Automatic Characterization of the Cell Organization in a Set of Microscopic Images of Wood

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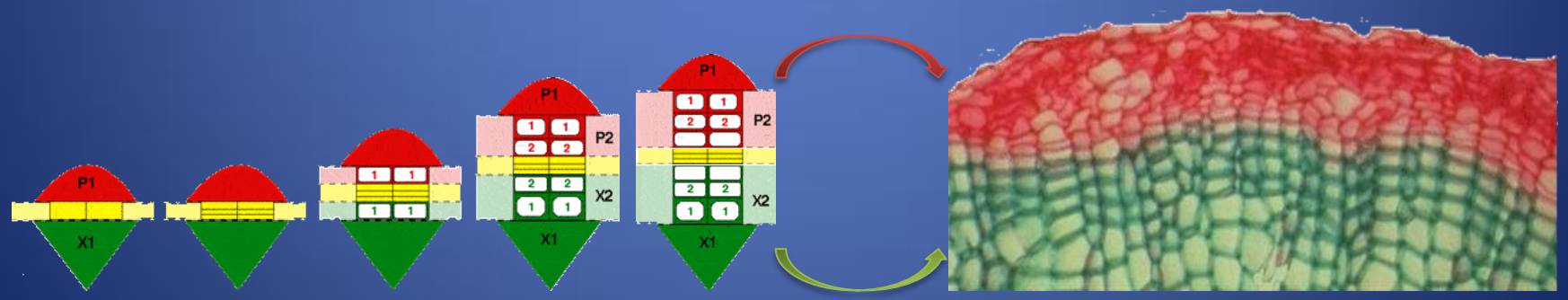
MOTIVATION

- Analyser, comprendre et prédire es mécanismes de croissance du bois :
  - *Développement, Plasticité, Production || **Génétiques**, Environnementaux*

- Nécessite de travailler sur des grandes zones d'étude pour capter la variabilité (invariants, rythmicité des patterns..)
  - Traitement de masse



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Enjeux de la thèse

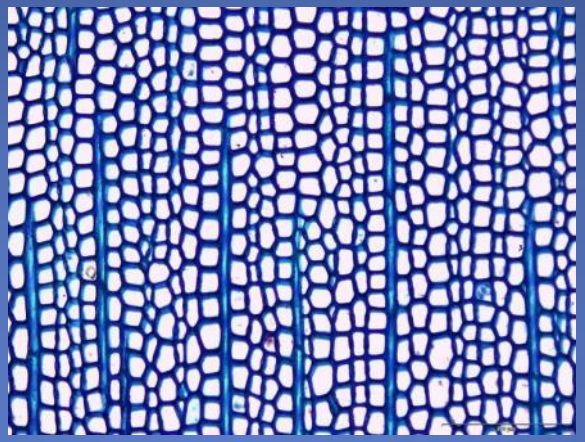
- Individualisation des éléments structurants
  - Traitement d'image
- Caractérisation de la topologie
  - Modélisation géométrique et topologique
- Détection d'organisations géométriques
  - Théorie des graphes

- *Fiabilité des paramètres calculés*
- *Fusion des données*

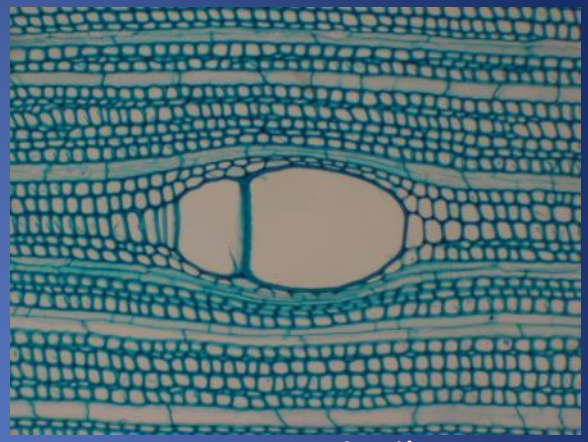
Préparation et Acquisition

Microscope équipé d'une **platine**
→ Coordonnées connues

Coupe histologique ≈ 20-25µm d'épaisseur

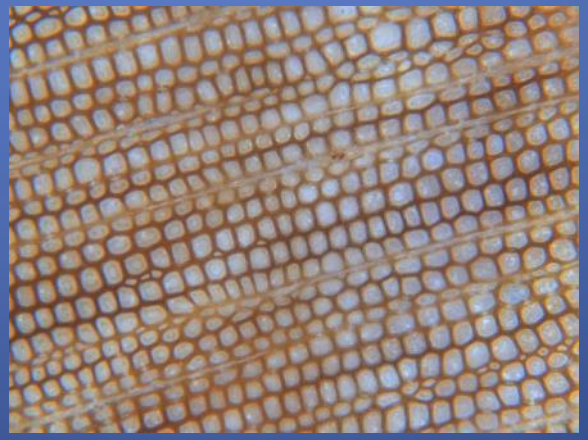


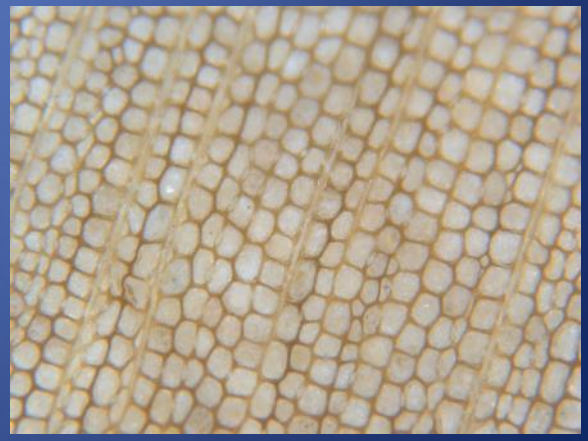
Coupe transversale de Sapin



Coupe transversale d'Acajou

Section de bois poncé ≈ 2cm d'épaisseur





Coupe transversale de Pin

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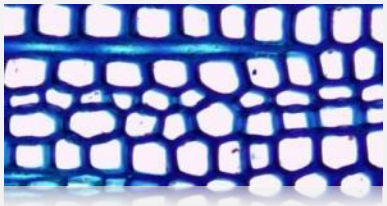
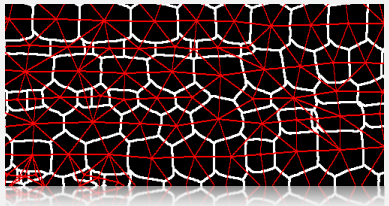
Mise en œuvre

