Tree Defect Segmentation using Geometric Features and U-net

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Overview

1. Context
2. State of the art
3. Segmentation process
4. Experimental results
5. Conclusion

1. Context

Tree climbing

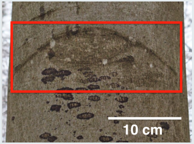
Forest production trading

Estimate the tree quality :

- Look at external defects
- Deduce the internal impacts

WoodSeer project : Evaluate the use of machine learning to predict the interior distribution of defects inside roundwood **from the external geometry of the wood.**

Defects diversity



Branch scar (beech)

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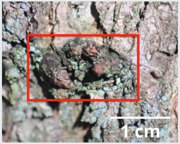
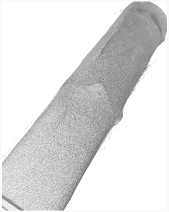


Picot (oak)

1. Context

TLS



Point cloud

Mesh

Defect detection

Approach

- Build a 2D representation of the trunk mesh
- Generate the training dataset
- Train a defects segmentation model
- Detect defects for new input data

2. State of the art

Main idea of the article

[KKM+13](2013) : build an intensity map by fitting a cylinder on the tree trunk point cloud, and then use it to detect trunk defects.

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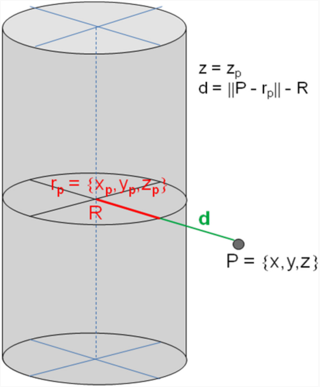
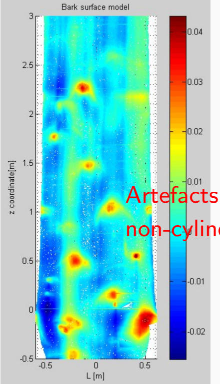
fitting.jpg



Cylinder fitting



Artefacts appear in case of non-cylindrical trunks

Intensity map

2. State of the art

Main idea of the article

[NKDR+16](2016) : use the trunk centerline [KKDRL16] to segment defect via a local relief representation (called **delta distance**).

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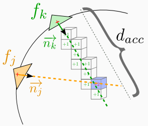
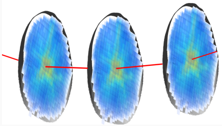
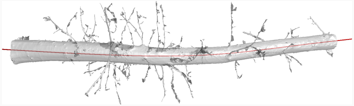


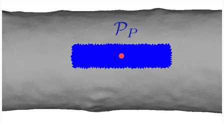
Accumulation



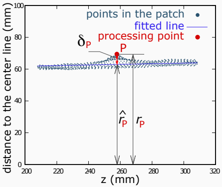
Tracking step



Centerline (red)



