Pith Estimation on Tree Log End Images

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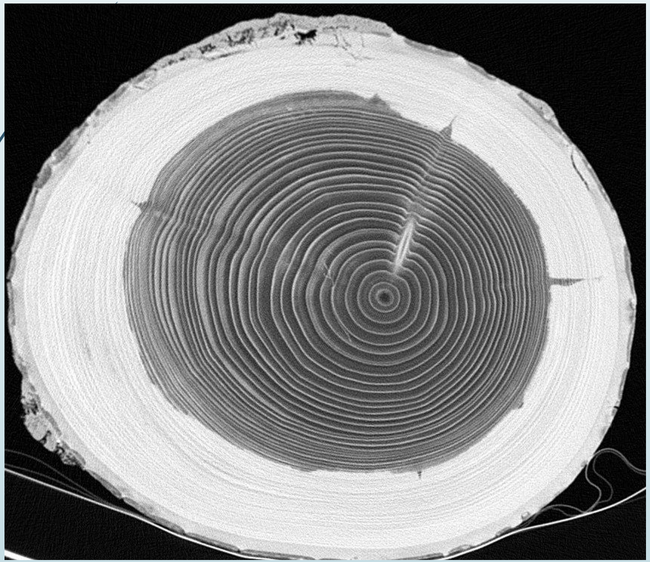
Context
CT images / RGB images

X-ray CT:

+ Efficiency both external and internal
- Still expensive, few sawmills can afford such a material



Low-cost camera:

+ Cheap
+ Fast capture
- Only external measures
- Not all characteristics

Context
Wood Quality Features

Wood quality ?

- Mechanical resistance
  - Bending, Load-carrying
- Durability
  - Fungi / Insect resistance (without chemical treatment)

External features on RGB images

- Pith
- Amount of Sapwood / Heartwood
- Mean annual ring width
- Cracks
- Rot
- Reaction wood

… for instances

Context
Overall Process

Acquisition	Acquire images (forest, logyard, sawmill, …)
Segmentation (optional)	Remove background if needed
Descriptors	Extract features (Pith)
Classification	Classify using previously computed descriptors

Challenging: w/o segmentation + Real-time + Variability (Forest/Logyard/ Sawmill)

State-of-the-art

What has been done so far for pith estimation on rough log ends images ?

→ Few results in the literature.

Norell & Borgefors[1]:	Quadrature filters & linear symmetry (2008)
Schraml & Uhl [2]:	Fourier Transform (2013)
Kurdthongmee et al. [3]:	Histogram of Oriented Gradients (HoGs) (2018)
Kurdthongmee et al. [4]:	Neural Networks (NN) (2020)

[1] Norell, K., Borgefors, G. 2008. Estimation of pith position in untreated log ends in sawmill environments. *Computers and Electronics in Agriculture 63(2)*, 155 – 167
[2] Schraml, R., Uhl, A. 2013. Pith estimation on rough log end images using local fourier spectrum analysis. In: *Proceedings of the 14th Conference on Computer Graphics and Imaging (CGIM'13)*, Innsbruck, AUT
[3] Kurdthongmee, W., Suwannarat, K., Panyuen, P., Sae-Ma, N. 2018. A fast algorithm to approximate the pith location of rubberwood timber from a normal camera image. In: *15th International Joint Conference on Computer Science and Software Engineering (JCSSE)*. pp. 1−6. IEEE
[4] Kurdthongmee, W.: A comparative study of the effectiveness of using popular dnn object detection algorithms for pith detection in cross-sectional images of parawood. Heliyon 6(2) (2020)

State-of-the-art

All developed methods can be summed up this way (except NN):

