Detection, vectorization and characterization of linear structures from LIDAR images

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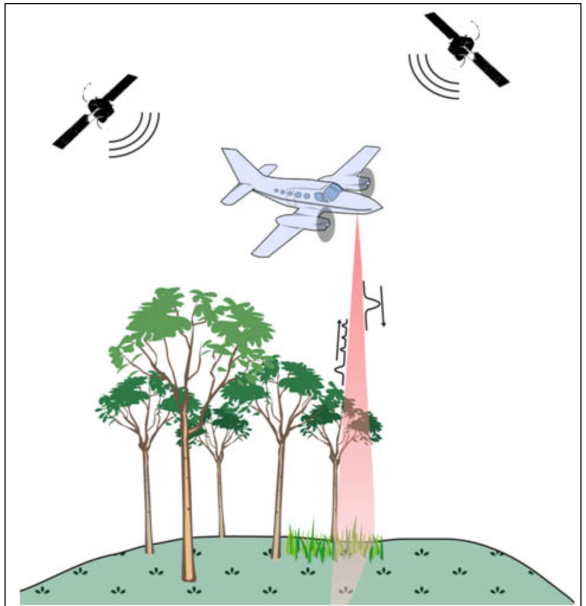
Outline

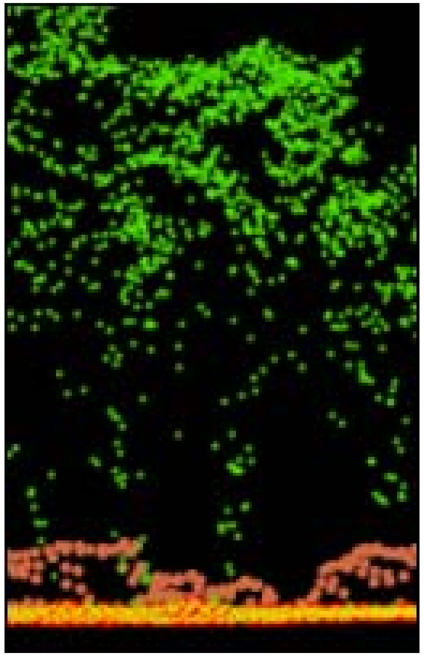
- Introduction
  - Context : SOLIDAR project
  - Collaboration between archeologists / computer scientists
  - Targeted frameworks
- From LIDAR data to the targeted layers
  - Characteristics of the desired archaeological structures
  - First approach: Image processing
  - Second thought: Machine learning approach
- Vectorization and tagging
  - Selected vectorization technique
  - Interest of Post-processing
- Conclusion et perspectives

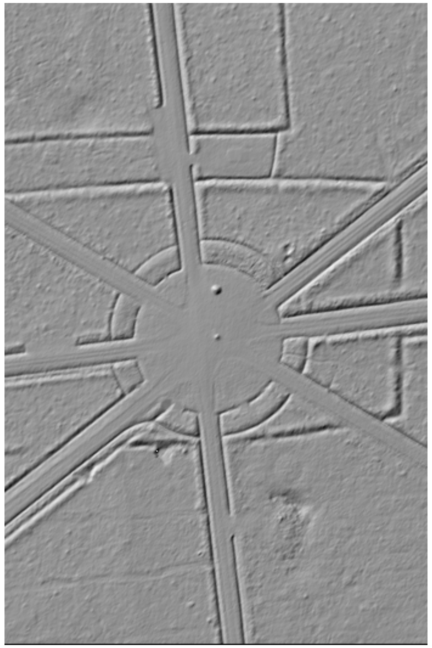
Introduction

- SOLIDAR project
  - Supported by Region Centre
  - Studied Location: Forêts de Chambord, Boulogne, Russy et Blois
- Provided data
  - LIDAR XYZ point cloud ➔ Classification and filtering
    ➔ Digital Elevation Model(DEM) that represents the ground
  - Mass of data, High précision (50cm x 50cm), …



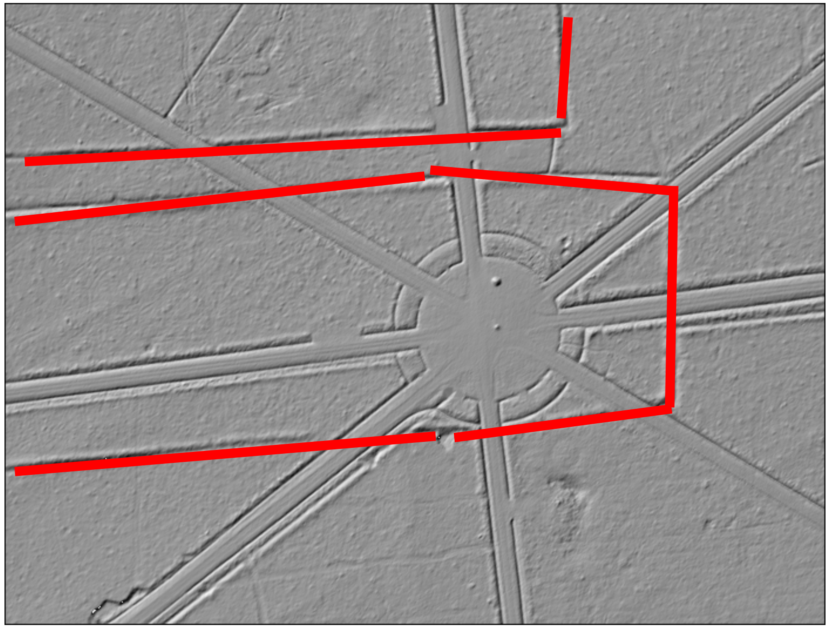
2 Schéma du fonctionnement du LiDAR (C. Laplaige, 2012)

