

Automatic Characterization of the Cell Organization in Light Microscopic Images of Wood

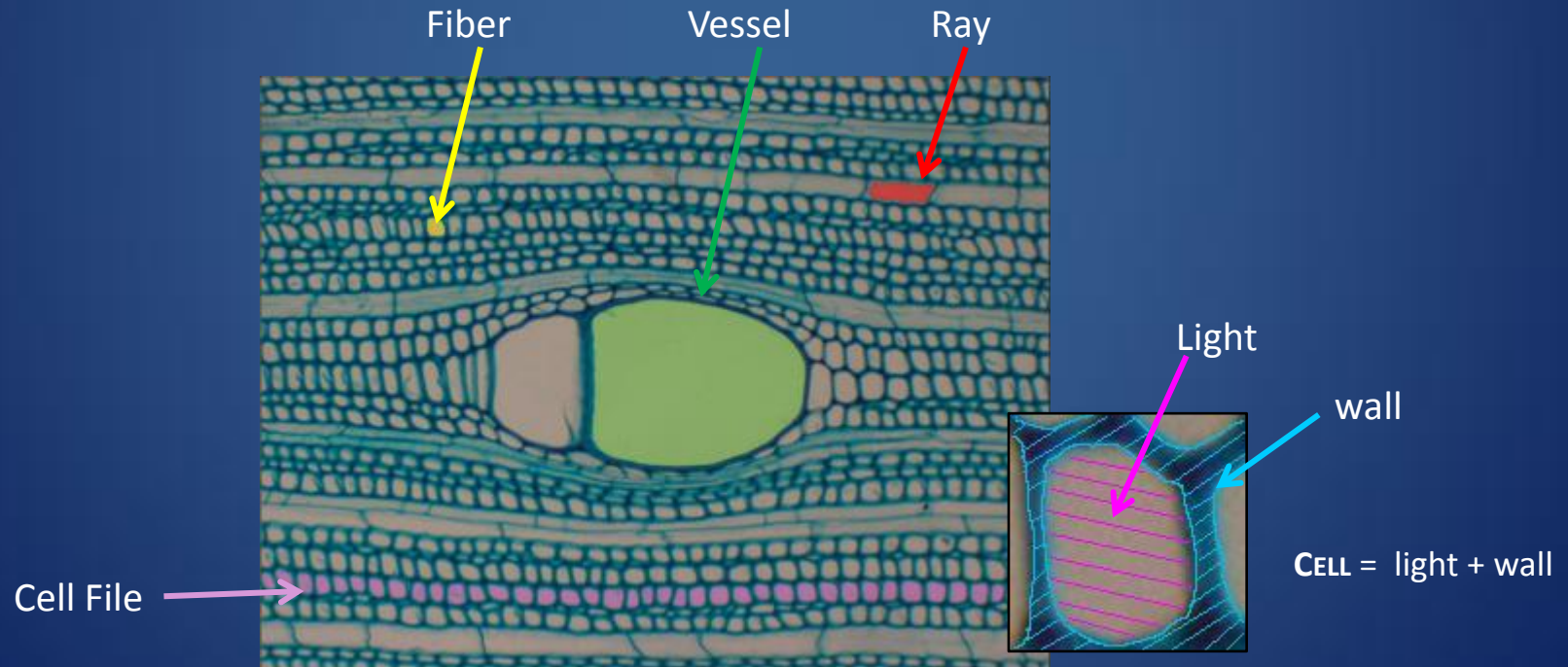
Guilhem Brunel^{1,2}, Philippe Borianne², Gérard Subsol³, Marc Jaeger² & Yves Caraglio²

¹UMII; ²CIRAD – UMR AMAP
Montpellier, France
Guilhem.brunel@cirad.fr

³CNRS – LIRMM
Montpellier, France

Biology

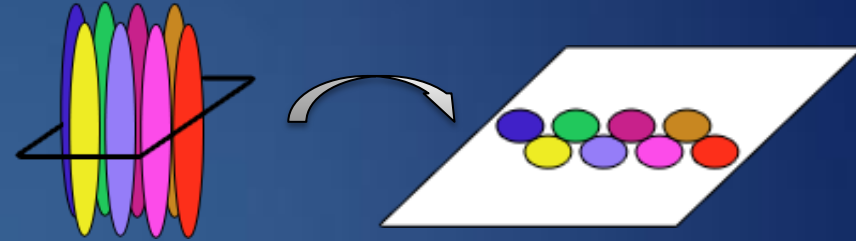
- Environmental modifications on the functioning plasticity or production of plants
- Cell organization studies



Cross Section of Mahogany

Preparation and digitization

- Vibratome¹ ; Sections of 20-25 μ m
- Coloured ; methylene blue, safranine...
- Digitized ; camera and microscope²
- Resolution ; 1600x1400 pixels
- Pixels size :



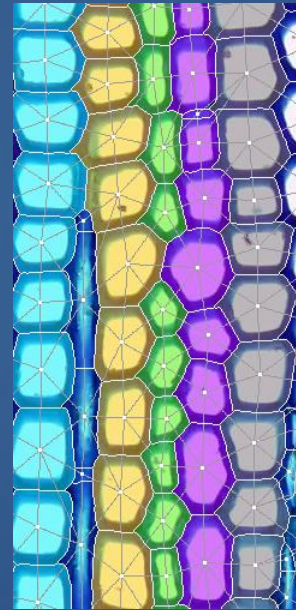
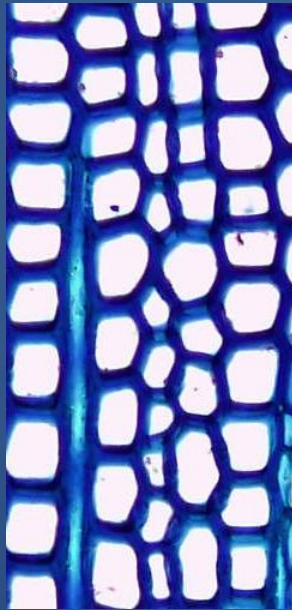
1 ; Vibratome Series 1000 Sectioning System



