# Photogrammetry for forest inventory.

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1- **Photogrammetry**

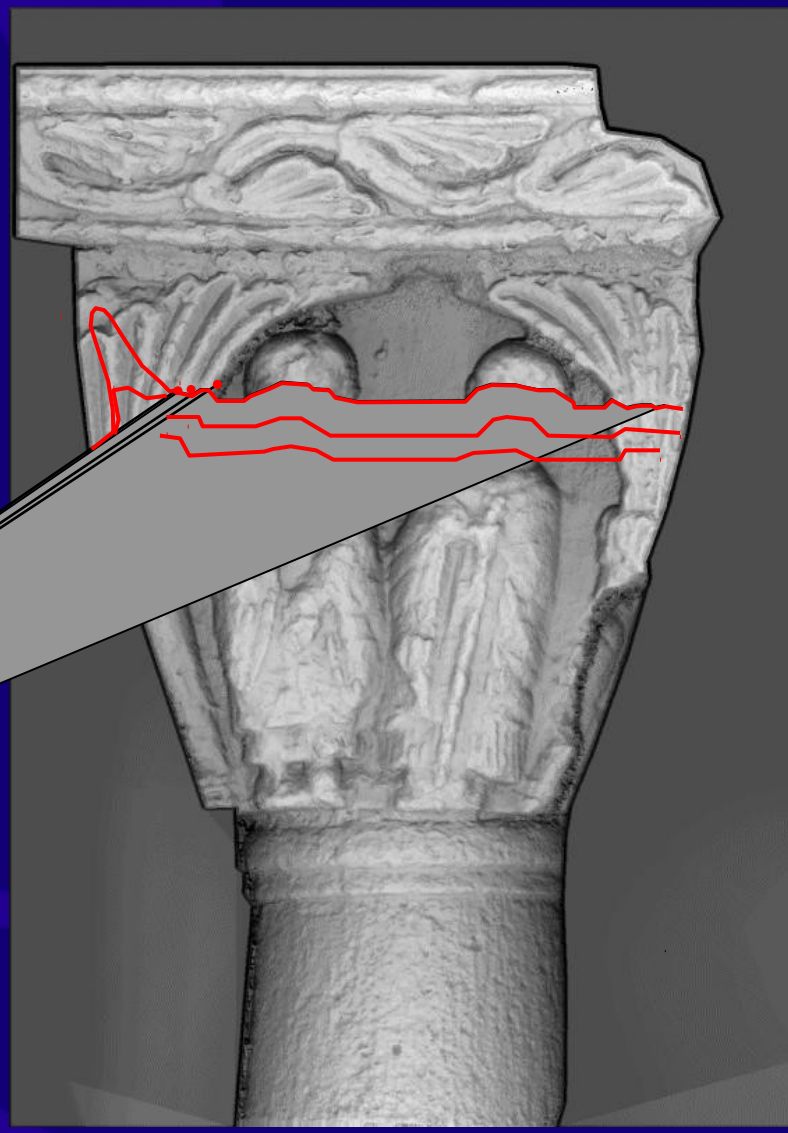
2- **Application to forestry**

3- **Tools and proposed actions**

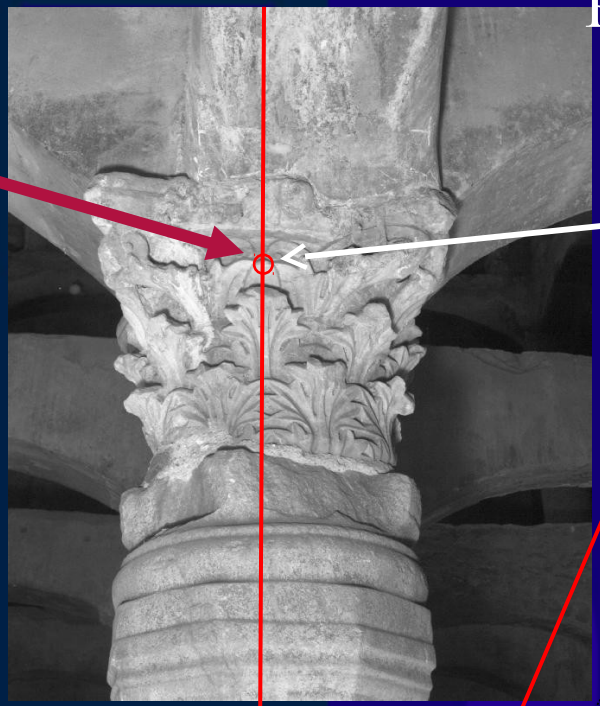
# 1- Photogrammetry

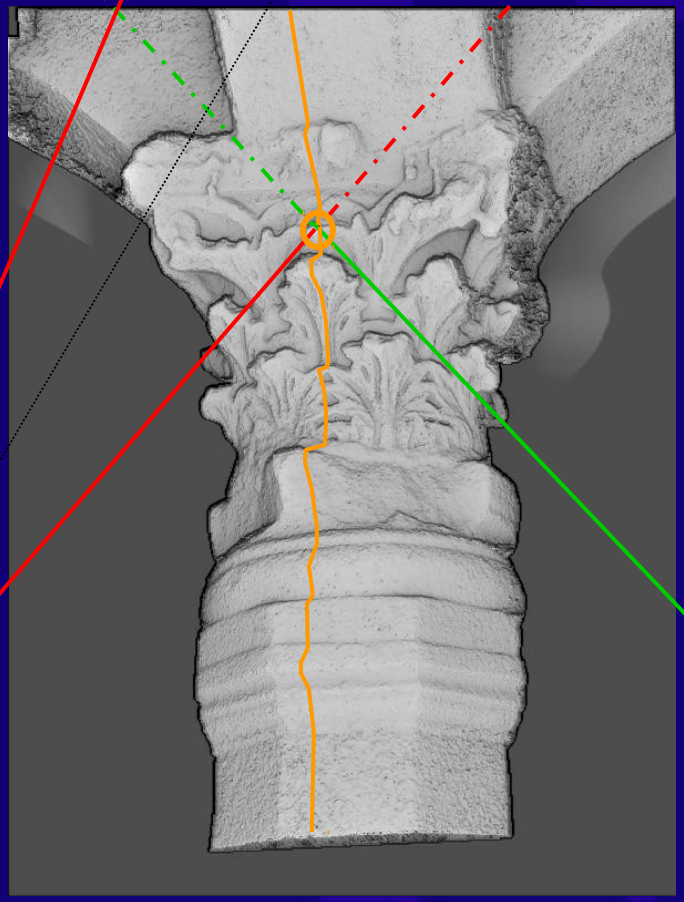
## *Photogrammetry vs lidar*

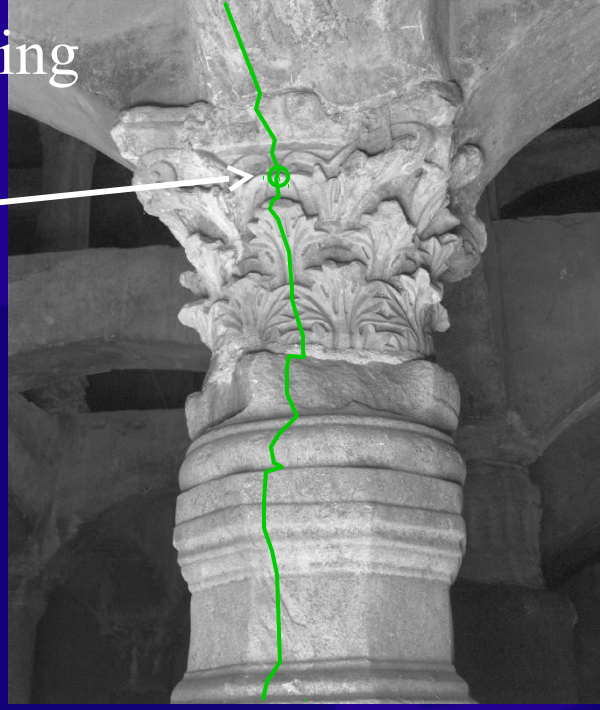