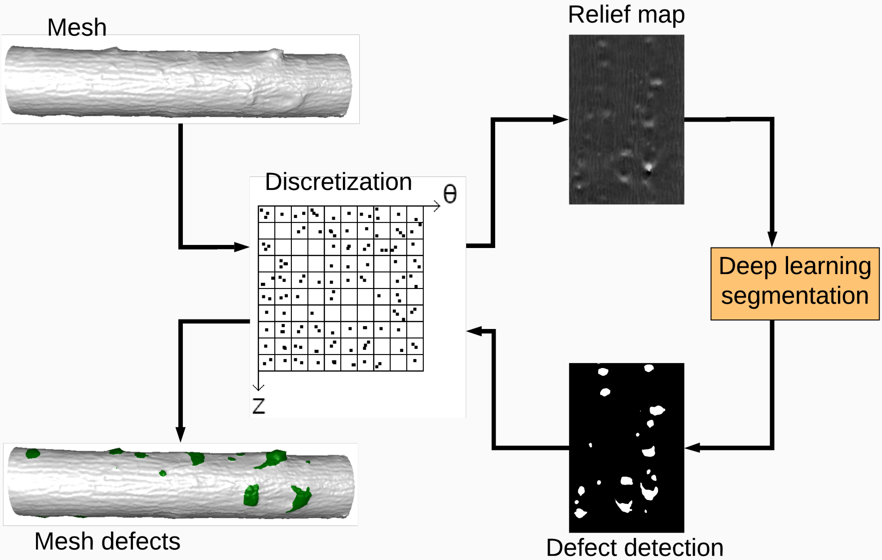
Patch



Delta distance

An automatic thresholding is used to classify the points as defects

3. Segmentation process



3.1 Relief map

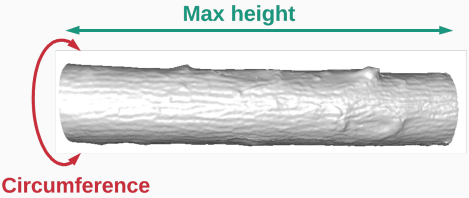
Discretisation

Width $= 2\pi * r_m$, with r_m the average radius of the trunk.

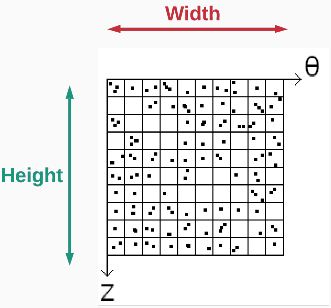
Height $= P_{z_{max}} - P_{z_{min}}$, with $P_{z_{max}}$ and $P_{z_{min}}$ are height max and min, respectively.

Value of the cells = maximum **delta distance** of all points in the cells.

Empty cells are recovered by a **multi resolution analysis**.

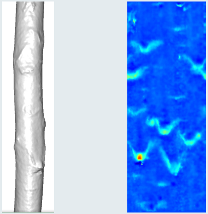


Mesh

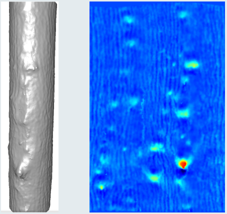


Discretization

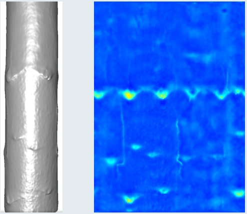
Examples of relief map (RGB)



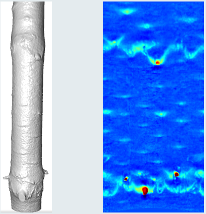
Birch



Elm



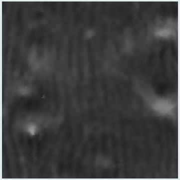
Fir



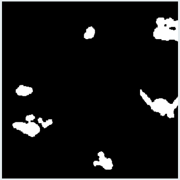
WildCherry

Network training

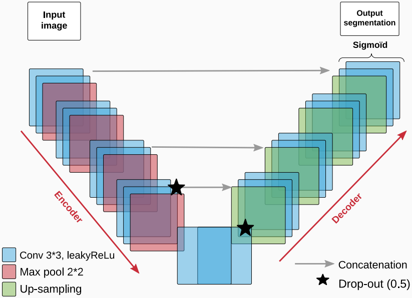
- **U-Net** [RFB15]: Auto encoder.
- **Data** : 25 relief maps cut out in 465 thumbnail.
- **Parameters** : **40** epochs, **63** steps, **10** images per batch (14s/epoch).



Relief map



Label image



3.2 Segmentation with U-Net Architecture

Network training

- **U-Net** [RFB15]: Auto encoder.
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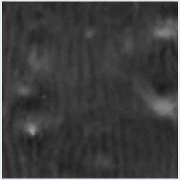
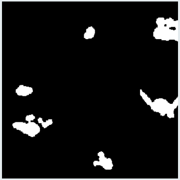


Relief map



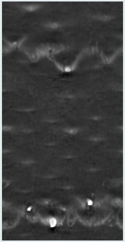
Label image

Details

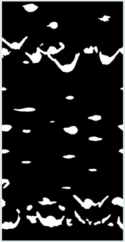
- **GPU** : RTX 2080Ti with Tensorflow 2.2 and Keras.
- **Ground-truth** : Binary image (same dimension as the relief map).
- **Data augmentation** : Rotation, vertical and horizontal flip, zoom and deletion of rectangular area randomly [DT17].
- **Loss function** : Binary crossentropy.
- **Thumbnail size** : 320*320pi.