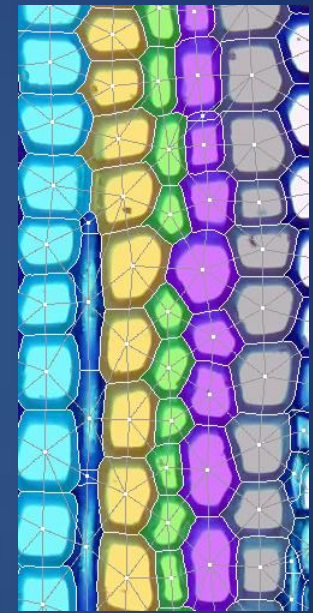
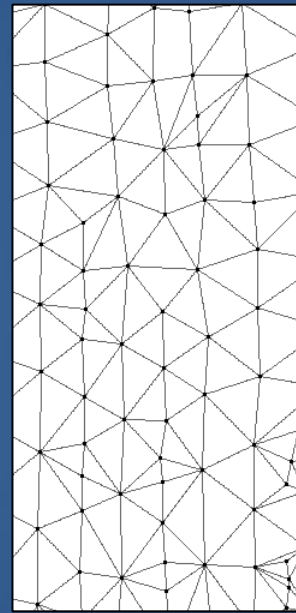
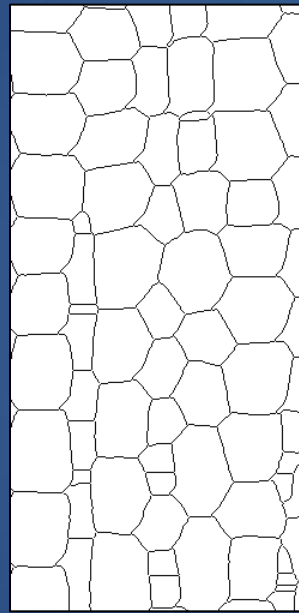
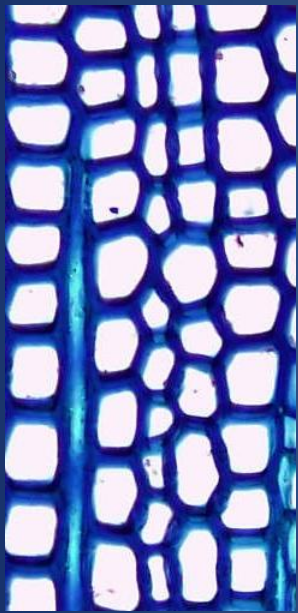
2 ; Olympus DP71 LCD camera mounted on a Olympus BX51 microscope