# LIDAR 3D modeling

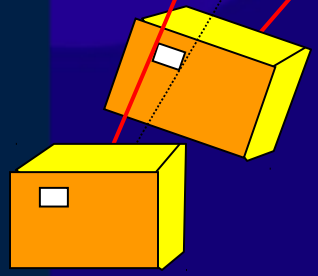


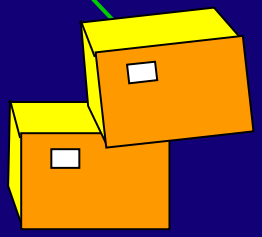
# Photogrammetry 3D modeling











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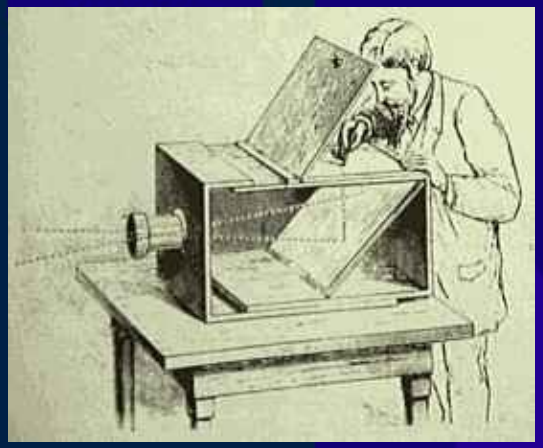
# Untill recently, when one heard « photogrammetry » what does came to mind ?



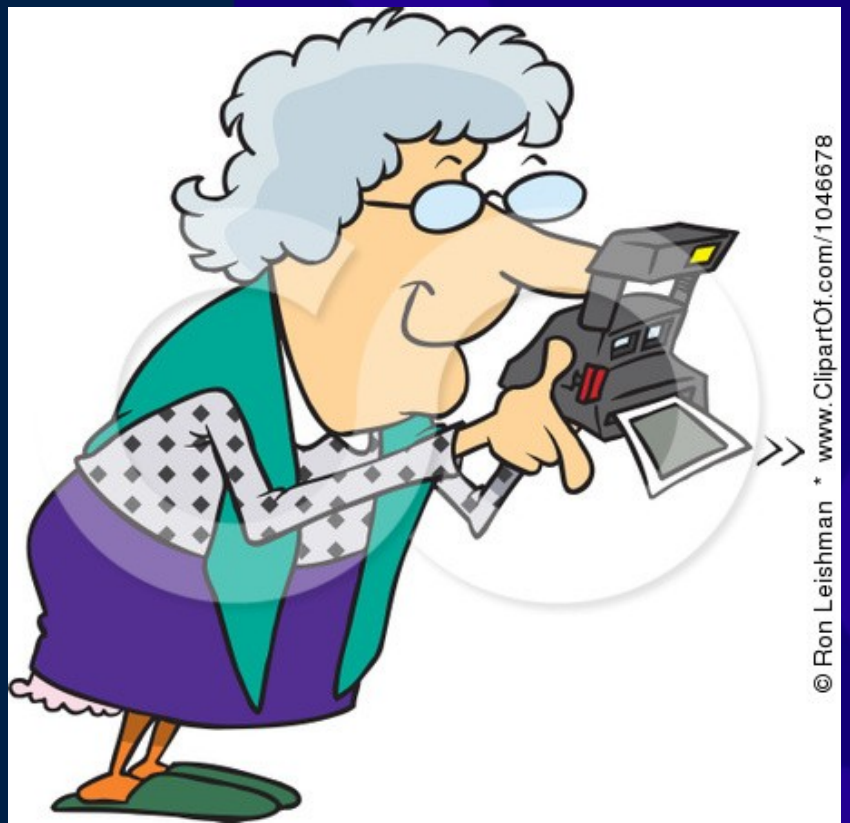
An old technique

Requiring specialized material and people

But not fullly automatic, precise and complete as lidar

# At the begining of year 2000, most people thought that photogammetry was :

A respectable, old lady of the scientific word




That should profit of her well deserved retirement

An make room for « modern young people » (LIDAR, RADAR…)