3.2. Segmentation with U-Net Architecture

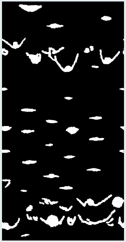
Test the prediction



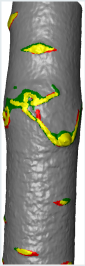
Input



Prediction



Ground truth



Mesh

Compared to the ground-truth

- Yellow is true positive.
- Red is false negative.
- green is false positive.

Details

- Prediction threshold = 0.5 for the normalized probabilities output
- Re-projection of the predicted defect output back to 3D point cloud

Results

Dataset : 25 trunk samples with defect annotation.

F-measure (F1) : Harmonic mean of precision and recall.

Experiment 1 : Comparison with the rectangular patch method (15 samples for training and 10 for testing).

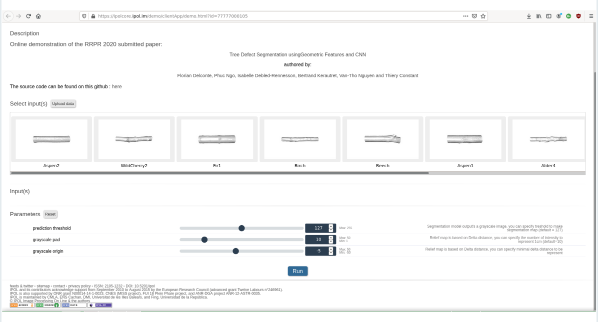
Our method (F1)	**0.79**
[NKDR+16] Patch method (F1)	0.71

Experiment 2 : Robustness of the method over the dataset (5-fold cross-validation)

	K1	K2	K3	K4	K5
Our method (F1)	**0.750**	**0.712**	**0.724**	**0.787**	**0.721**
[NKDR+16] Patch method (F1)	0.563	0.643	0.635	0.676	0.597

Reproducibility

- Code, data and commands to reproduce results are available :
  https://github.com/FlorianDelconte/TLDDC
- Free online demo (no need to install dependencies) :
  https://kerautret.github.io/TLDDC



5. Conclusion

Contributions :

- A deep learning based approach to segment defects on meshes of tree trunks.
- Only 25 annotated trunk meshes are used.
- Bash script to reproduce the obtained results.
- An online demonstration.

Future works :

- Compare the performances of CNN architectures for the defect segmentation.
- Train a network for semantic segmentation (One color for each defect type).

References

- Terrance Devries and Graham W. Taylor, *Improved regularization of convolutional neural networks with cutout*, CoRR **abs/1708.04552** (2017).
- Bertrand Kerautret, Adrien Krähenbühl, Isabelle Debled-Rennesson, and Jacques-Olivier Lachaud, *On the implementation of centerline extraction based on confidence vote in accumulation map*, International Workshop on Reproducible Research in Pattern Recognition, Springer, 2016, pp. 116–130.
- Ursula Kretschmer, Nadeschda Kirchner, Christopher Morhart, Heinrich Spiecker, et al., *A new approach to assessing tree stem quality characteristics using terrestrial laser scans*, Silva Fenn **47** (2013), no. 5, 1071.
- Van-Tho Nguyen, Bertrand Kerautret, Isabelle Debled-Rennesson, Francis Colin, Alexandre Piboule, and Thiéry Constant, *Segmentation of defects on log surface from terrestrial lidar data*, 2016 23rd International Conference on Pattern Recognition (ICPR), IEEE, 2016, pp. 3168–3173.
- Olaf Ronneberger, Philipp Fischer, and Thomas Brox, *U-net: Convolutional networks for biomedical image segmentation*, CoRR **abs/1505.04597** (2015).