Method: Concepts

- Stability
- Similarity
- Validity



Method: Overview



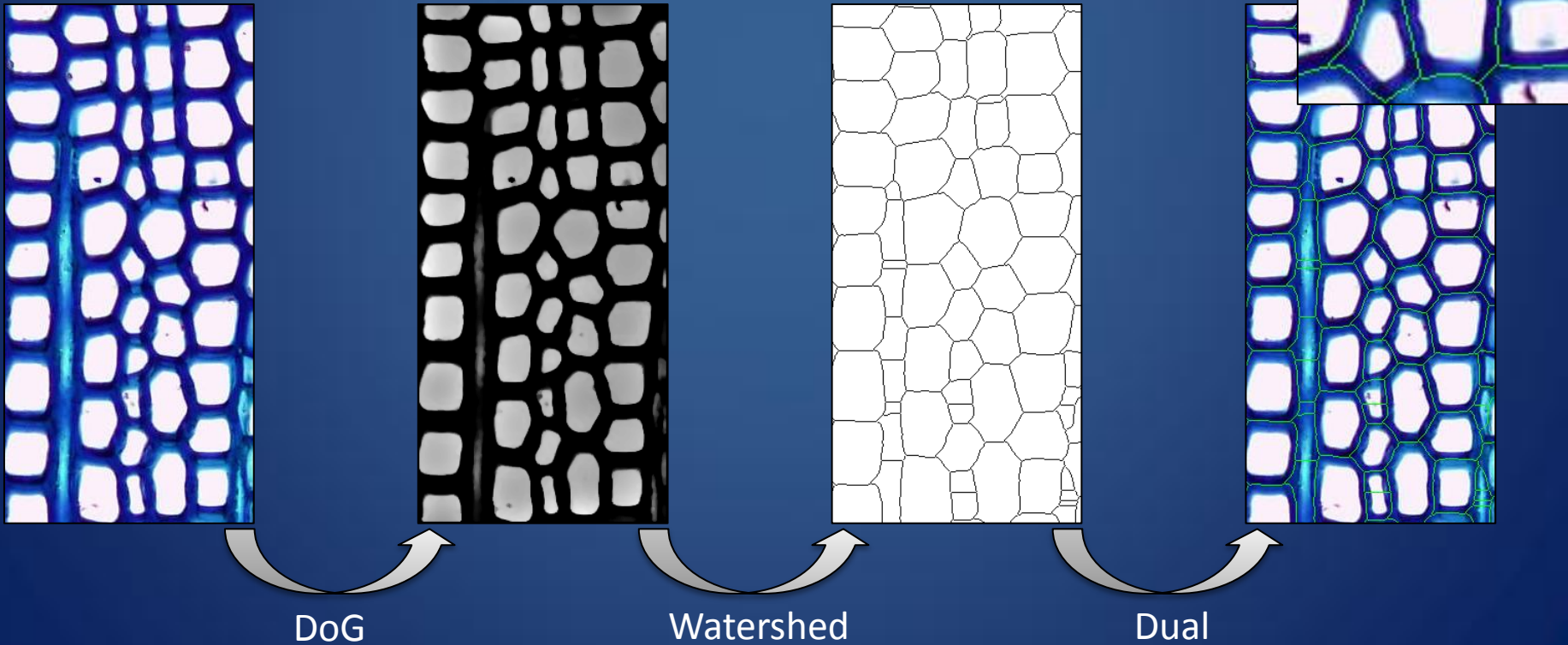
Individualization

Adjacency

Cell file

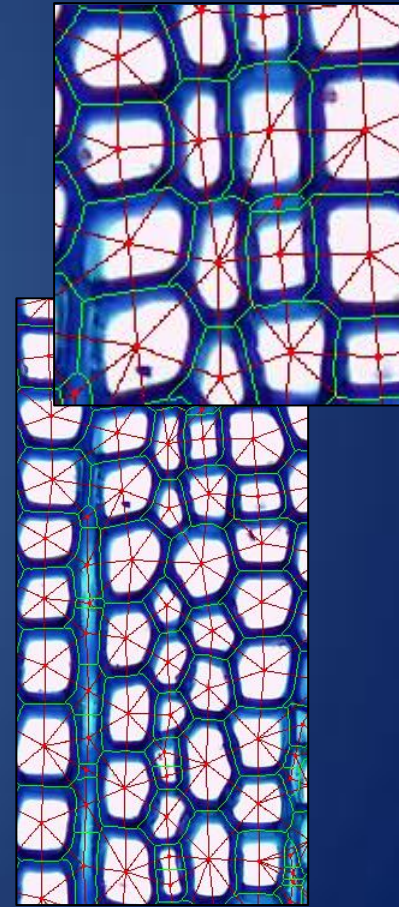
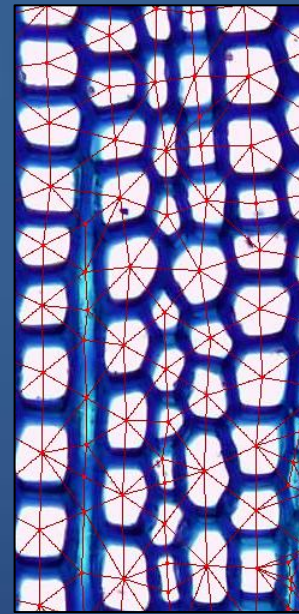
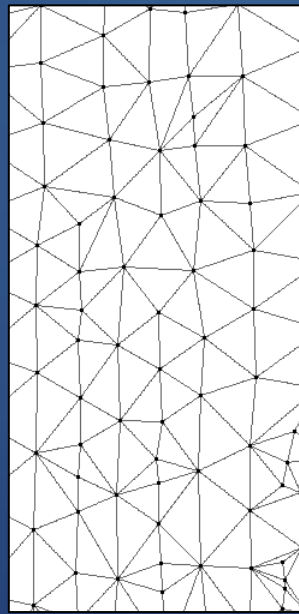
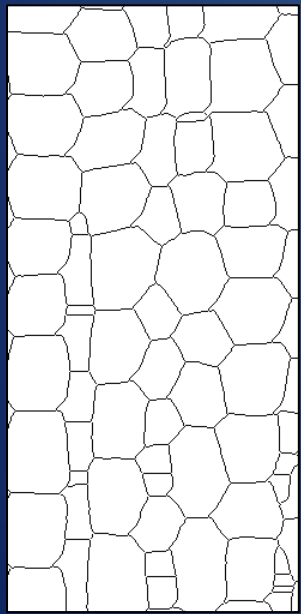
Method : Individualization

