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Non-destructive analysis of Norway spruce (Picea abies (L.) Karst.) logs by means of CT scans

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Non-destructive analysis of Norway spruce (*Picea abies* (L.) Karst.) logs by means of CT scans

Fleur Longuetaud

9ème rencontre annuelle FOBAWI-LERFoB, INRA Champenoux, 5-6 avril 2005

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3.3.1 Whorl location ✓

3.3.2 Knot detection (in progress …)

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1. Introduction

In this study spruce logs were scanned with a medical CT scanner.

Objectives:
Automatic detection of wood characteristics (pith, heartwood/sapwood boundary, knots, ...)

Possible applications:
•Variability analysis of wood properties in a nondestructive way
•Sawing simulation for optimizing the quality of sawn products

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2. Materials

24 trees from 4 stands in the north-eastern part of France

Stands	*Age*	*Density (stems/ha)*	*Fertility class (Décourt)*	*Dominant height at 100 years (m)*	*Average diameter (cm)*	*Average height (m)*
31	66	510	4	33	31.4	23.6
32	95	520	2	36.1	39	33.5
33	68	800	2	38.3	32.1	29.4
34	133	520	4	31.1	43.2	31.9

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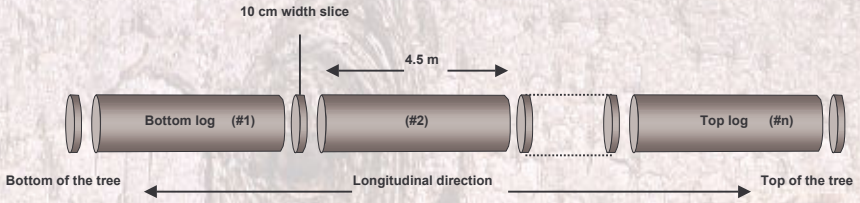
The trees were cut in logs ...

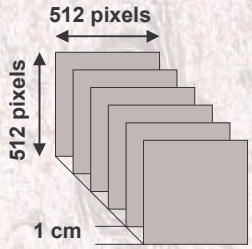


Then, each log was scanned in a **medical CT scanner**

(European Research Project STUD)

… resulting in a **stack of CT slices**

Size of a pixel: between 0.68 and 0.88 mm



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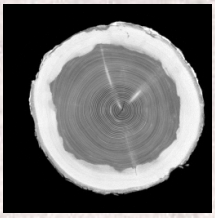
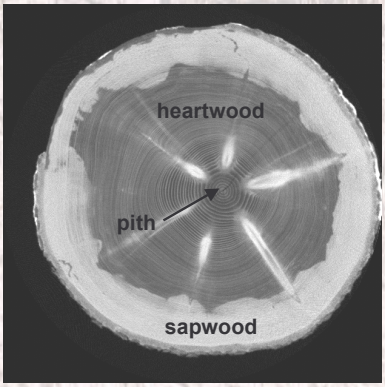
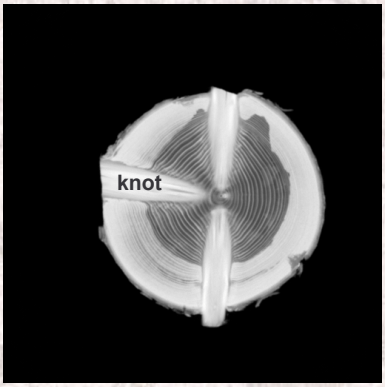
Some examples of CT slices





Bottom log (34-4-1)



Top log (34-3-5)

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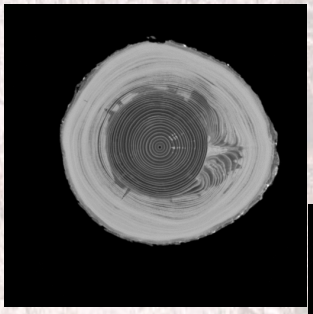
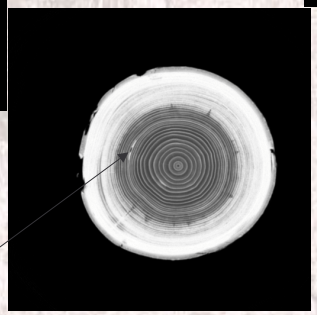
Some examples of particular CT slices



Wound ?

