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), ...
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

LIDAR data → Reconstruction → Image LRM (pixels) → Image HS (pixels) → Filtering, analysis, threshold → Layer $i-1$ → Layer $i$ of information (binary image) → Layer $i+1$ → Vectorisation & characterisation → Vectorized and tagged data (SVG++)

LIDAR data → Reconstruction → Image LRM (pixels) → Image HS (pixels) → Characterisation Classification → Layer $i-1$ → Layer $i$ of information (prob. maps) → Layer $i+1$ → Vectorisation & characterisation → Vectorized and tagged data (SVG++)
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
  - Talus-fossé
  - Fossés bordiers

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 $\Rightarrow$ Polygonal approximation of the skeleton or **contours**
- Which method? recursive, **iterative** $\Rightarrow$ VectoGraph [Ramel2000]
- Higher level results: Vectors + Quadrilaterals + CC
Vectorisation and tagging (layer 1)
Vectorisation and tagging (layer 2)

Still working…
Conclusion et perspectives

- Actual situation / results
  - Data and terminology understanding
  - Study of the related works (LIDAR $\rightarrow$ image $\rightarrow$ 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