- Increase the contrast
- Segmentation
- Geometric modeling



Method : Adjacency

- Topological modeling
- Connections between neighboring cells

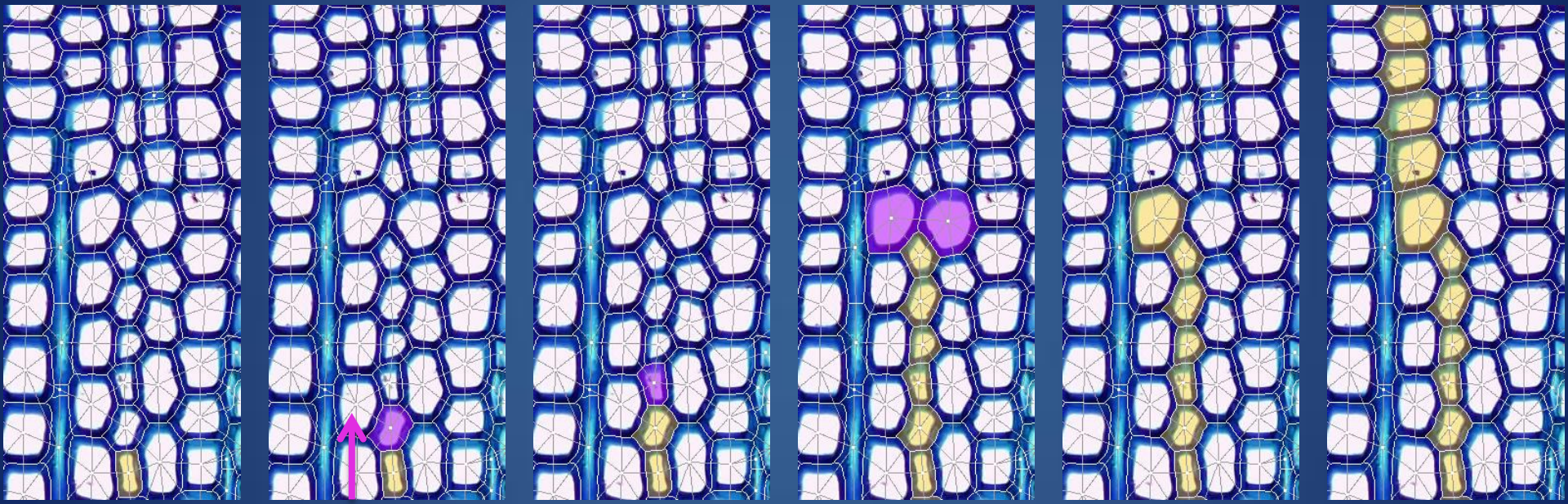


Graph

Dual

Graph & Watershed lines

Method : Alignment Principle



Cell seed

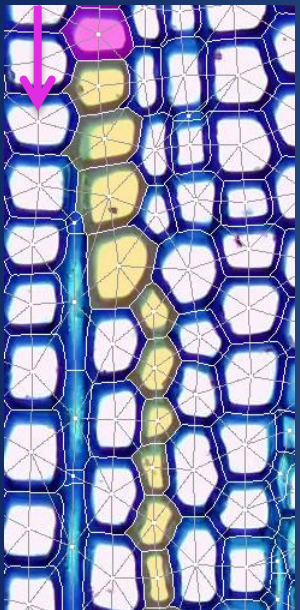
Path in the direction of the cell file

How find the better neighbor?

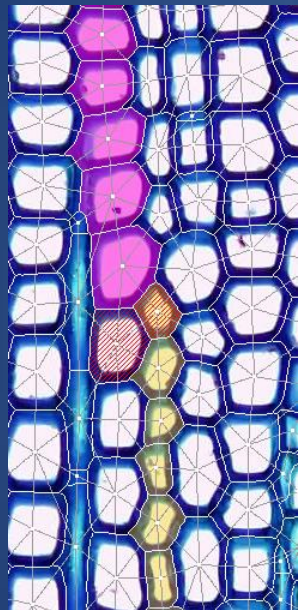
- Angle deviation
- Similarity – Bray Curtis criterion



Method : Feedback check principle



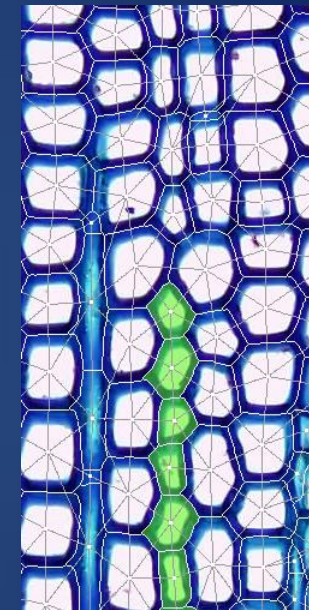
Reserve path



Deleted cells



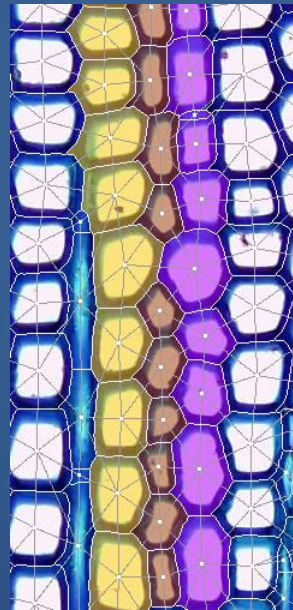
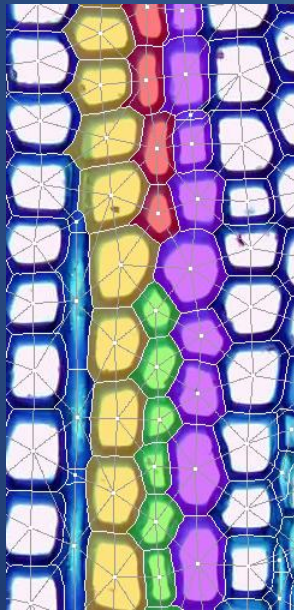
Restart path