Détection des Cellules

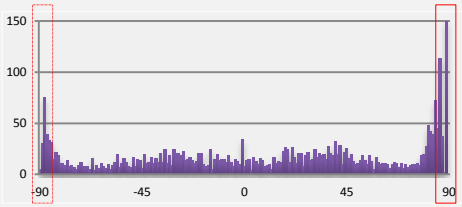
- Prétraitement
- Partitionnement - Watershed
- Modélisation topologique - Graphe

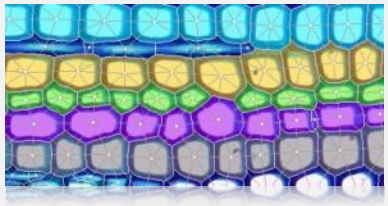




Organisation Cellulaire

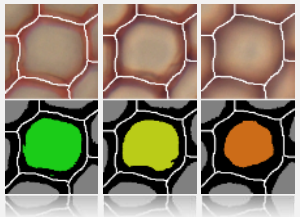
- Détection de l'orientation
- Création des files cellulaires





Classification

- Fiabilité de données
- Fusion des données
- Typage cellulaire



	A	B	C	D	E	F	G	H	I
1	file	length_ratio	cell_ratio	cell	xcenter	ycenter	lumen_aera	ratio_wall	circular
2	59	100	80	918	838	1015	173	279	0,699
3	59	100	80	875	840	978	1080	989	0,768
4	59	100	80	835	843	926	807	824	0,769
5	59	100	80	782	840	870	1134	1125	0,684
6	59	100	80	722	839	804	1230	1110	0,746
7	59	100	80	648	841	732	1369	1230	0,721
8	59	100	80	579	845	656	1037	1126	0,723
9	59	100	80	526	845	595	466	838	0,762
10	59	100	80	479	842	547	455	893	0,639
11	59	100	80	409	840	485	1035	1281	0,752

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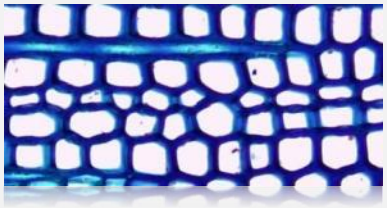
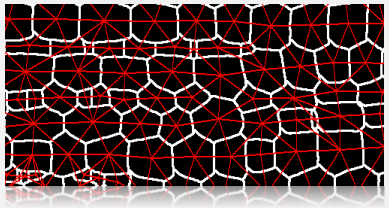
Mise en œuvre

Détection des Cellule

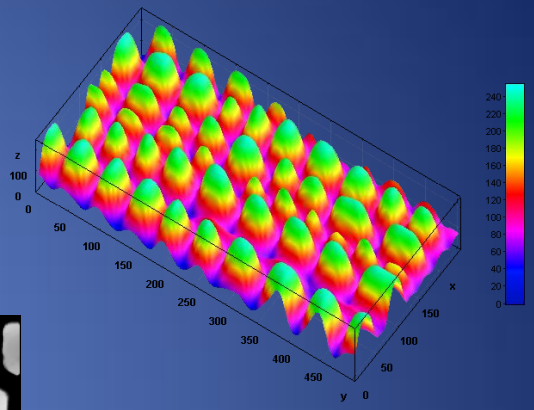
- Prétraitement
- Partitionnement - Watershed
- Modélisation topologique - Graph