Compression wood



Resin pocket

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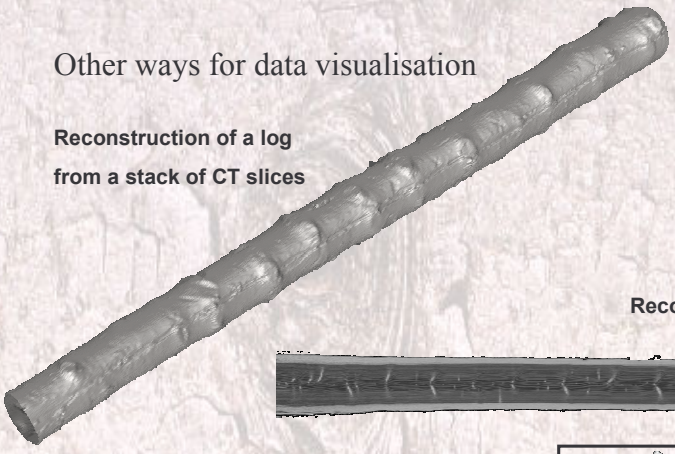
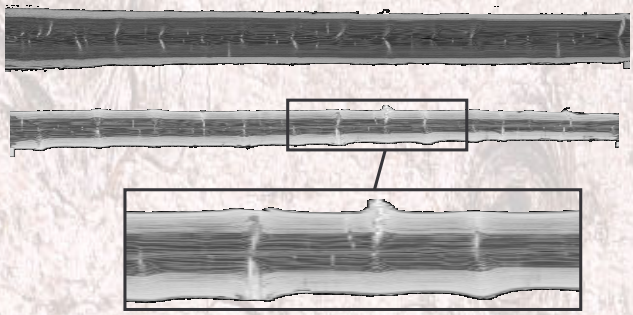
Other ways for data visualisation

Reconstruction of a log
from a stack of CT slices



Reconstruction of boards



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3. Automatic detection (AD) and results

Structure of the work done during the thesis

AD of the **pith** — Pith density (in progress); Eccentricity

↓

AD of the **heartwood/sapwood limit** — Analysis on the amount of heartwood and sapwood

↓

Knotiness

- AD of **whorl location** inside logs
- AD of **individual knots** (in progress)

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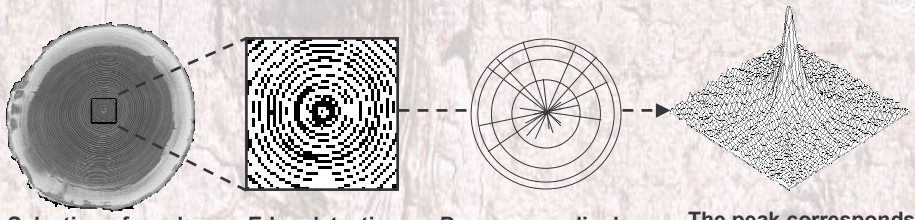
3.1. Pith detection

Completely automatic detection of the pith location inside logs.
A Hough transform was used based on the annual ring pattern.

Example of a slice without knots:



Selection of a sub-image containing the pith | **Edge detection of annual rings** | **Draw perpendicular line to each pixel belonging to an edge** | **The peak corresponds to the location of the highest number of line intersections = PITH**

The algorithm also deals with slices containing knots but this more complicated case will not be presented here.