Cell line built

Method : Merge

- Concatenate several part of line
- Topological rules



Section : **S1** and **S2**

File : **F3** and **F4**

$[F3;F4] \supset S1$

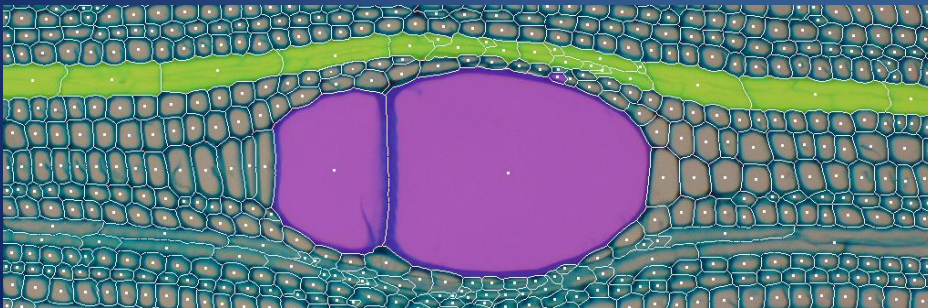
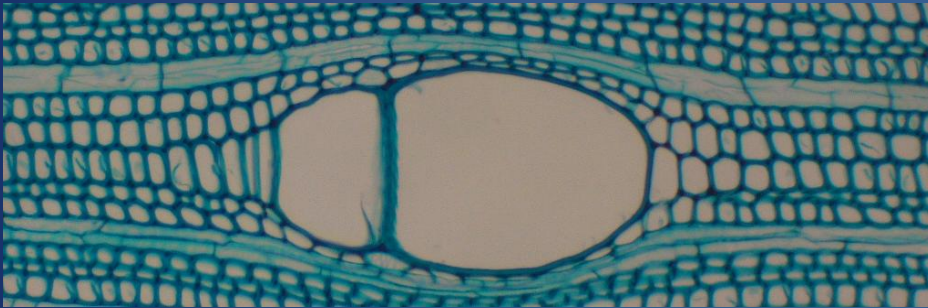
$[F3;F4] \supset S2$

$F1,2 = S1 \cup S2$

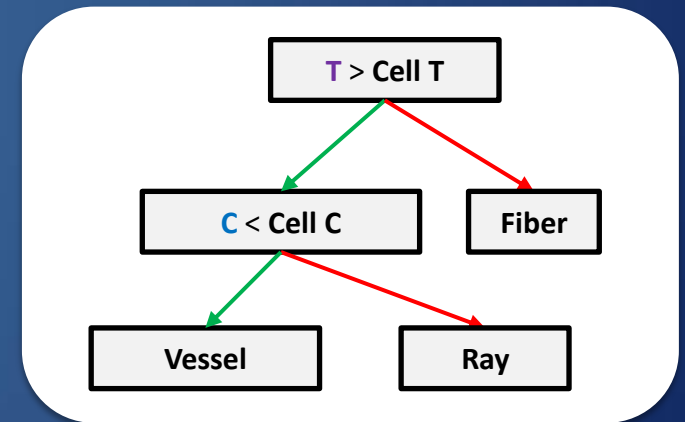
New File : **F1,2**

Method : Classification

- Classify different cells
- Geometric and densitometric characterization



Top, Cross Section of Picnanthus. Down, Classification Vessels et Rays



Decision Tree. T represents the threshold of the perimeter and C the threshold of circularity

Score

$$Score_f = \underbrace{file(length, State \dots)}_{\text{Methods fiability}} + \underbrace{\frac{\sum_k^p Cell(Blur_k, Size_k \dots)}{p}}_{\text{Cells quality}}$$

Methods fiability

Cells quality

$$size_k \begin{cases} \text{If } S_k < \text{threshold}; t = \frac{S_k}{\text{threshold}} \\ \text{Else } t = 1 \end{cases}$$

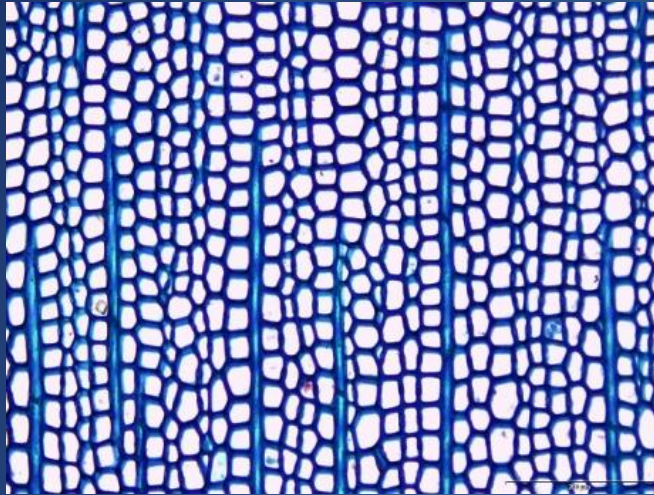
$$state \begin{cases} 1 \text{ if direct} \\ 0.75 \text{ if reconstruct} \\ 0.5 \text{ if isolated} \end{cases}$$

$$length \begin{cases} \text{If } NbCell < \text{threshold}; l = \frac{NbCell}{\text{threshold}} \\ \text{Else } l = 1 \end{cases}$$

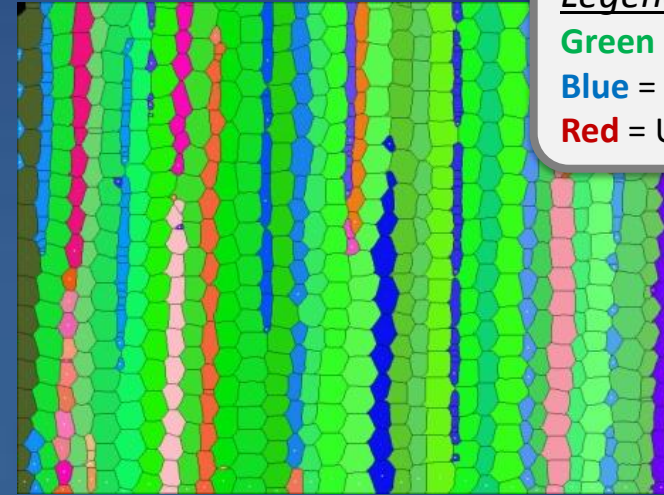
$$blur_k = 1 - \frac{\sigma_k - \sigma_{min}}{\sigma_{max}}$$