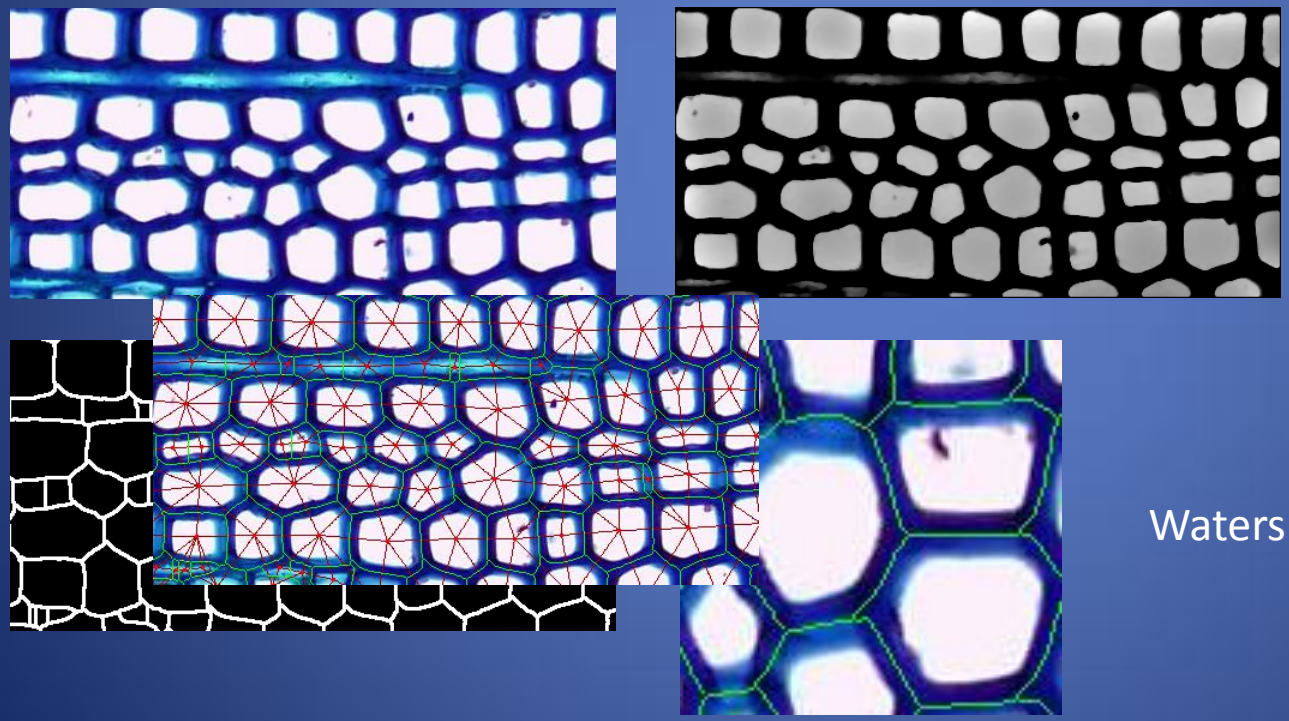




INDIVIDUALISATION DES STRUCTURES

- Augmenter le contraste – **Différence de Gaussiennes**
- Segmentation – Algorithme du **Watershed**
- Modélisation géométrique





Watershed = Sur-segmentation

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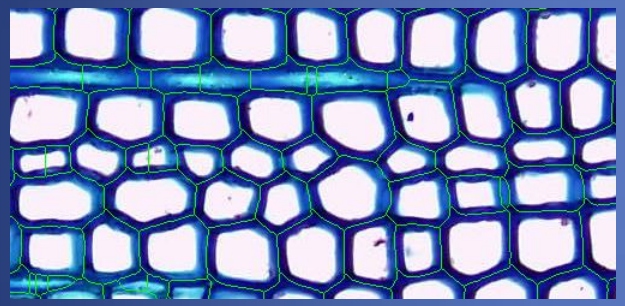
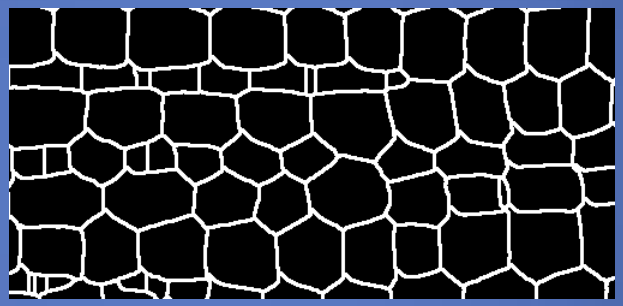
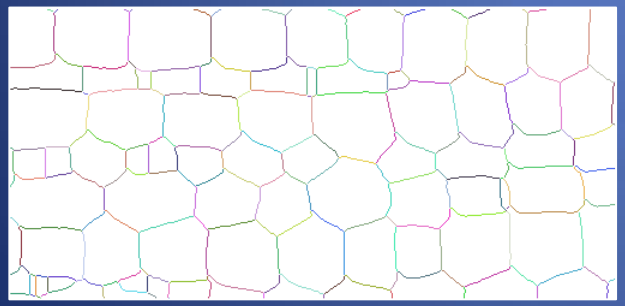
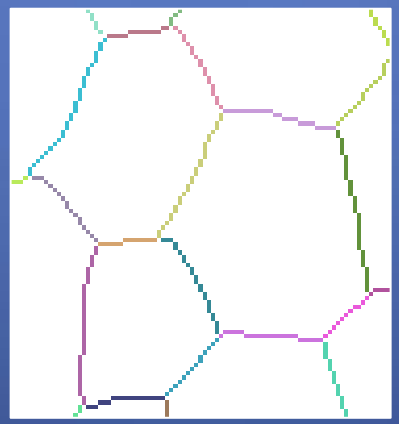
Contrôle de la sur-segmentation

- Etude des lignes du Watershed
  - Nombre bassin adjacent ≤ 2 : Pixel Arête
  - Nombre basin adjacent > 2 : Pixel de sommet









D'autres méthodes?

- Waterfall
- P-algorithm

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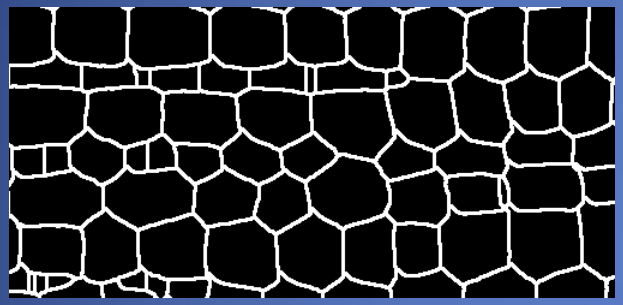
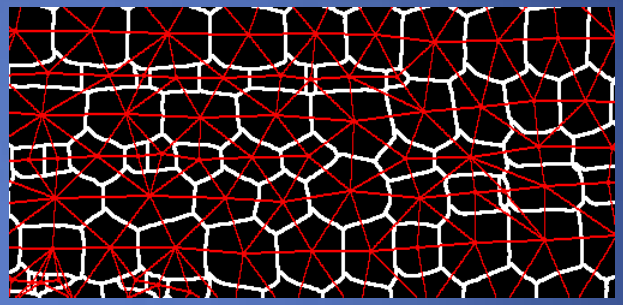
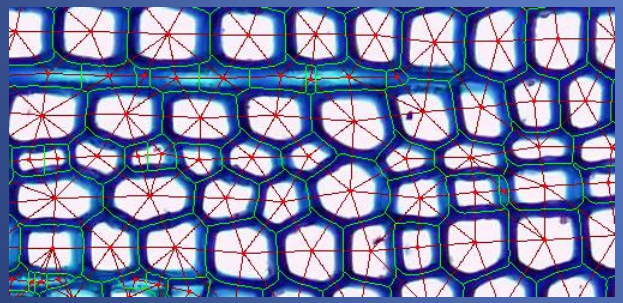
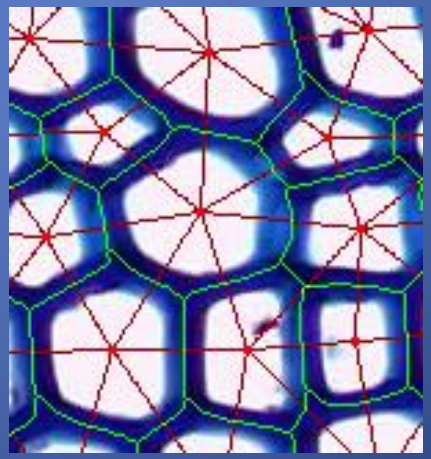
Modélisation Topologique