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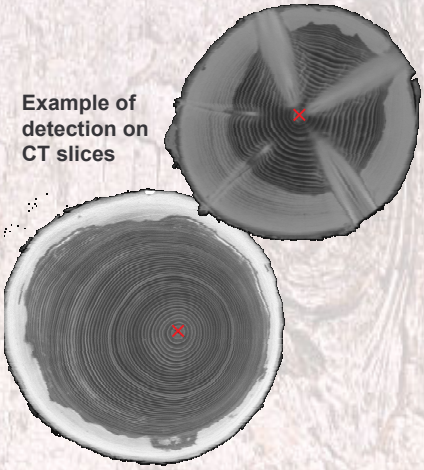
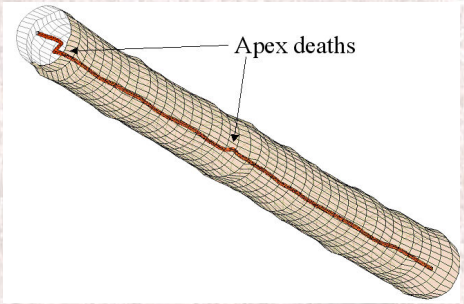
Results

Example of detection on CT slices





3D pith profile inside a log

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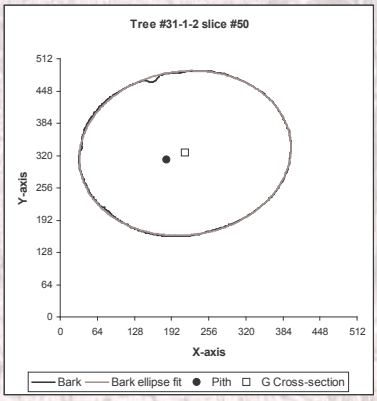
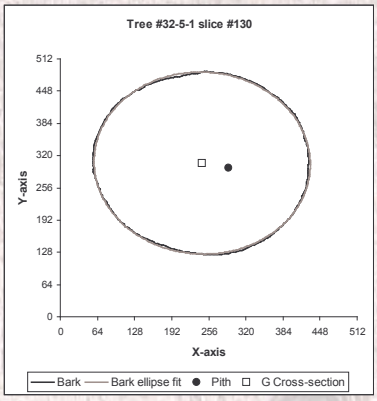
An example of direct application





Eccentricity measurements

Other applications ...

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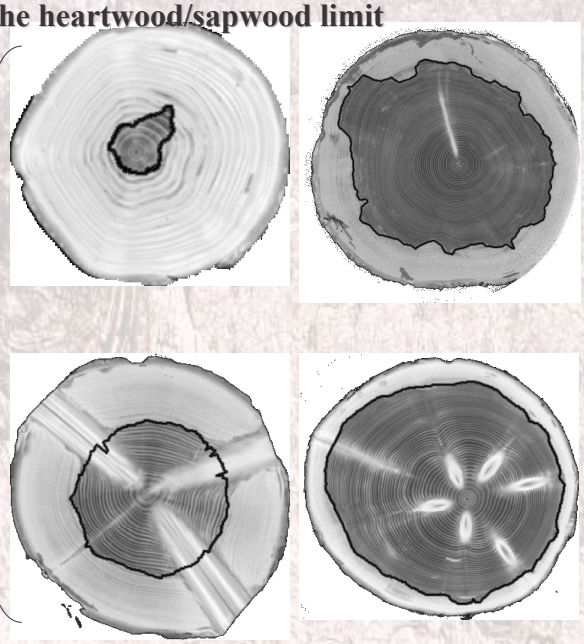
3.2. Detection of the heartwood/sapwood limit

Completely automatic detection inside logs

Few examples on CT slices



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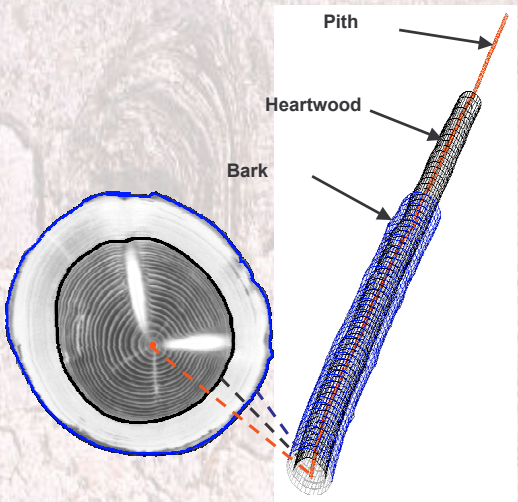