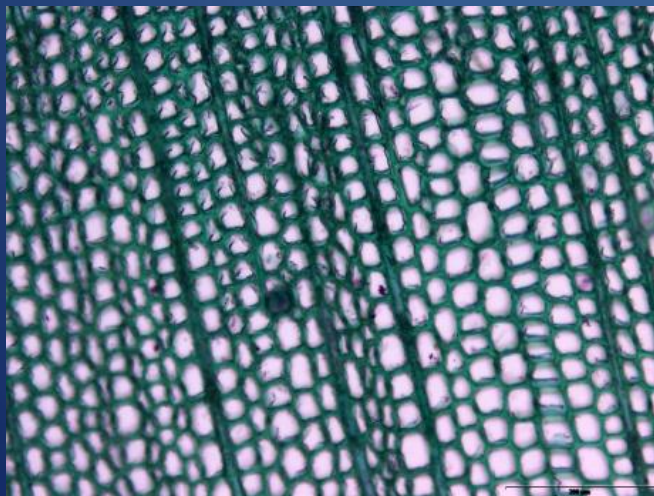
Experimental results: simple examples



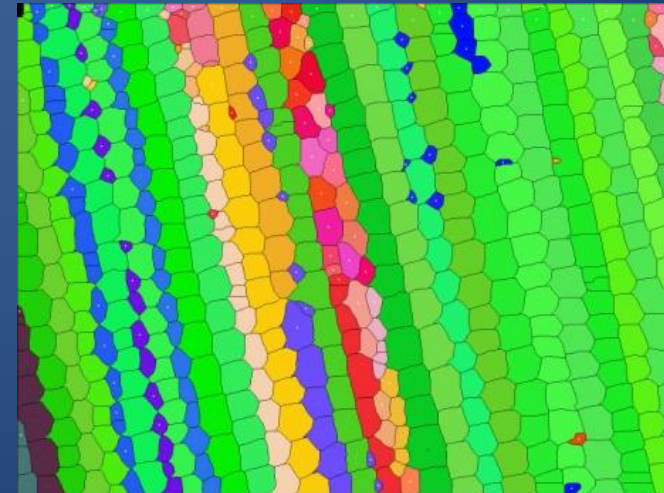
Automatic identification of cell lines from a cross section of Abies alba



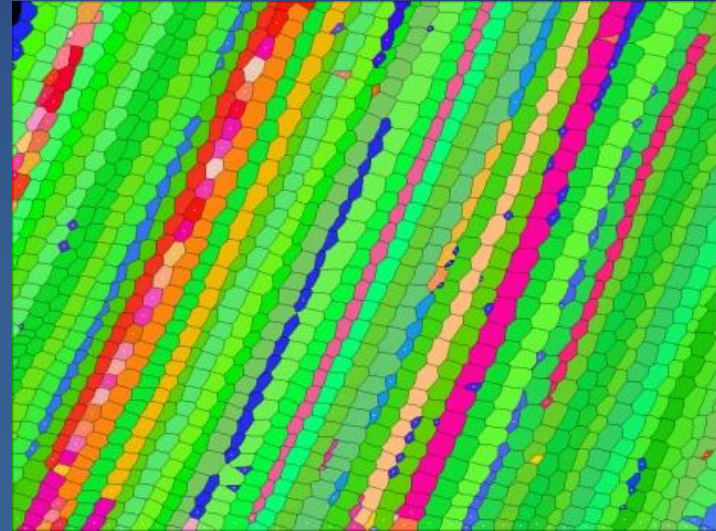
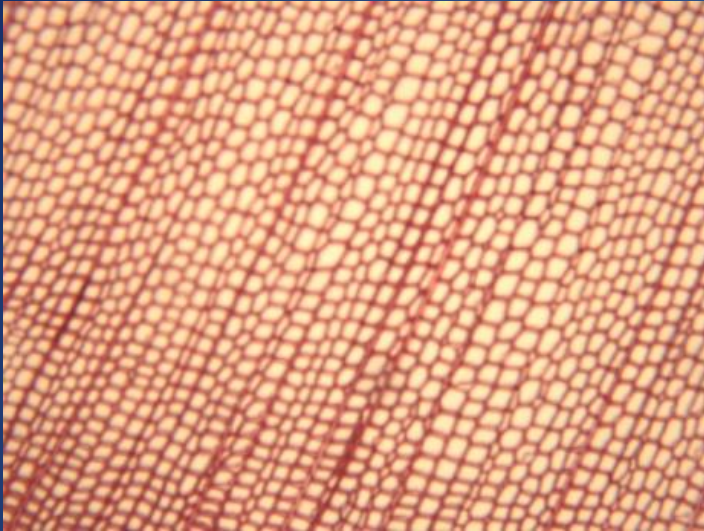
Legend :
Green = Good
Blue = Merged
Red = Undefined