- Modélisation topologique





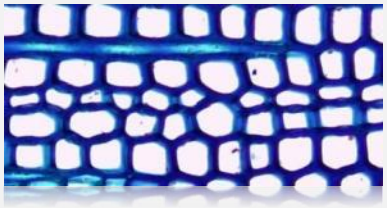


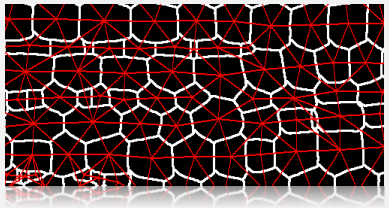


Mise en œuvre

Détection des Cellule

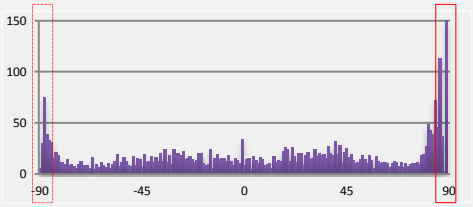
- Prétraitement
- Partitionnement - Watershed
- Modélisation topologique - Graph

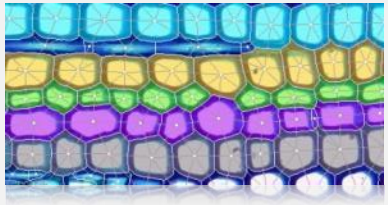




Organisation Cellulaire

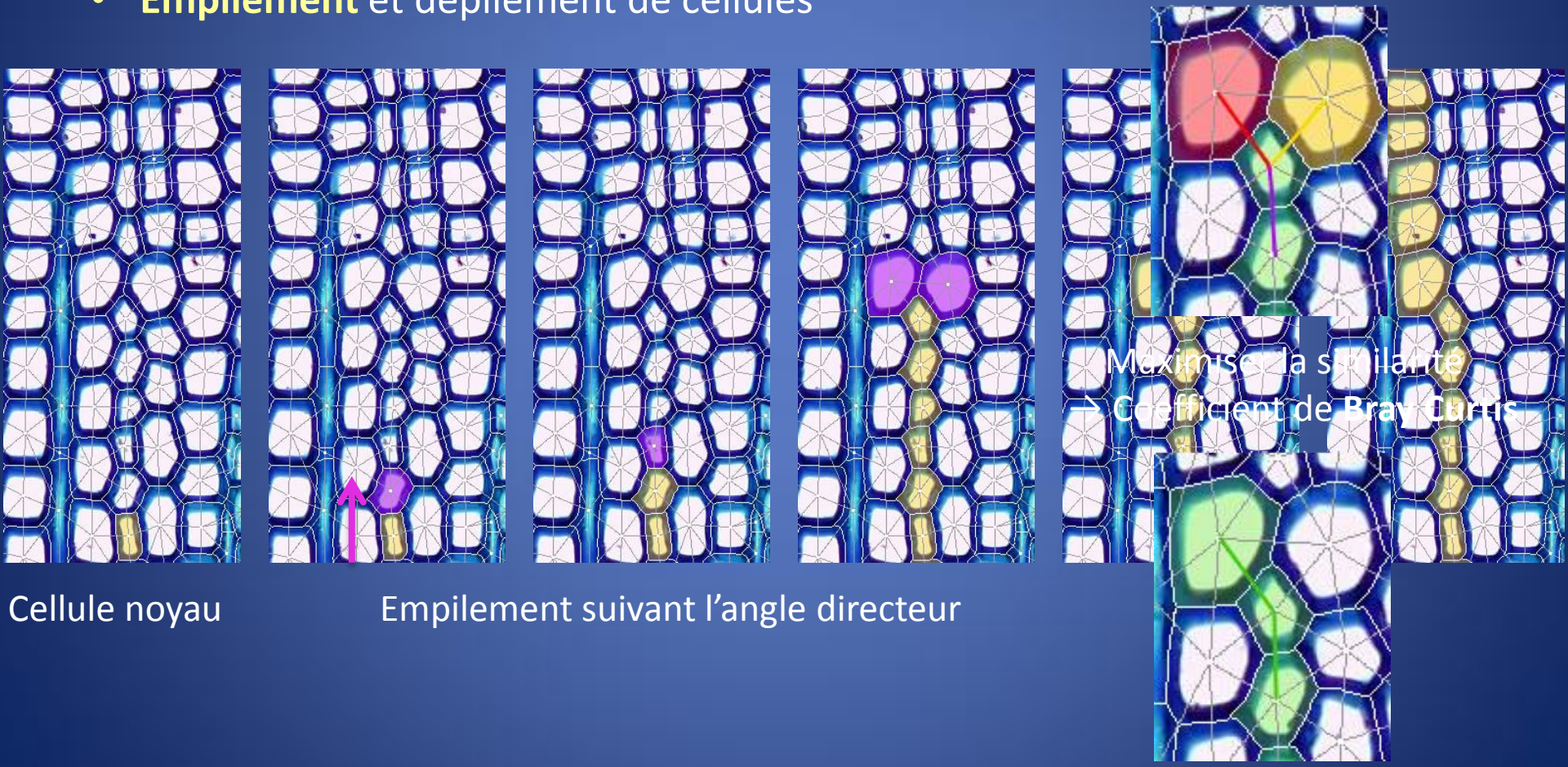
- Détection de l'orientation
- Création des files cellulaires