2D and 3D visualisation of pith (red), heartwood (black) and bark (blue)

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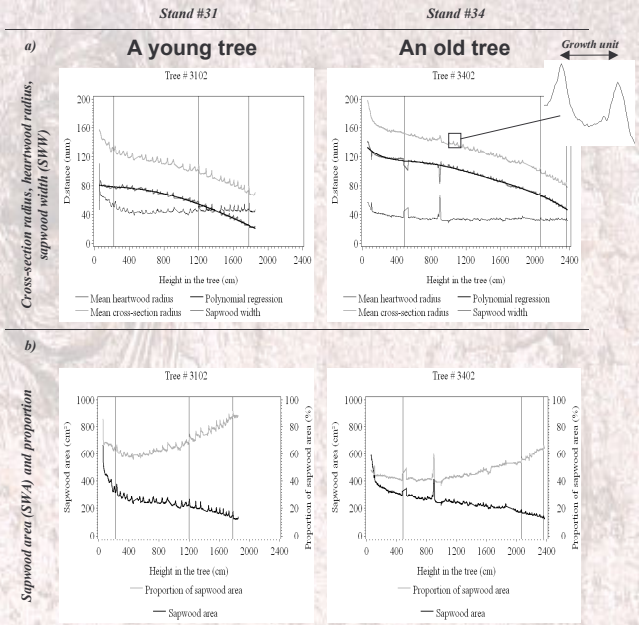
The detection of the heartwood/sapwood boundary makes it possible variability analysis

Within-tree variations



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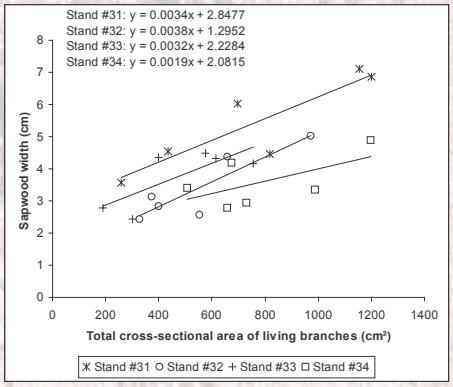
Example of between-tree variations and relationship with the crown size



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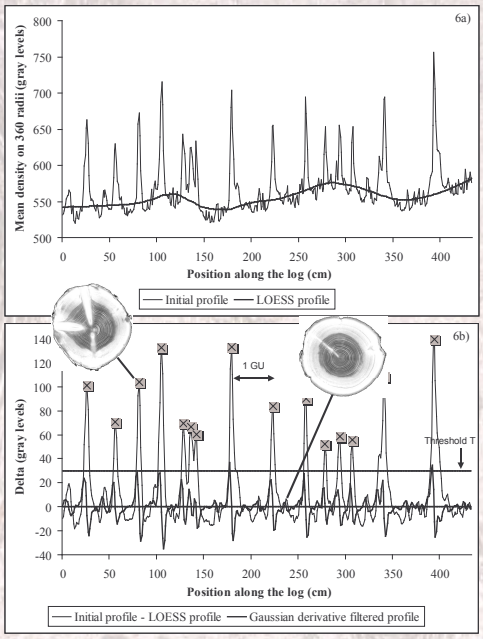
3.3. Knotiness

3.3.1 Whorl location

Possibility to detect the whorls and to measure the length of annual growth units.

The main difficulty was the presence of lamma shoots (more than one annual growth unit in one year) ...