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**But since, two major issues have change the story :**

**Digital photography :**


**Progress in image processing :**

***Result of sift algorithm***

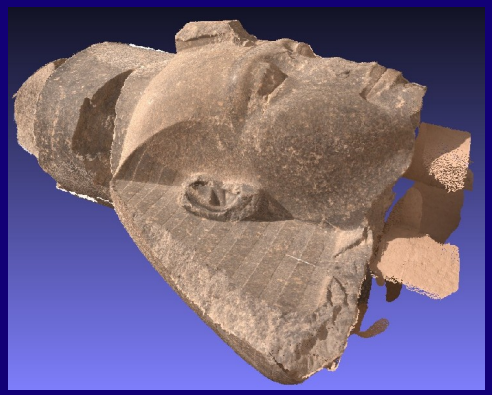
Digital photography : taking photo is free => take as many photo as you need :

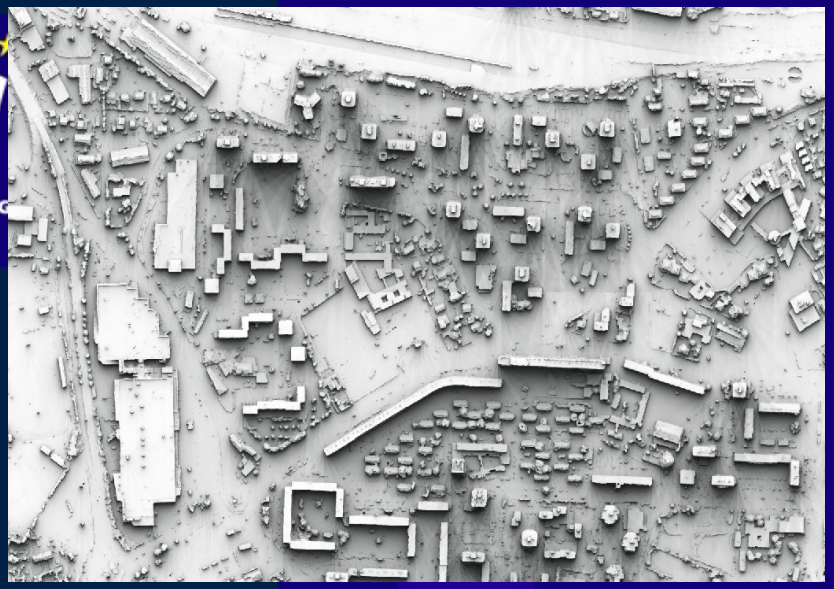
High quality of images, high redundancy of information :

(Potential) robustness :

