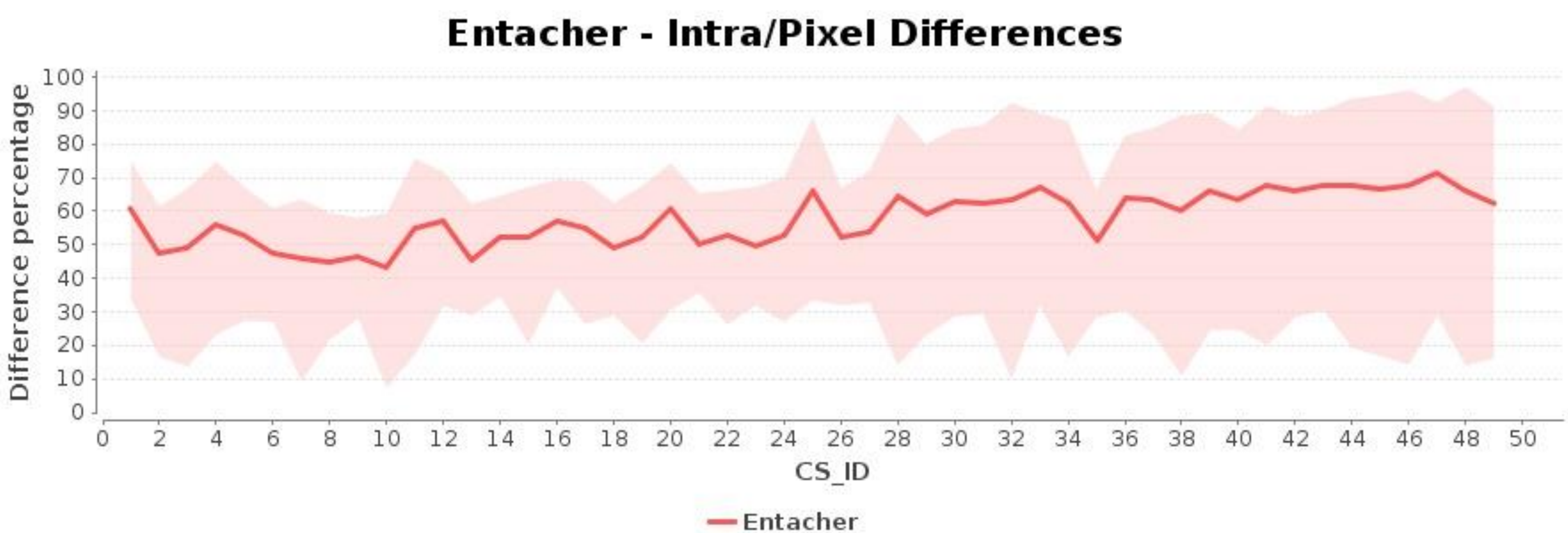
65
70
75
80
85
90
95
100
105
110
115
120
125
CS_ID
MayrMelnhof


Entacher - Intra/Pixel Differences
Difference percentage
0
10
20
30
40
50
60
70
80
90
100
0
2
4
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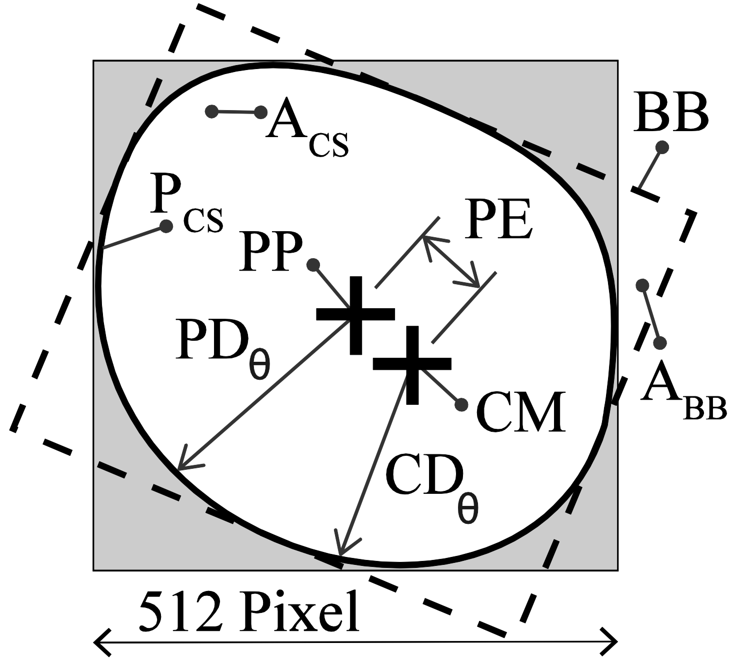
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
CS_ID
Entacher

Appendix 2

- HU-Moments (H_1-H_7)
- Circularity (C)
- Rectangularity (R)
- Eccentricity (E)
- Pith Eccentricity (PE)
- Centroid Distances (CD)
- Pith Distances (PD)
- **Zernike Moments(Z)**



High discriminative power and reliability!

- Validation and Reliability of the Discriminative Power of Geometric Wood Log End Features, ICIP'2015, Quebec, Canada

Appendix 3

- Validation and Reliability of the Discriminative Power of Geometric Wood Log End Features, ICIP'2015, Quebec, Canada

SEG/PE	HU_1	HU_2	HU_3	HU_4	HU_5	HU_6	HU_7	C	R	E	PE	CD	PD	Z
GT	11.35	13.76	19.5	25.73	31.7	28.68	29.13	17.33	22.02	8.04	7.24	2.81	1.43	6.29
SEG-G/PE-PCA	36.0	38.92	39.69	45.04	45.14	40.94	43.84	34.82	49.65	29.79	29.15	28.0	19.98	5.71
SEG-G/PE-Peak	37.25	34.43	38.77	44.06	45.16	41.18	44.2	36.06	47.57	28.91	28.57	27.09	20.32	5.68
SEG-C/PE-PCA	37.78	39.09	37.31	44.81	46.73	40.7	43.49	29.11	38.46	23.99	27.6	20.43	16.71	5.57
SEG-C/PE-Peak	35.97	34.26	38.26	44.34	45.38	41.13	43.47	30.47	46.57	24.09	26.11	19.36	15.18	5.43

Table 2: EERs[%] for each geometric feature.

CSSEG/PE	k=2	k=3	k=4
GT	PD,CD 0.74	PD,CD,Z 0.54	PD,CD,Z,R 0.68
SEG-G/PE-PCA	PD,H_4 20.12	PD,H_4,R 20.07	PD,H_4,R,H_7 20.10
SEG-G/PE-PEAK	PD,C 21.84	PD,E,C 22.52	PD,CD,E,C 23.28
SEG-C/PE-PCA	PD,CD 15.75	PD,CD,E 15.81	PD,CD,E,H_6 15.88
SEG-C/PE-PEAK	PD,CD 15.36	PD,CD,R 15.34	PD,CD,R,E 15.61

Table 1: EERs[%]: SFFS-based score level fusion. Z is not considered in case of SEG/PE.