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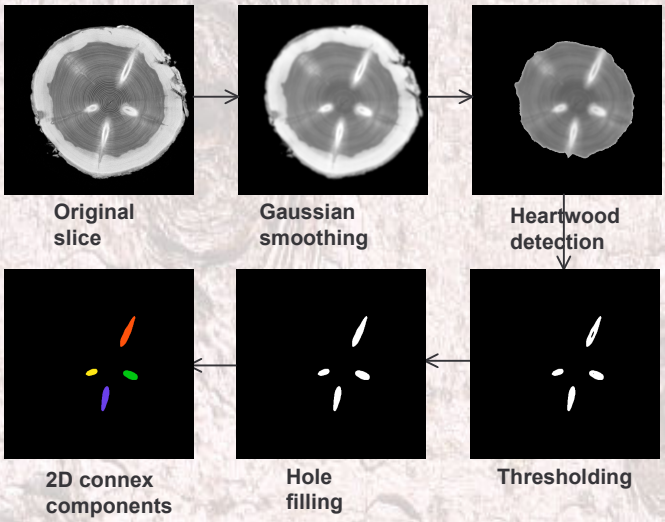
3.3.2 Knot detection (in progress …)

Preliminary results: knot detection in 2D in the heartwood



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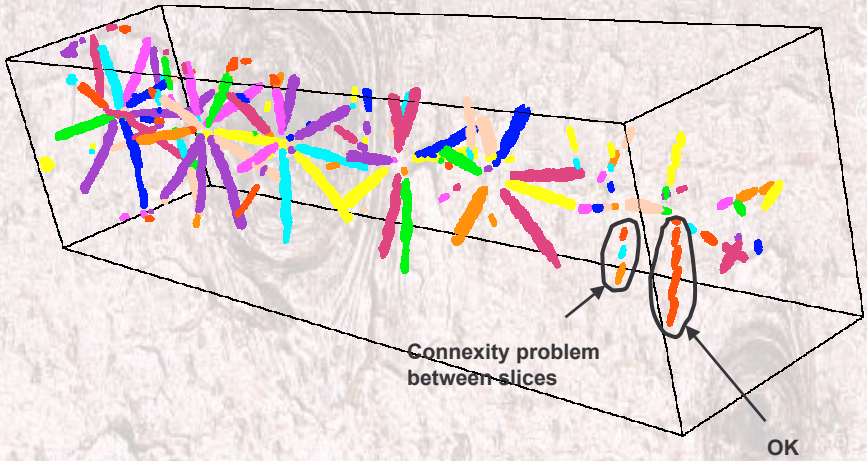
Previous obtained results for the 3D reconstruction of knots using 3D connex components.



Modifications and improvements are in progress ...

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4. Perspectives

Before the end of the Ph.D:

- Finalizing the knot detection in the heartwood:
  3D reconstruction and parameter measurements
  (diameter, azimuth, inclination)

Post-doc:

- Knot detection in sapwood
- Annual ring detection (I already obtained interesting results)
- Compression wood detection

...

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THANK YOU

References:

Longuetaud, F., Mothe, F., Leban, J.-M., Mäkelä, A. 2005. Analysis of *Picea Abies* Sapwood by Means of CT Images: Within-tree variations and Relationships with Tree Measurements. Submitted in Scandinavian Journal of Forest Research.

Longuetaud, F., Mothe, F.& Leban, J.-M. 2005. Automatic Detection of the Heartwood/Sapwood Boundary on Series of CT Images of Norway Spruce (*Picea abies*) Logs. Submitted in Computers and electronics in agriculture.

Longuetaud, F., Saint-André, L., Leban, J.-M. 2005. Automatic detection of annual growth units on *Picea abies* logs using optical and X-ray techniques. Journal of Nondestructive evaluation 24(2), in press.

Longuetaud, F., Leban, J.-M., Mothe, F., Kerrien, E., Berger, M.-O. 2004. Automatic detection of pith on CT images of Spruce logs. Computers and Electronics in Agriculture 44, 107-119.