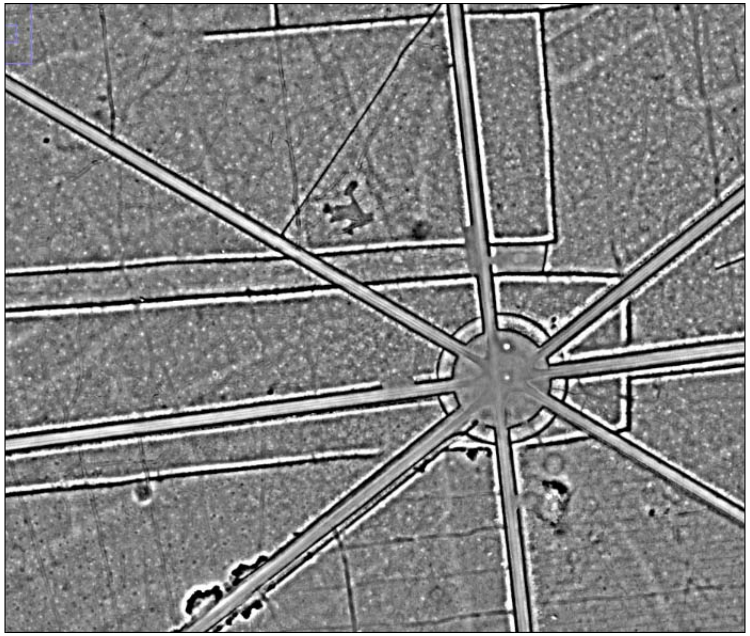




Introduction

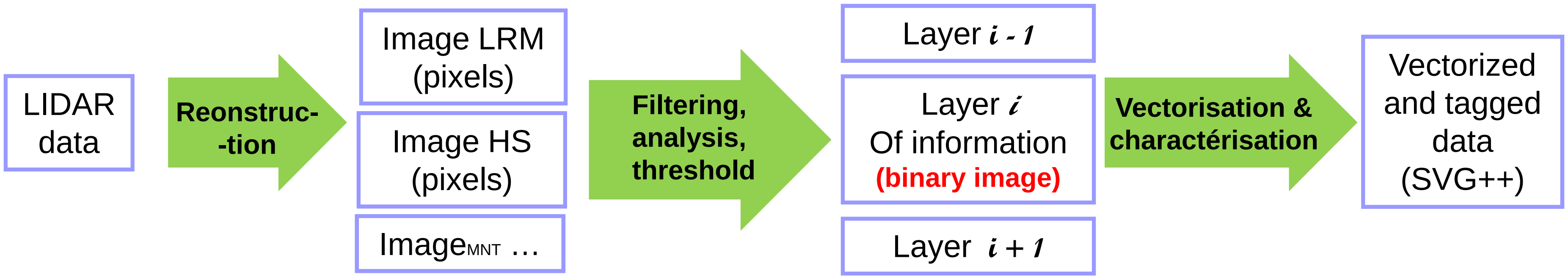
- Detection and Analysis of linear structure (lineaments)
  - Thousand of kilometers inside the studied place in SOLiDAR
  - Visual analysis and manual vectorization is a tedious task
  - Subjectivity and non-exhaustivity
- Which kind of raster images derivated from LIDAR to used?
  - Adequacy with lineament detection
  - Hillshade Model? Slope/Gradient Model? **Local Relief Model**? ...
  - Second thought: use of multiple sources (multimodal analysis)



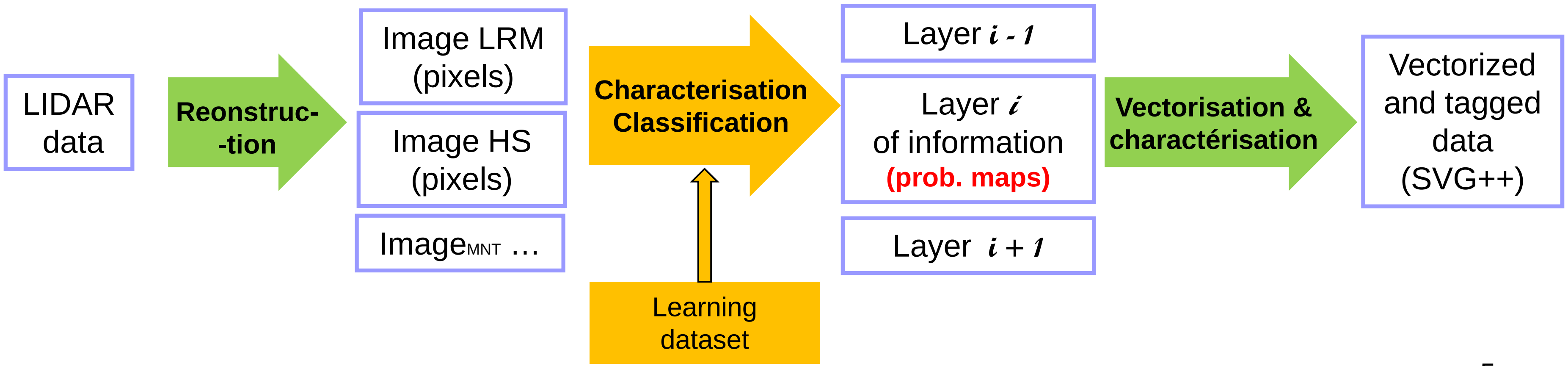


Introduction

- It is just the beginning… ➔ Targeted Frameworks
  - First approach: Image processing