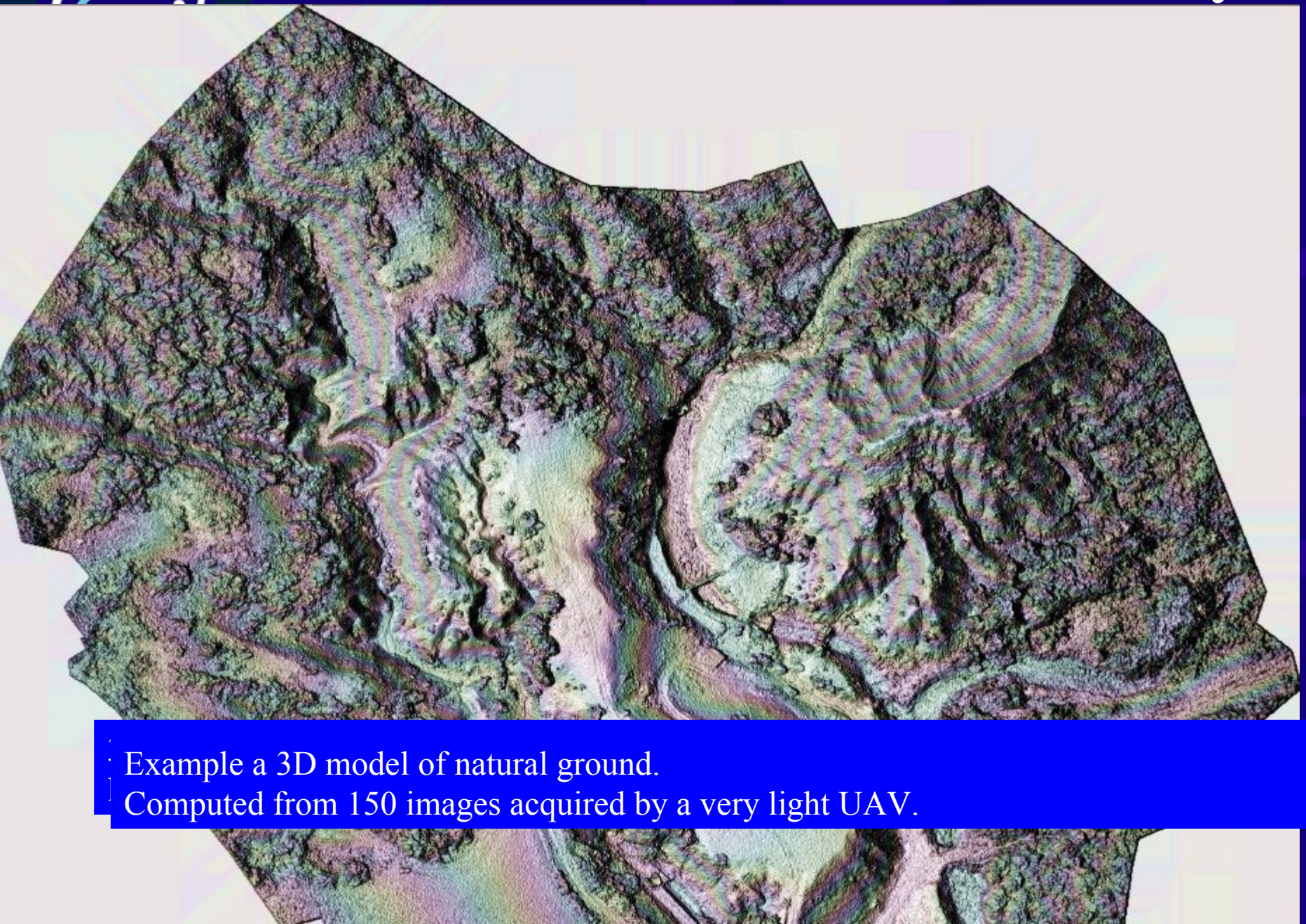
(Potential) accuracy

(Potential) automation





# 3D model for environmental survey:



Example a 3D model of natural ground.
Computed from 150 images acquired by a very light UAV.

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**Is the old lady photogrammetry back ? Ready to take her revenge and throw away the insolent young lidar …**


**Of course , that's not so simple …..**

# Lidar VS photogrammetry

## Lidar

More robust

Constant precision

Few processing (direct measurement)

## Photogrammetry

Cheap material

Precision adaptable

Light weigth and instantaneous

-Put it on UAV or a bone, Submarine application,
- quick acquisition,

Get the photo as an « extra »

Both are useful. Research on fusion is required.

**For forestry application photogrammetry cannnot replace LIDAR in all topics:**

**Aerial acquisition** : photogrammetry wont give the DTM model under canopy as LIDAR can do;

**Terrestrial acquisition** : photogrammetry wont give Photorealsitic 3D model of tree, as LIDAR can do.

**But, it can still do a lot of thing for much lower cost:**

Aerial photogrammetry can provide model of canopy

Terrestrial photogrammetry can provide main measurements :height, diameters of trees

# 2- Application to forestry

# A few forestry domains in which photogrammetry may be utilized

**National scale :**

**two stages sampling inventory**
**using aerial/satellite imagery**

**Local scale :**

**Aerial photogrammetry for**
**Precision forestry**

**Stand and tree levels :**

**Terrestrial photogrammetry**

# Forest canopy modelization

DSM (Digital Surface Model)

Canopy Height Model:

CHM = DSM - DTM

DTM (Digital Terrain Model)

# Use of canopy height model

- Information in term of
vertical and horizontal structure
(maturity, recruitement, irregularity)