Détection des alignements

- Détection automatique de l'orientation des files
- Parcours du graphe sous **contrainte géométrique** et **topologique**
  - **Empilement** et dépilement de cellules



Cellule noyau

Empilement suivant l'angle directeur

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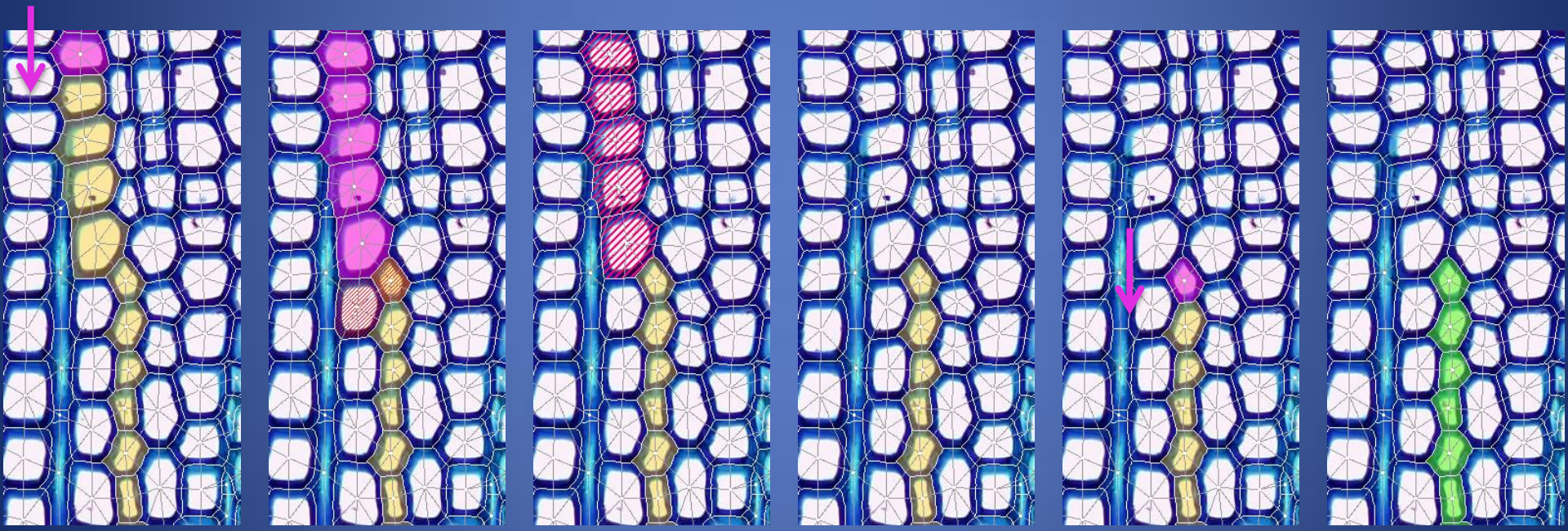
Détection des alignements

- Parcours du graphe sous **contrainte géométrique** et **topologique**
  - Empilement et **dépilement** de cellules
- **Réversible**



Parcours inverse

Suppression des cellules

File cellulaire

La **réversibilité** assure une bonne détection des files (tronçons) cellulaires

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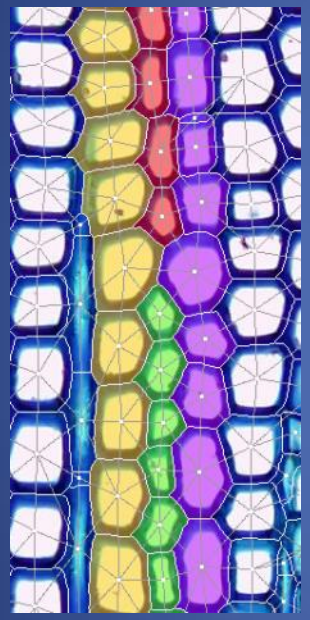
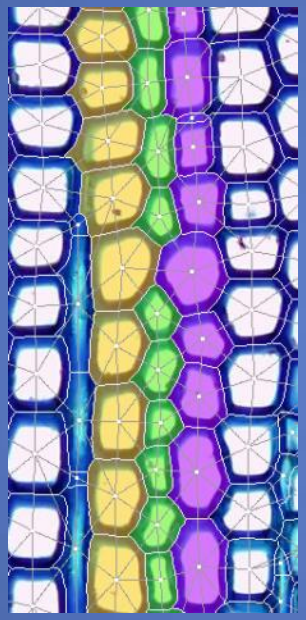
DÉTECTION DES ALIGNEMENTS

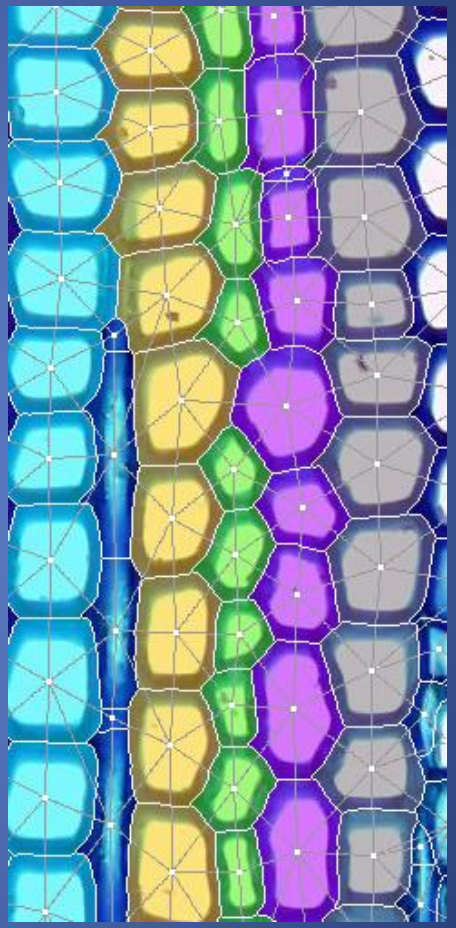
Que faire des tronçons de files ?