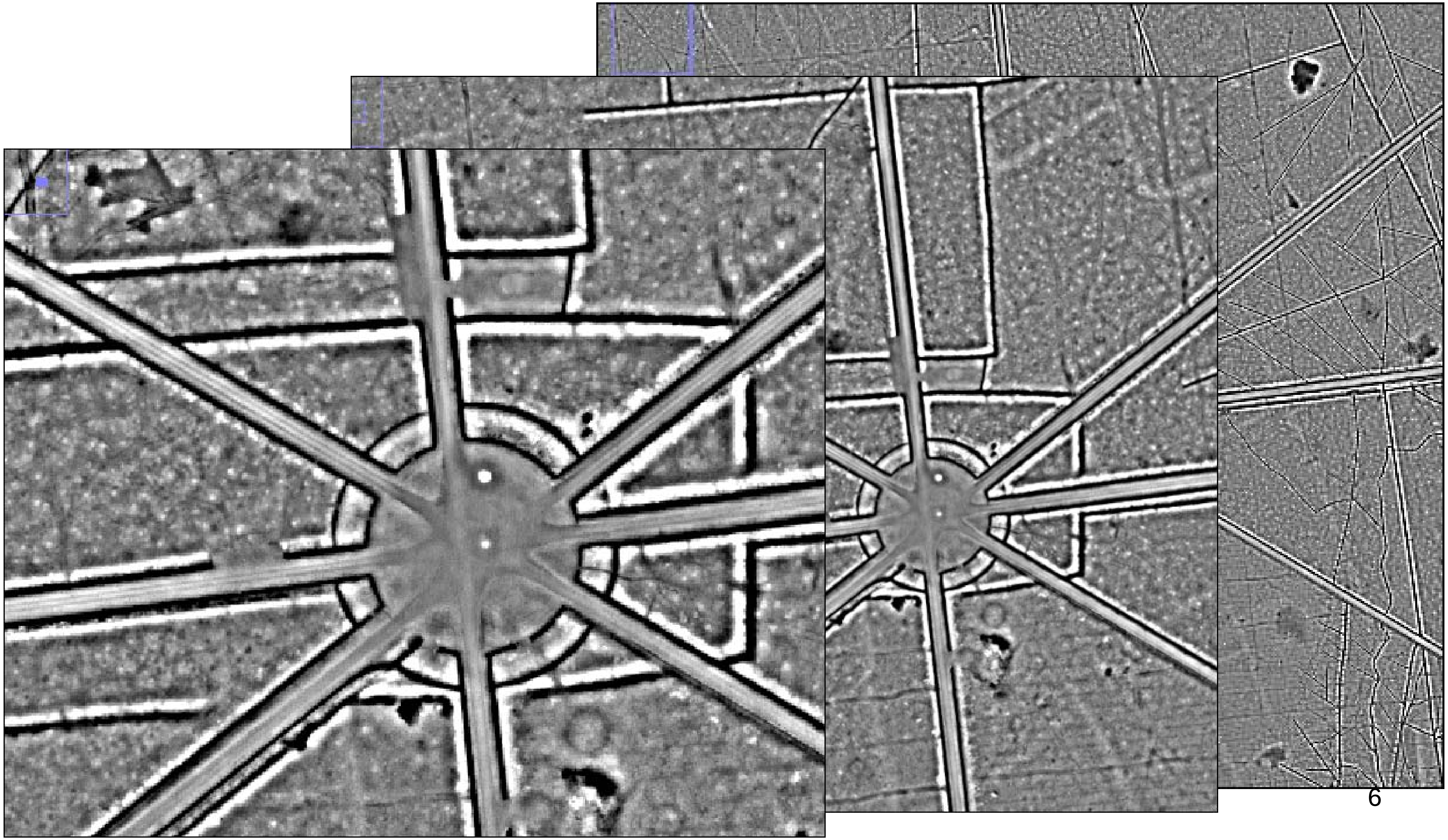


  - Second thought: Machine Learning



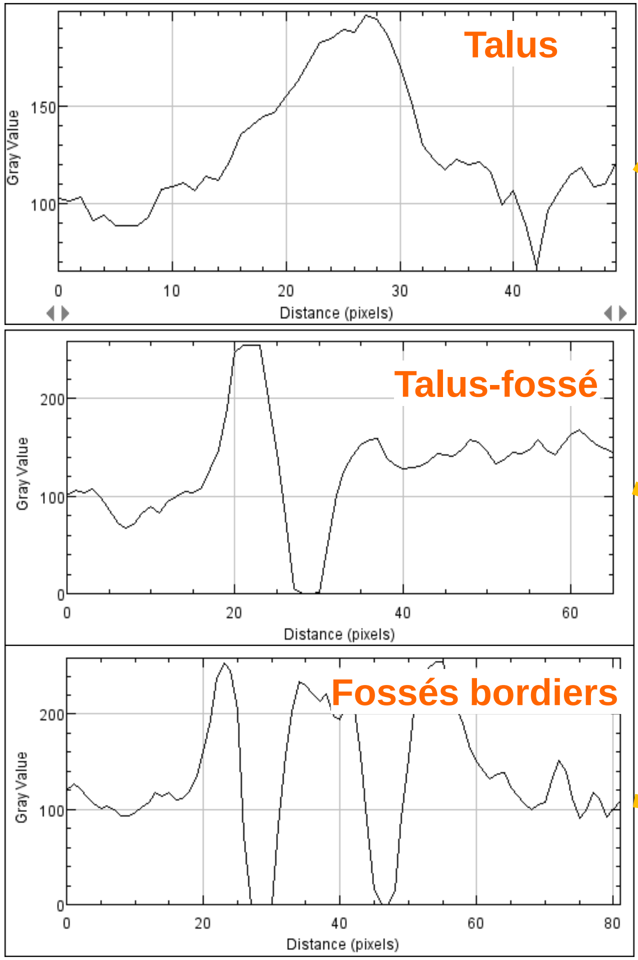
From LIDAR data to the targeted layers

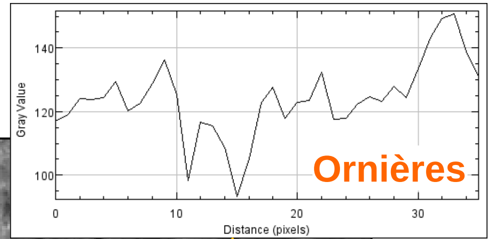
- Selection the good scale or multi-scales analysis