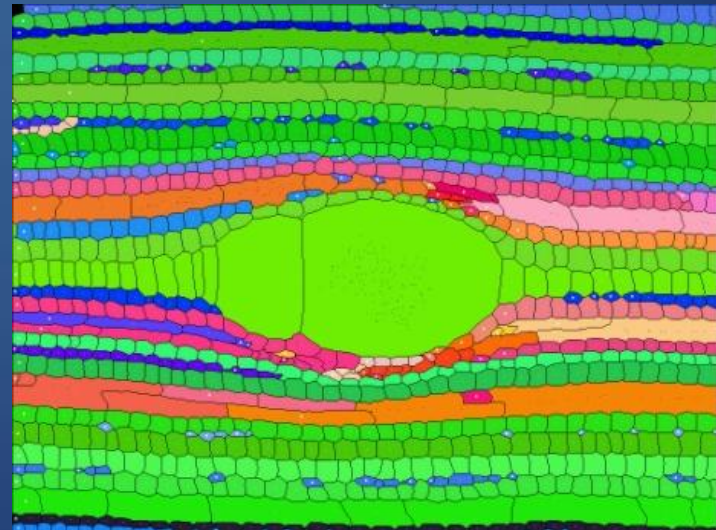
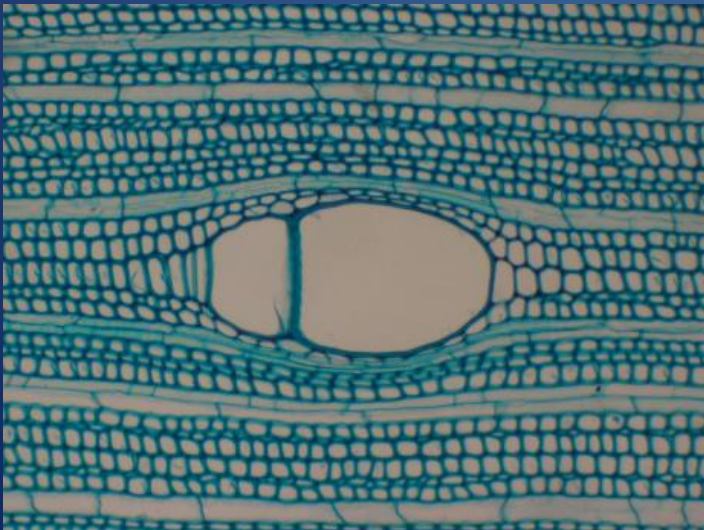
Automatic identification of cell lines from a cross section of Pinus Caribensis



Experimental results: more difficult



Automatic identification of cell lines from a cross section of Pinus Negria



Automatic identification of cell lines from a cross section of Picnanthus

Result

- Summary of some significant results

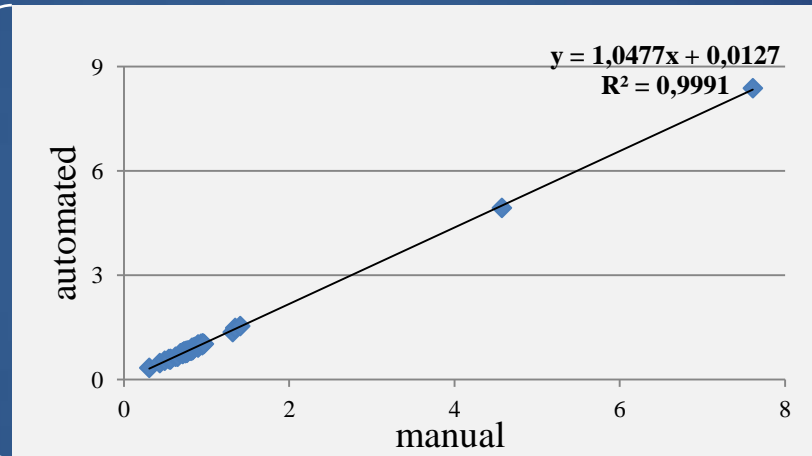
Species	Size (pixels)	Cells numbers	Times (sec)	Total Quality (%)
Mahogany	1024x768	1359	14.3	83
Fir	1360x1024	800	12.4	92
Black Pine 1	1600x1200	1873	23.2	73
Caribbean Pine	1360x1024	828	11.5	91
Black Pine 2	1600x1200	1458	16.1	93

Summary of some significant results: the size of images processed, the number of cells extracted, the CPU time obtained on a machine with an Intel Xeon at 2.3GHz

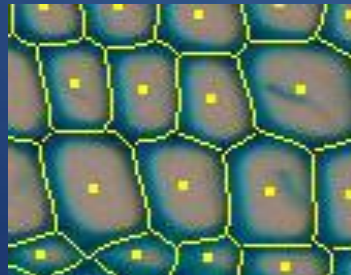
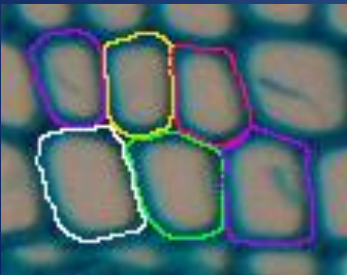
Experimental results: accuracy

- Strongly correlated areas
- Weak over-valuation of the automated method
- Medium error of 5%