FUSION DES TRONÇONS

- *Caractérisation de la topologie des files*
- *Règles de fusion (simple)*



Toutes les files cellulaires sont identifiées

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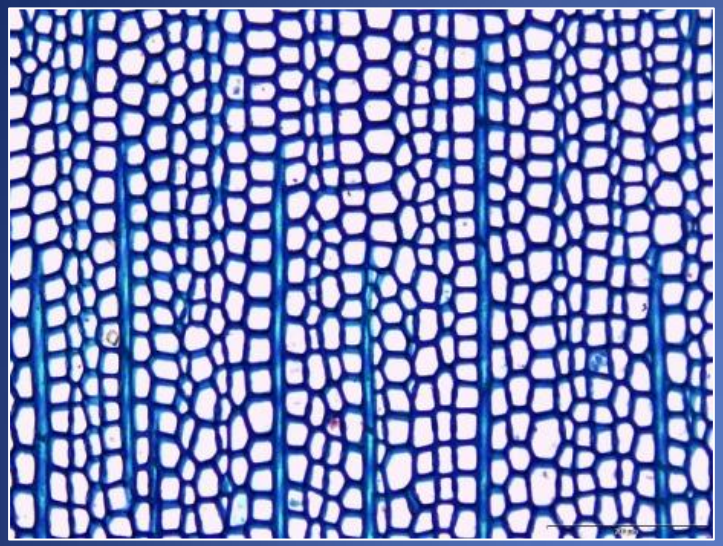
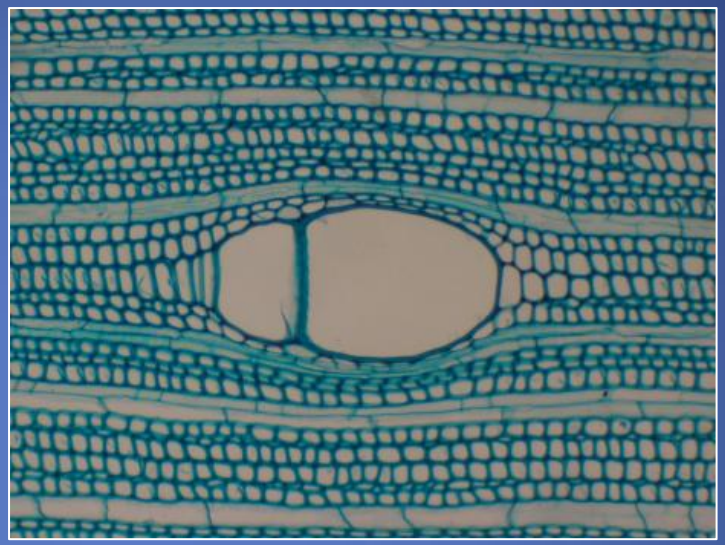
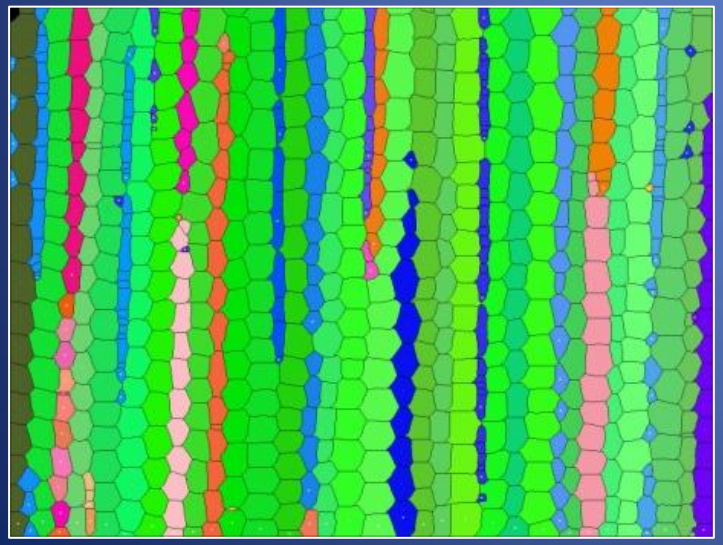
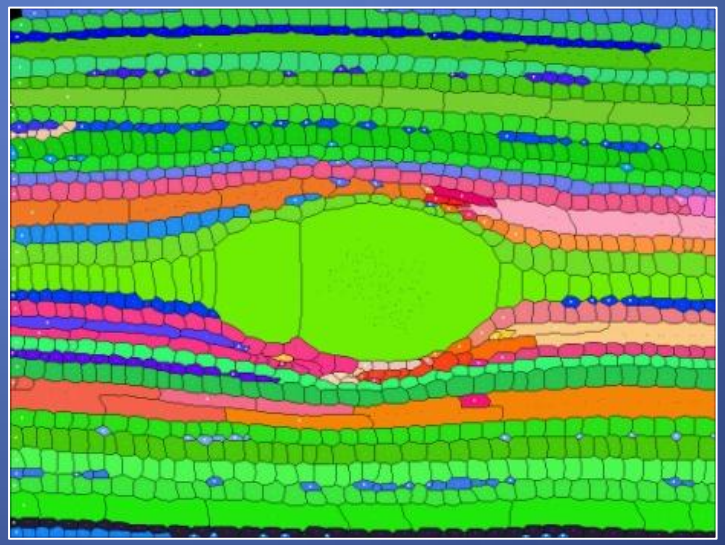
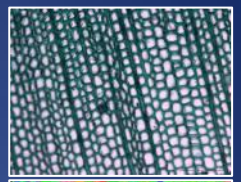
RÉSULTATS