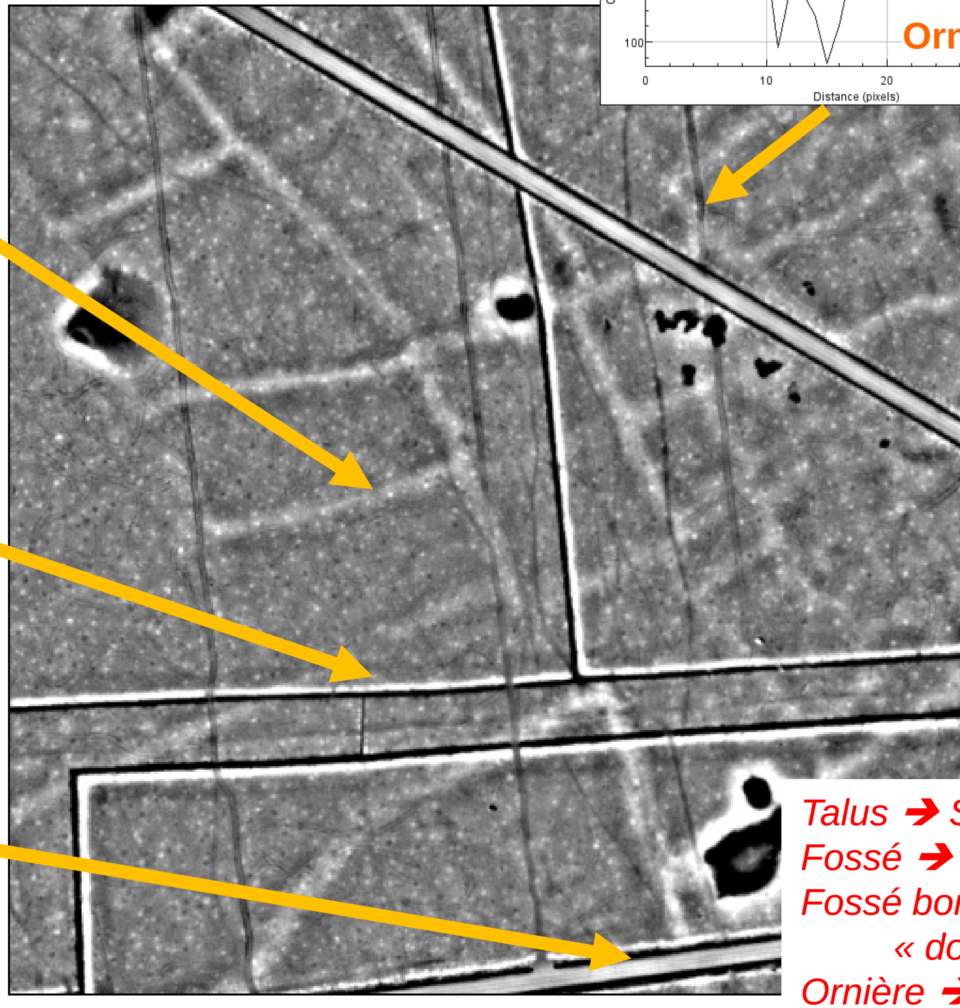


From LIDAR data to the targeted layers

- Characteristics of the lineaments
- 4 selected categories :