*normalized
automated areas*



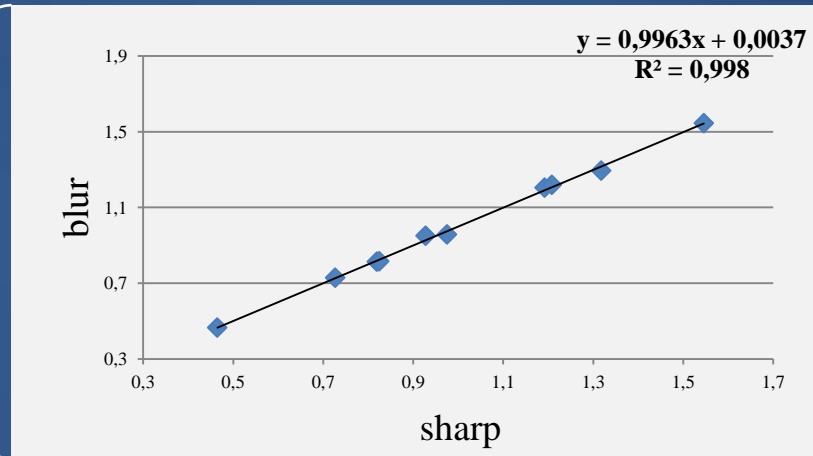
normalized expert areas



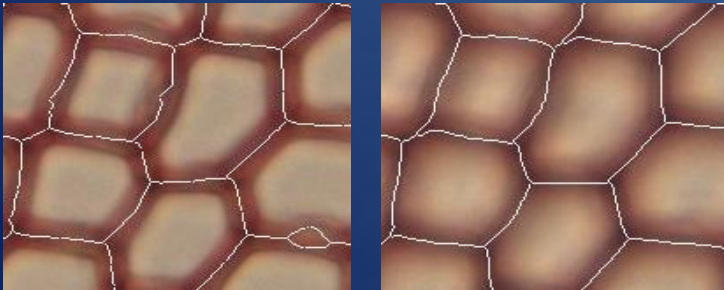
Experimental results: sharpness studies

- Strongly correlated areas
- Weak under-valuation of the automated method
- Medium error of 2.8%

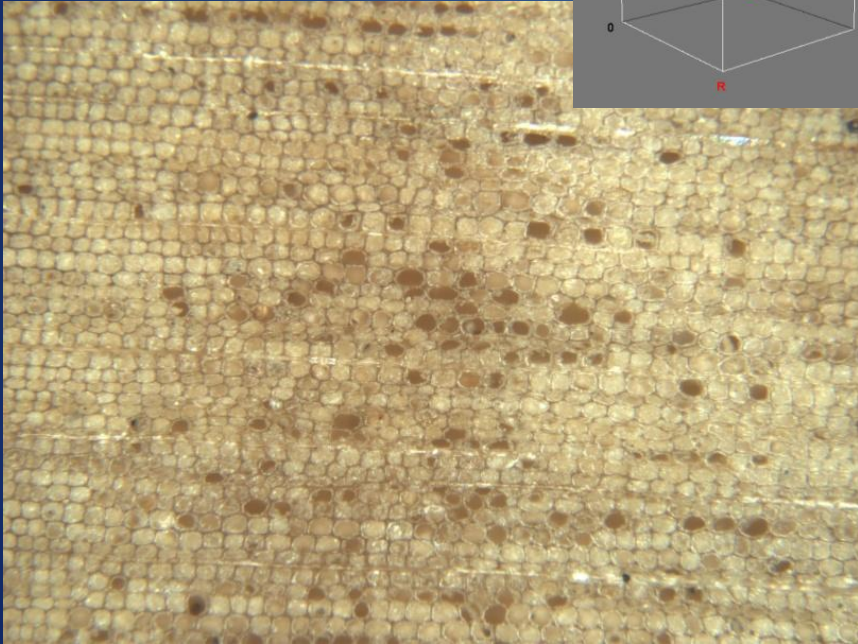
*numerical detection on
image blurred*



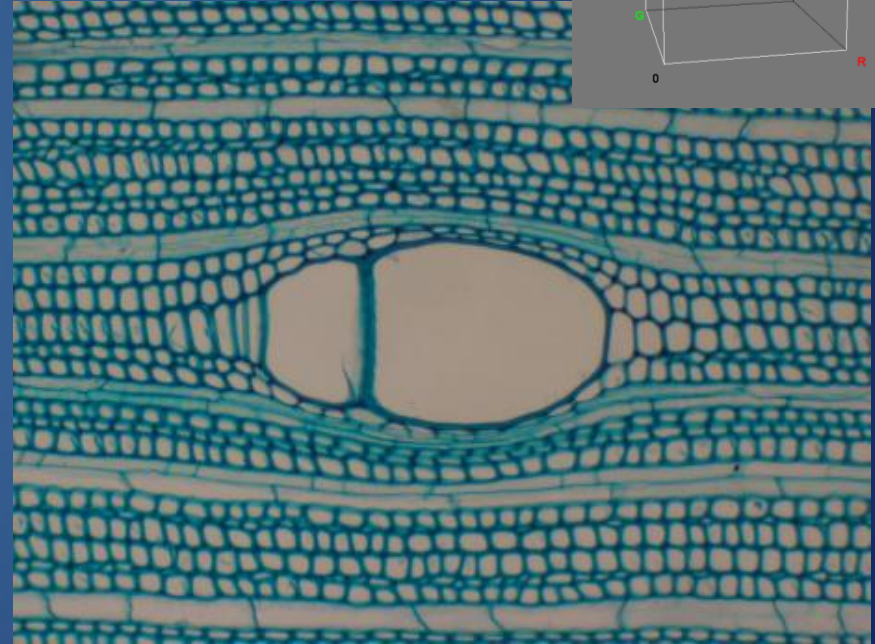
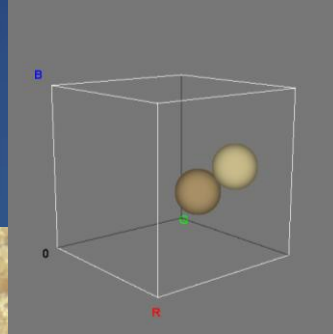
numerical detection on image sharp



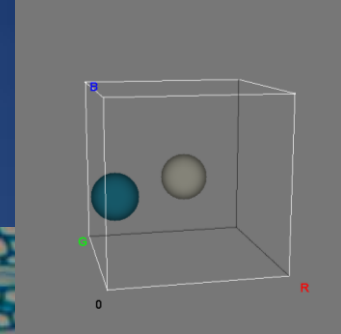
Limits: segmentation



Cross section of Pinus Negria sanded



Cross section of Picnanthus colored with toluidine blue



Conclusion

- Fully-automated method to characterize the cell organization
- Self conditioned algorithm
- Morphological and Topological analysis

Thanks for your attention