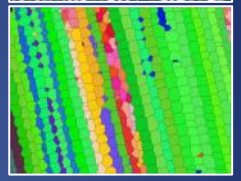


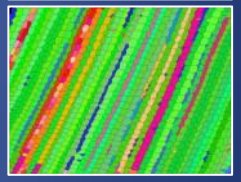


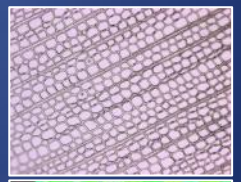


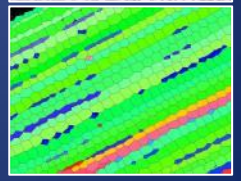












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Comparaison Expert / Méthode automatique

Table 1. 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 and a Total Quality Index defined as the ratio of the number of lines automatically identified and reconstructed on the total number of lines.

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
Caribean Pine	1360x1024	828	11.5	91
Black Pine 2	1600x1200	1458	16.1	93

- 80% de files bien identifiées
- 20sec de traitement par image vs 1 à 3h manuellement

- Très bonne corrélation entre le détourage expert/méthode
- Légère surestimation
- **Méthode reproductible**

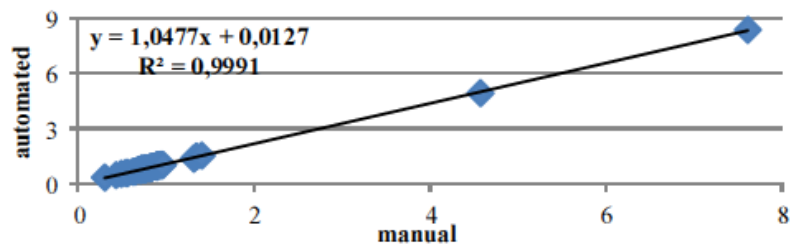

Figure 13. Basins surfaces study on Mahogany. In abcissa, the normalized aeras got from the fully manual method. In ordinate, those got from the automated method. The coefficient of determination is close to 1, showing a very well adjustment of areas.

Brunel G, Borianne P, Subsol G, Jaeger M, Caraglio Y. 2012. Automatic characterization of the cell organization in light microscopic images of wood: application to the identification of the cell files, Plant Growth Modeling, Simulation, Visualization and Applications, IEEE press, ISBN 978-1-4673-0070-4, pp. 58-65

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STABILITÉ AU FLOU

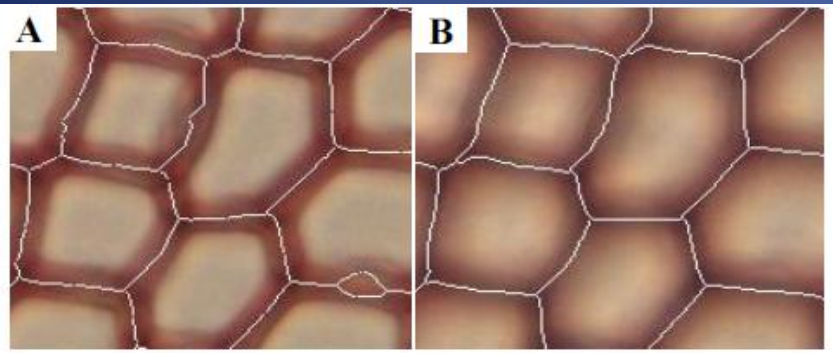
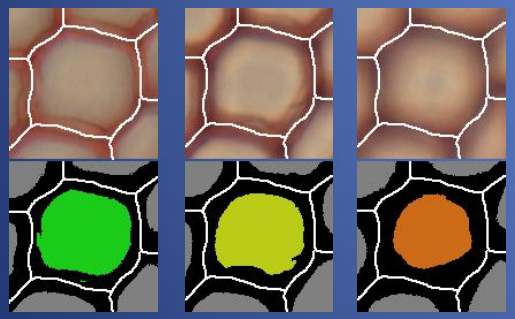


Figure 15. Compared watershed result on Pine cross section. A : crests lines of a sharp image. B : crests lines of a blurred image. Outline of the basins is nearly identical between a sharp and a blur image. On the sharp image, a small additional basin of a detachment of the wall issued from cutting. This basin is skipped during the supernumerary removal phase.

L'algorithme du Watershed est insensible au flou

Nb: sur les images issues de blocs poncés: présence de (fort) flou périphérique



Surface du lumen dépende du flou

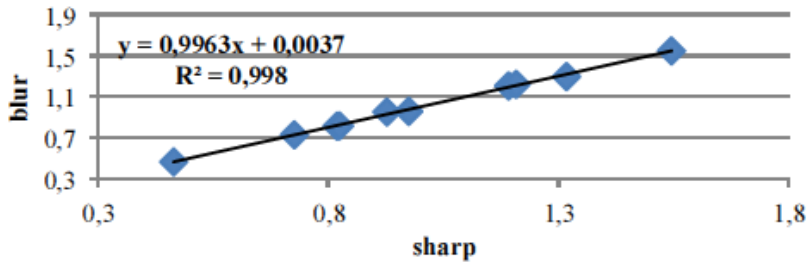


Figure 16. Basins surfaces study on Mahogany. In abcissa, the normalized aeras got from sharp images. In ordinate, those got from blur images. The coefficient of determination is close to 1, showing a very well adjustment of areas.