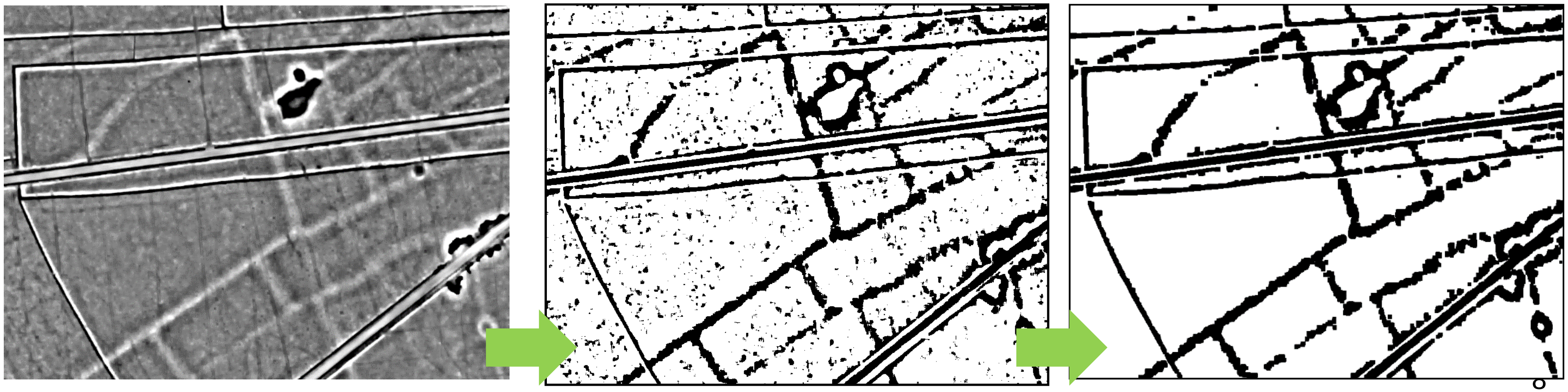




Talus ➔ Slope
Fossé ➔ ditch, gap
Fossé bordier ➔ « double ditch »
Ornière ➔ rut

From LIDAR data to the targeted layers

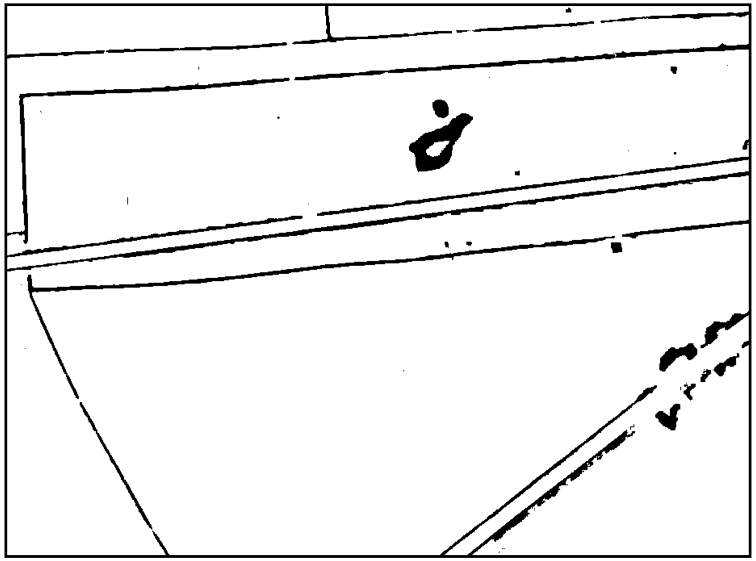
- Image analysis approach
  - Goal : Image (DEM) separation into the targeted information layers
  - Results : 1 layer = 1 binary image to vectorize
- Possible processing
  - Filtering: median /Gaussian…
  - Multiple thresholding
  - Mathematical Morphology operations
  - Connected component analysis
  - Arithmetic operation between processed DEM and layers



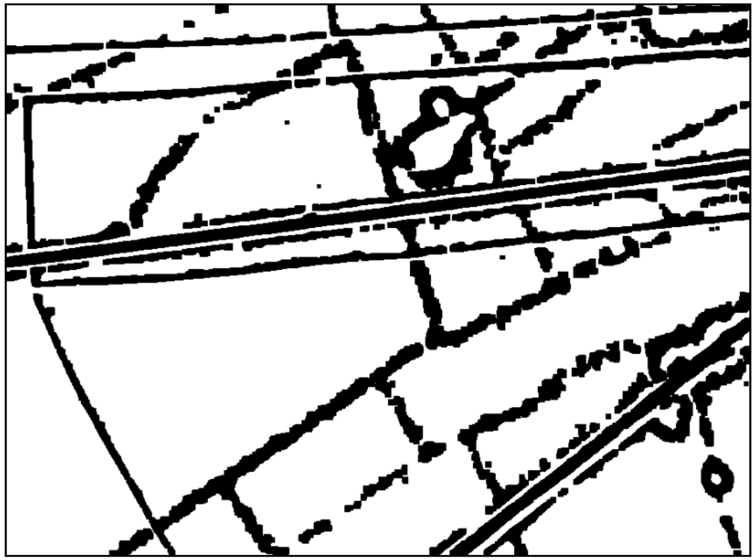
From LIDAR data to the targeted layers

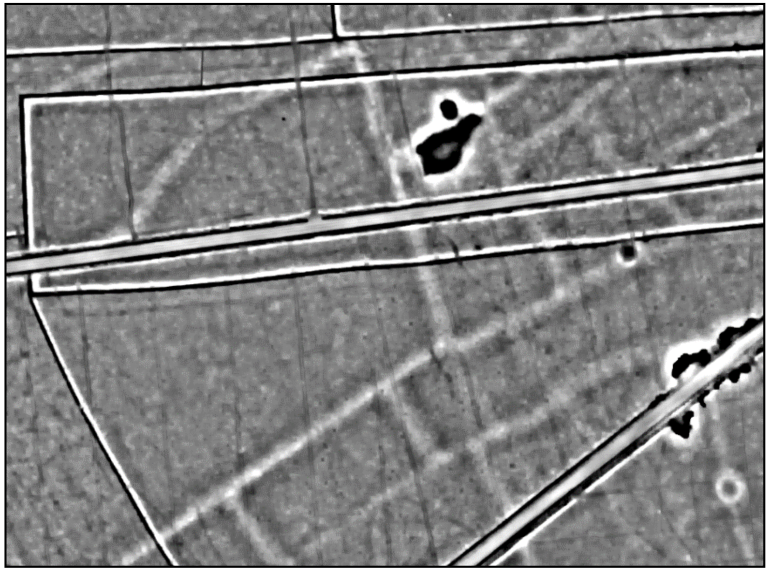
- Results :
  1 layer = 1 binary image

Layer fossés(gap)



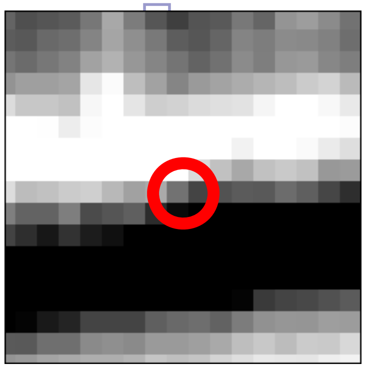
Layer Talus(slope) + fossés + ...