1. Estimate **local orientation** of tree rings and retrieve normal

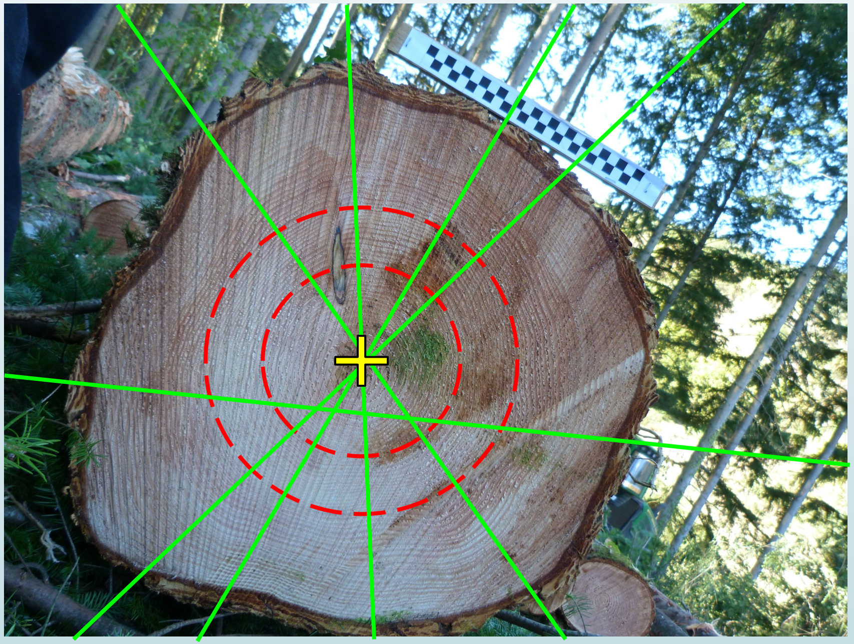
   Focus of state-of-the art

2. **Accumulate** normals

   Our focus

3. **Retrieve pith** according to accumulation space

4. **Iterate** eventually that process



Method

1. **Local orientation** of tree rings → Based on **Gradient**
2. **Accumulate** normals → Based on **Ant Colony Optimization**
3. **Retrieve** pith → **Barycentre** of high accumulations
4. **Iterative** the process → **Twice** (coarse / accurate estimation)

Reproducibility:

Pseudo-code and formulae
Code Source
Parameters are provided
Installation and command-line examples are given

Method
Ant Colony Optimization

Initialize: **K*K** **Ants** on grid

Global accumulation space

Iterative **N** times the following process

1. For each **ant**
   - Accumulate **local normals**
   - Move ant according to:
     - its **position**
     - **local normals**
     - **global accumulation**
2. Update **Global accumulation** with computed **local normals**

Method
ACO Demonstration

Experiments
Imagesets

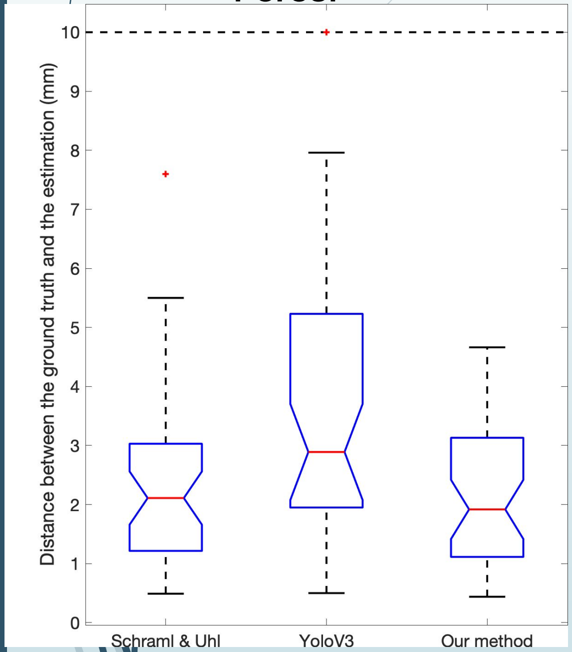
Same logs but at different stages

In forest
65 images

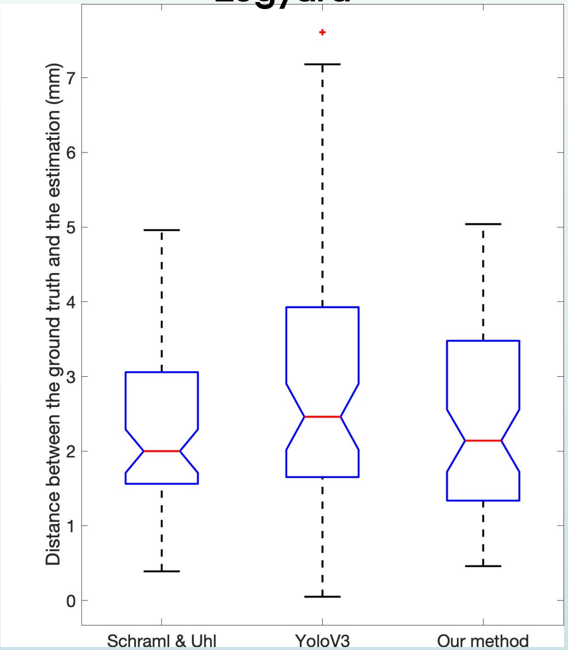
On logyard
40 images

Experiments - Results

Forest



Logyard



Three state-of-the-art methods:

- Schraml & Uhl (2013) [2]
- Kurdthongmee et al. (2018) [3]
- Kurdthongmee et al. (2020) [4]

As **accurate** as [2]
More accurate than [2,4] (no outliers)

Time Computation (ms):

- 8344 [2]
- **138** [3] (fast but not accurate)
- 667 [4]
- **1611** our method

5x Faster than [2] / Only **2x slower** than [4]

[2] Schraml, R., Uhl, A. 2013. Pith estimation on rough log end images using local fourier spectrum analysis. In: *Proceedings of the 14th Conference on Computer Graphics and Imaging (CGIM'13)*, Innsbruck, AUT
[3] Kurdthongmee et al.: A fast algorithm to approximate the pith location of rubberwood timber from a normal camera image. In: 15th International Joint Conference on Computer Science and Software Engineering (JCSSE). pp. 1–6. IEEE (2018)
[4] Kurdthongmee, W.: A comparative study of the effectiveness of using popular dnn object detection algorithms for pith detection in cross-sectional images of parawood. Heliyon 6(2) (2020)

Conclusion

Strengths
- Fast computation
- Accurate
- Real-time possible
- Done with or without segmentation
- Reproducible: code and demonstration available

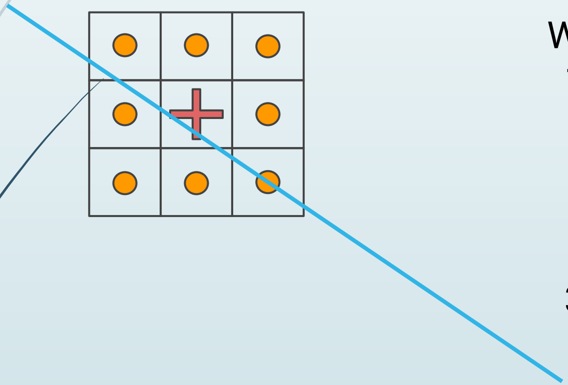
Limits
- Based only on tree rings
- Many parameters to set

Future works
- Not relying only on tree rings for pith estimation
- Automatic method for parameters

Any questions ?

Code: https://gitlab.com/Ryukhaan/treetrace/-/tree/master/pith
Video: https://gofile.io/d/WIr6Qy
Or in the gitlab link (directory video)

Appendix A
Ant Behavior - Local accumulation



We assume the **k**th ant is under consideration

1. Compute normals for each block (median of local orientation of the block)
2. Draw **line** passing through **block center** and according previous computed orientation
3. If a pixel ***u***=*(x,y)* is on one of the lines, then the matrix $\boldsymbol{\rho}_k$ at that position **u** is set to 1.

Appendix B
Ant Behavior - Moving

Probabilistic transition matrix for the **k**-th ant at the iteration **t** is $\boldsymbol{\tau_k^t}$

How it is computed ?

1. We need the global accumulation matrix at the iteration **t**: $\boldsymbol{\pi^t}$
2. We need the desirability matrix at the iteration **t**: $\boldsymbol{\eta_k^t}$

$$\eta_k^t(u,v) = \frac{1}{\sqrt{(u-a)^2+(v-b)^2+1}}$$

3. Then we combine the both matrices

$$\tau_k^t(u,v) = \frac{(\pi^t(u,v))^\alpha (\eta_k^t(u,v))^\beta}{\sum_{i,j}(\pi^t(i,j))^\alpha (\eta_k^t(i,j))^\beta}$$

(a,b) position of the **k**-th ant
(u,v) index of matrix

α and **β** parameter for weighting

Appendix C
Global accumulation

1. Global accumulation $\boldsymbol{\pi}^0$ is initialize to 0 (and randomly with normal distribution)
2. The update of $\boldsymbol{\pi}^{t+1}$ is done as follows:

$$\pi^{t+1} = (1-\gamma)\pi^t + \sum_{k=1}^{K} \rho_k^t$$

k index for ant
t iteration number
$\boldsymbol{\rho^t_k}$ matrix of local accumulation at iteration **t** by the **k**-th ant