Brunel G, Borianne P, Subsol G, Jaeger M, Caraglio Y. 2012. Automatic characterization of the cell organization in light microscopic images of wood: application to the identification of the cell files, Plant Growth Modeling, Simulation, Visualization and Applications, IEEE press, ISBN 978-1-4673-0070-4, pp. 58-65

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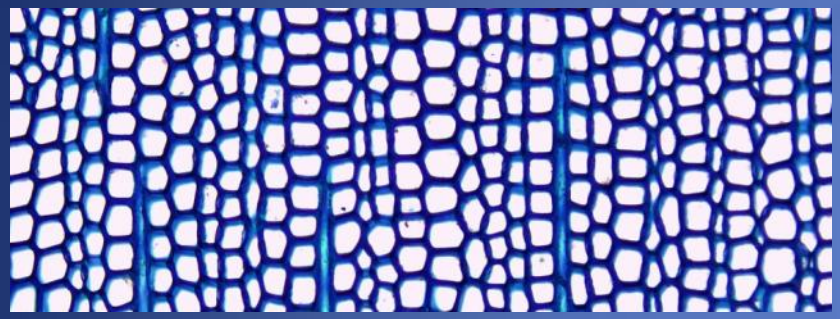
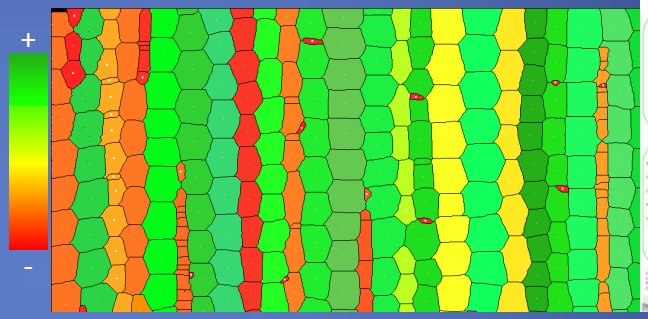
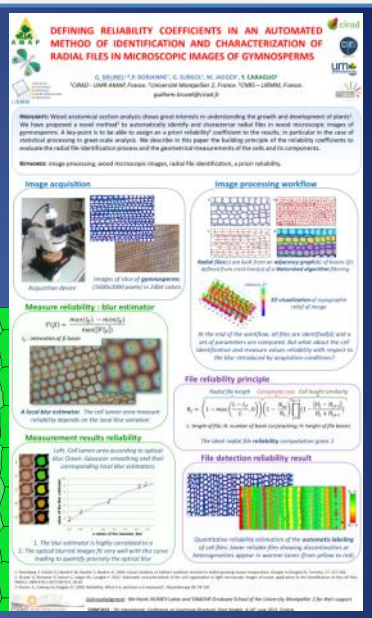
Travaux en cours

- ## Fiabilité des paramètres calculés

Brunel G, Borianne P, Subsol G, Jaeger M, Caraglio Yves. 2013. Defining reliability coefficients in an automated radial files identification and characterization method in microscopic images of gymnosperms. *FSPM'13, Finland. ISBN 978-951-651-408-9, pp. 82-84*

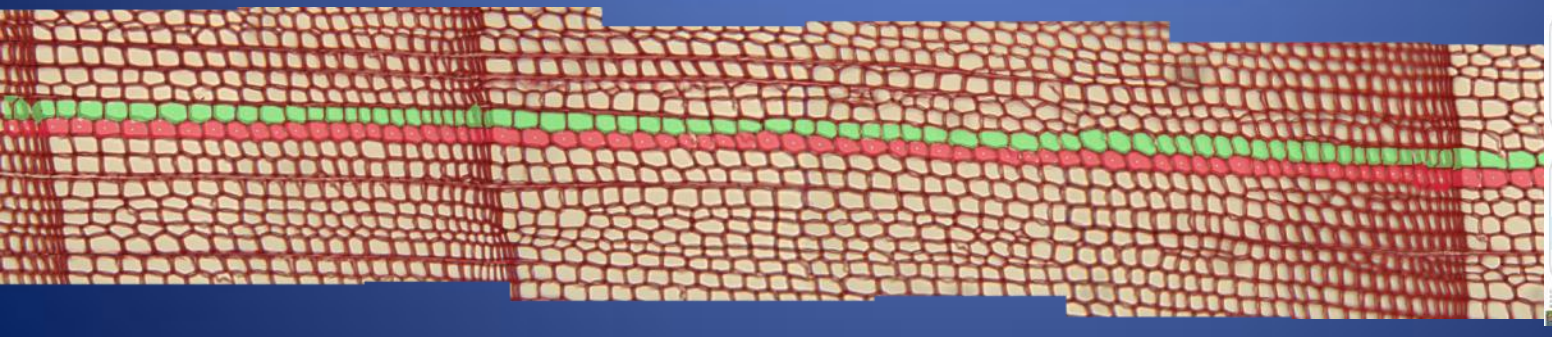


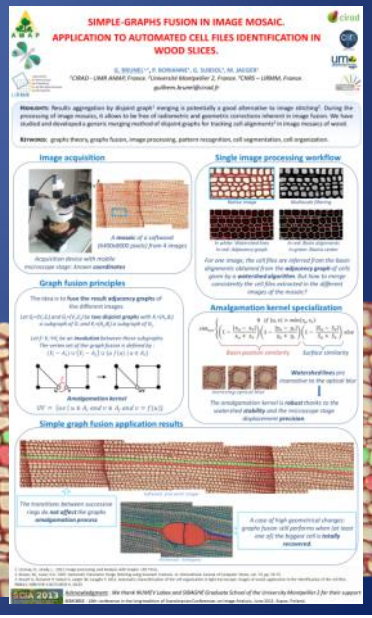




- ## Détection sur de grande zone

Brunel G, Borianne P, Subsol G, Jaeger M. 2013. Simple-graphs fusion in image mosaic. Application to automated cell files identification in wood slices. SCIA'13 Finland, LNCS 7944, pp. 34–43





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