From LIDAR data to the targeted layers

- Machine learning approach (to be done)
  - Goal : pixel classification into the 4 categories ≈ 4 layers
  - Results : 1 probability map = 1 fuzzy layer
- Tasks to do
  - Feature definition to describe the pixels
  - Construction of a Learning dataset
  - Classifier model definition (SVM, CNN, ...)
  - Analysis of probability maps (post-processing?)
  - Combination of classification results (probability maps)



1 pixel = List of features ➔ Classification ➔

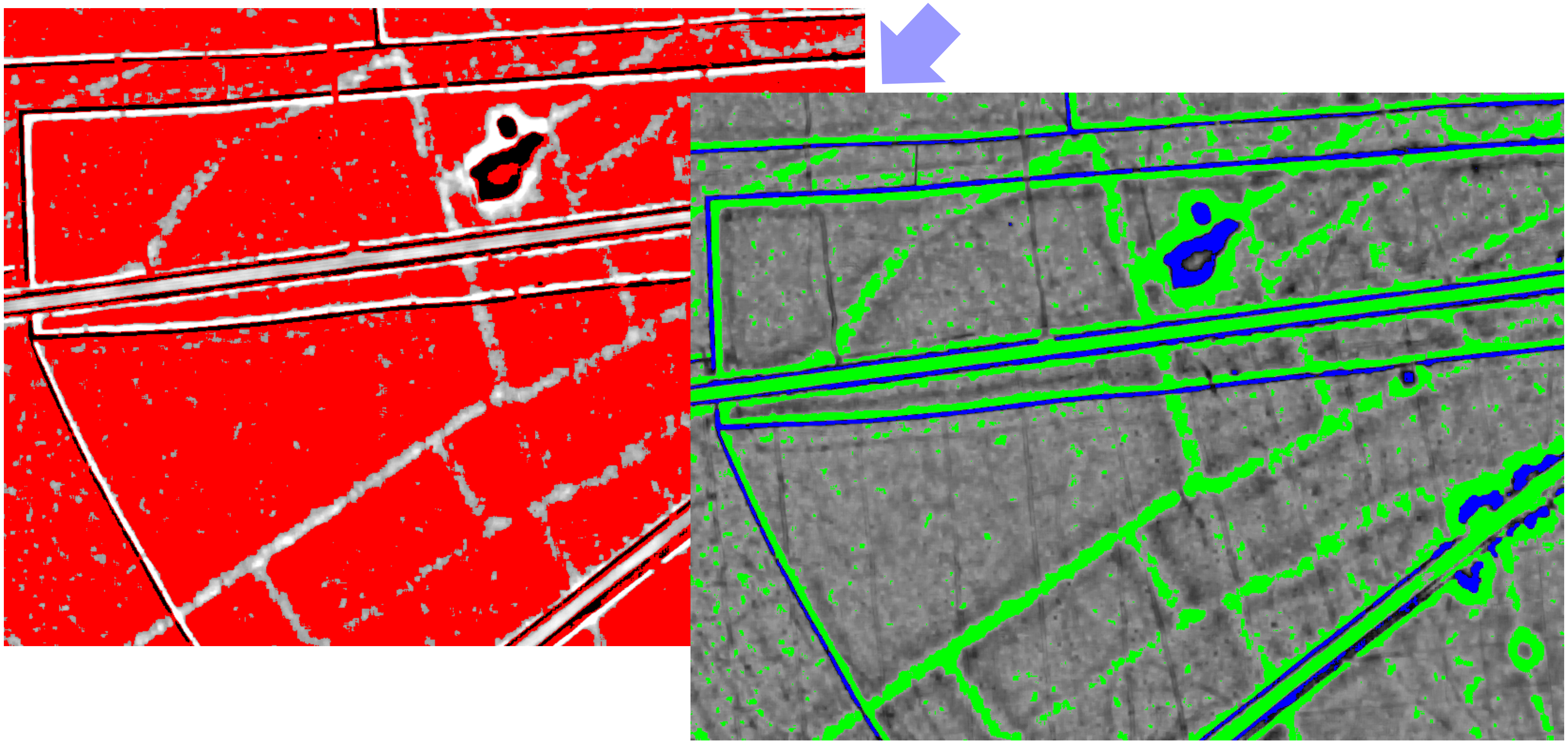
[Lidar, gradient, intensity, texture, ...]

- Fossé = *0,9*
- Talus = *0,3*
- Ornières = *0,1*

From LIDAR data to the targeted layers

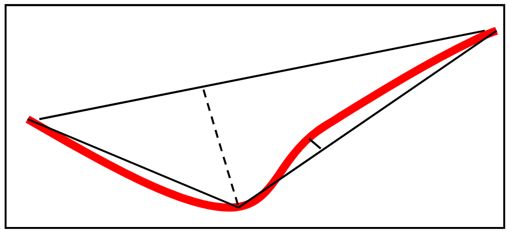
- What is a probability maps?
- 1 pixel = *n* probabilities corresponding to the *n* classes

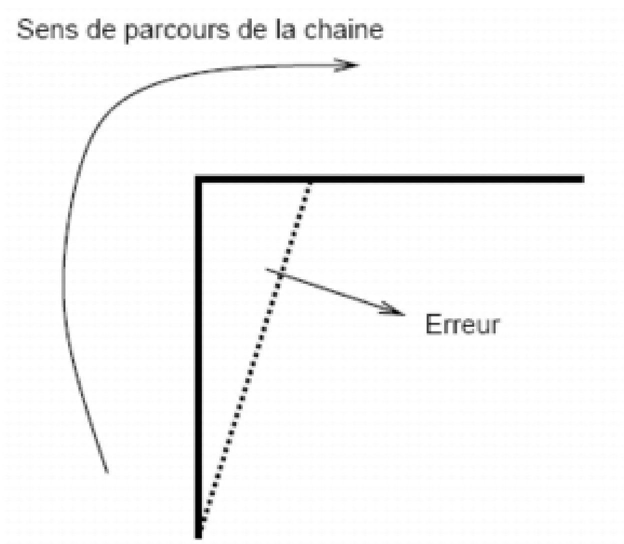
Visualisation : 1 probability value = 1 color intensity

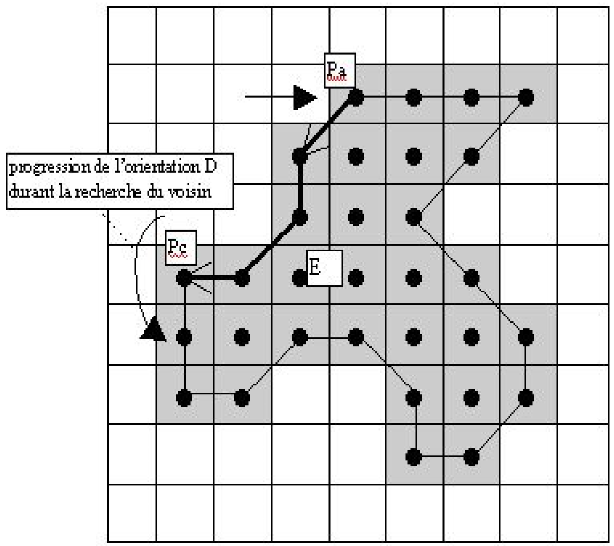


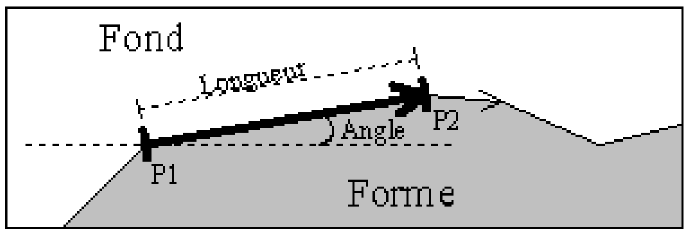
Vectorization and tagging

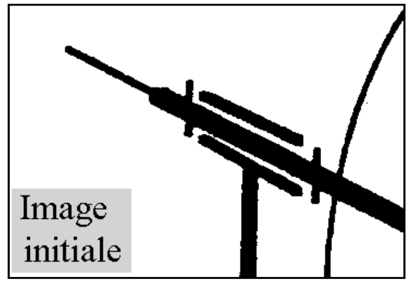
- Vectorization ➔ Polygonal approximation of the skeleton or **contours**
- Which method ? recursive, **iterative** ➔ VectoGraph [Ramel2000]
- Higher level results : Vectors + Quadrilaterals + CC

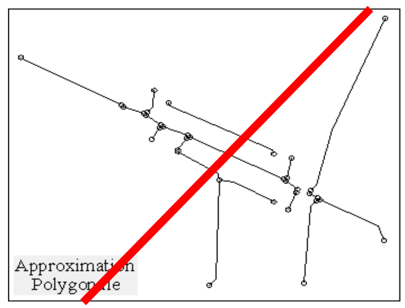


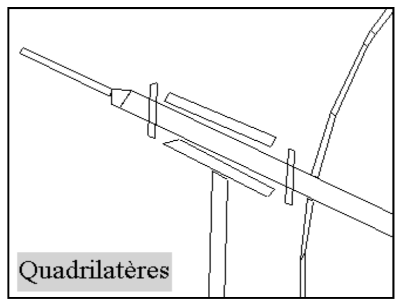




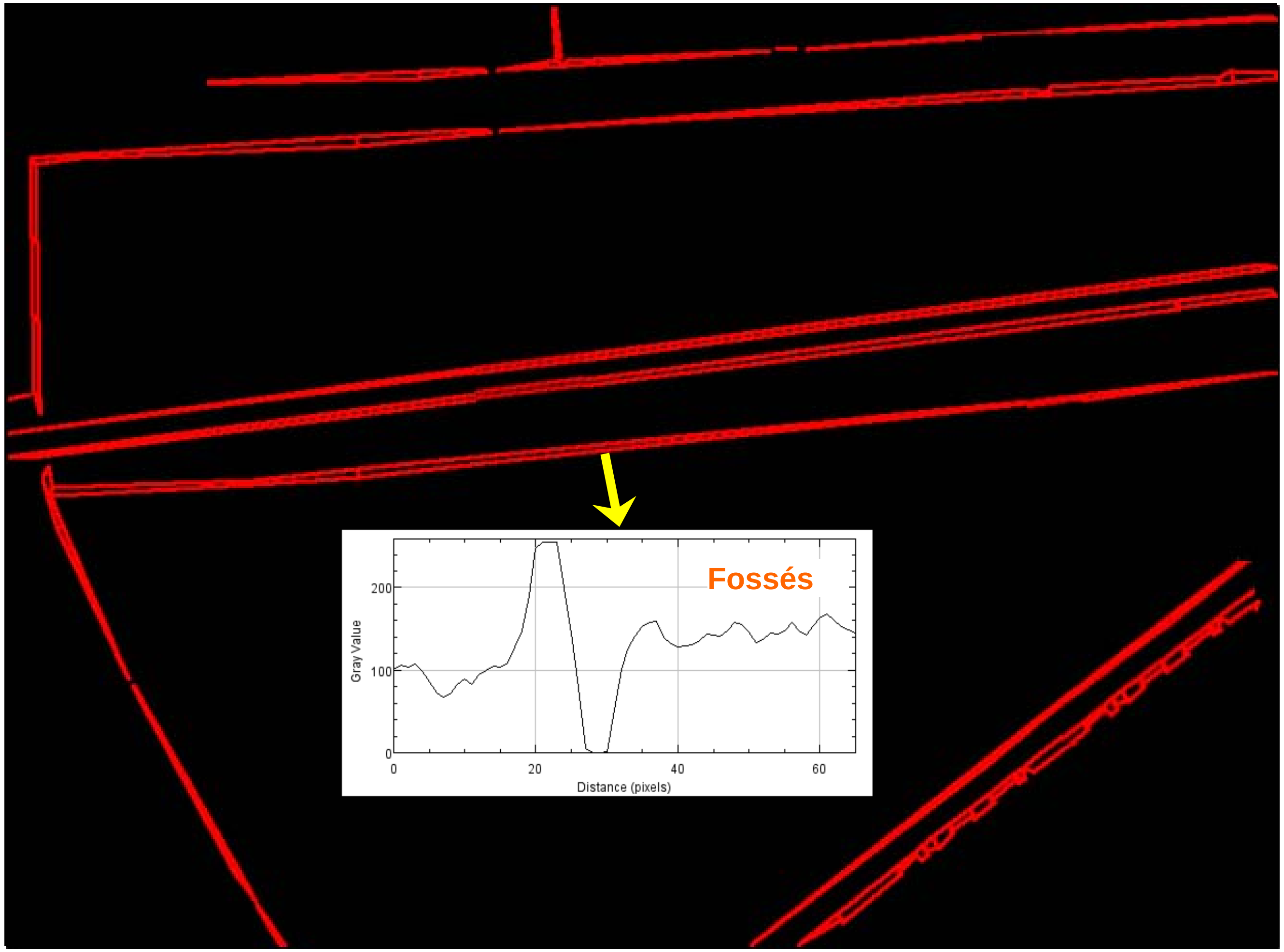








Vectorisation and tagging (layer 1)



Vectorisation and tagging (layer 2)

Conclusion et perspectives

- Actual situation / results
  - Data and terminology understanding
  - Study of the related works (LIDAR ➔ image ➔ interpretation)
  - Definition of possible frameworks
  - Implementation of the image processing part (layer extraction + vectorization)
  - Image processing approach will not be sufficient

- To do
  - Switching to Machine Learning approach
  - Feature selection, definition
  - Construction of the Learning dataset
  - Implementation of the classifier
  - Experiments for performance evaluation

Thanks

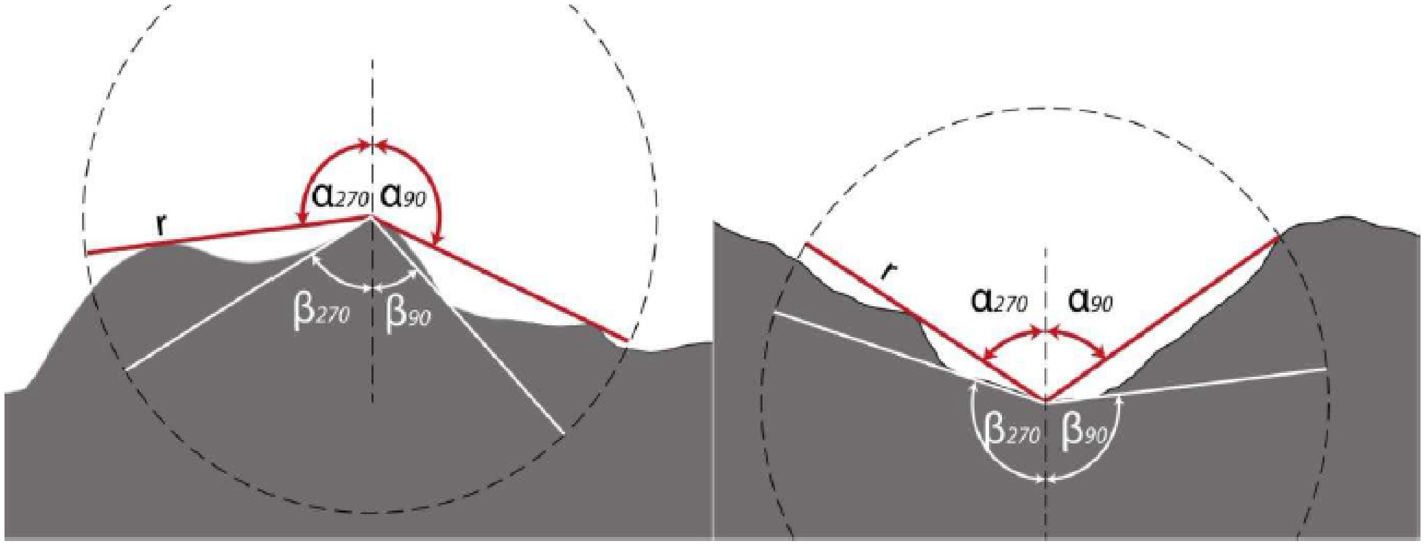
Questions ?

Annexe

- Model Sky View Factor

Sommet et terrain plat : angle de ciel visible important

Vallée ou creux : angle de ciel visible plus faible



In Michael Doneus : Openness as Visualization Technique for Interpretative Mapping of Airborne Lidar Derived Digital Terrain Models *Remote Sensing* **2013**, *5*(12), 6427-6442; doi:10.3390/rs5126427