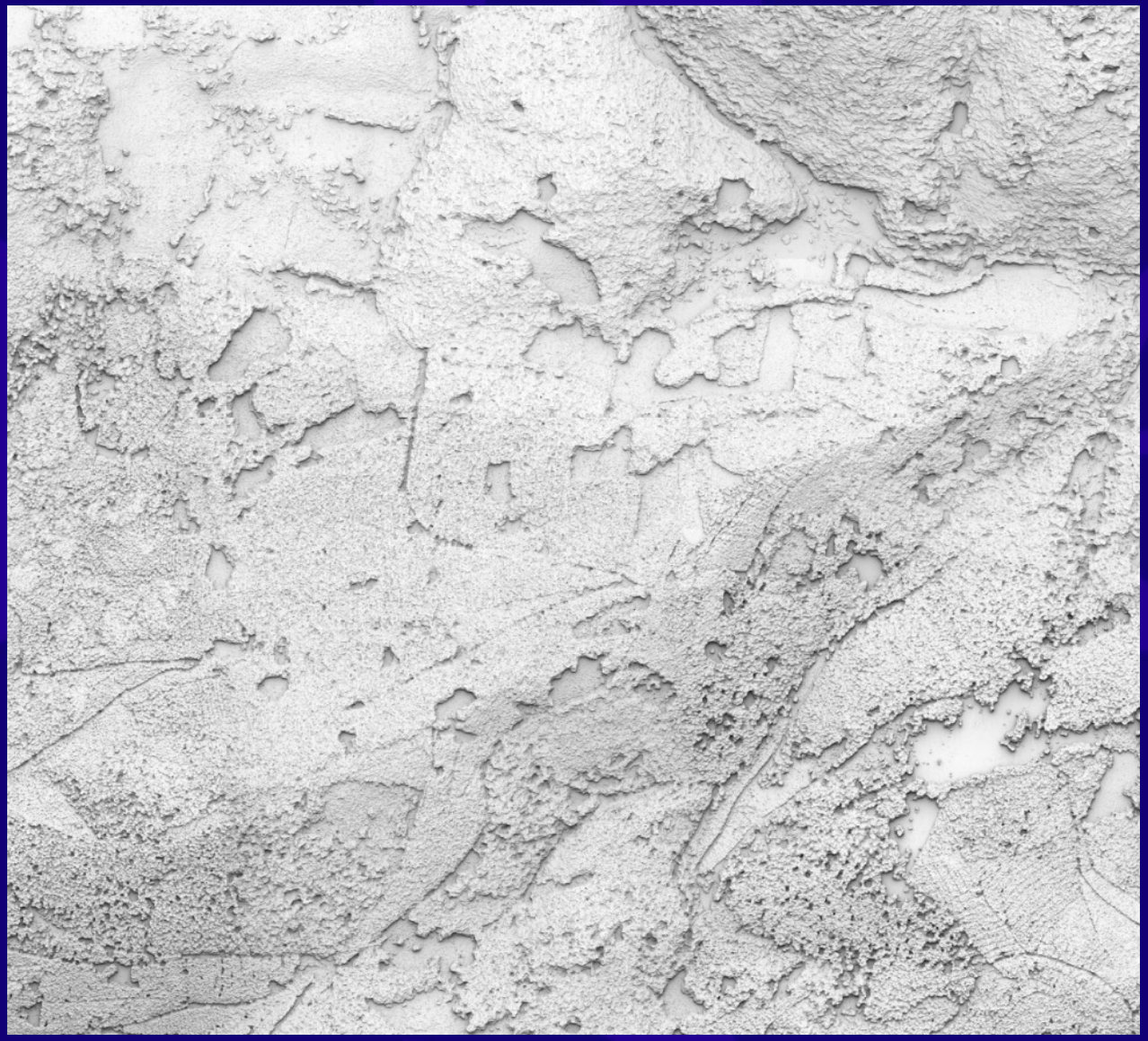
- Dominant height and
Site Index determination for even-aged stands

- Time serie of CHMs : height increment modelization

# Creation of a forest canopy surface model from aerial imagery

Survey: IGN France

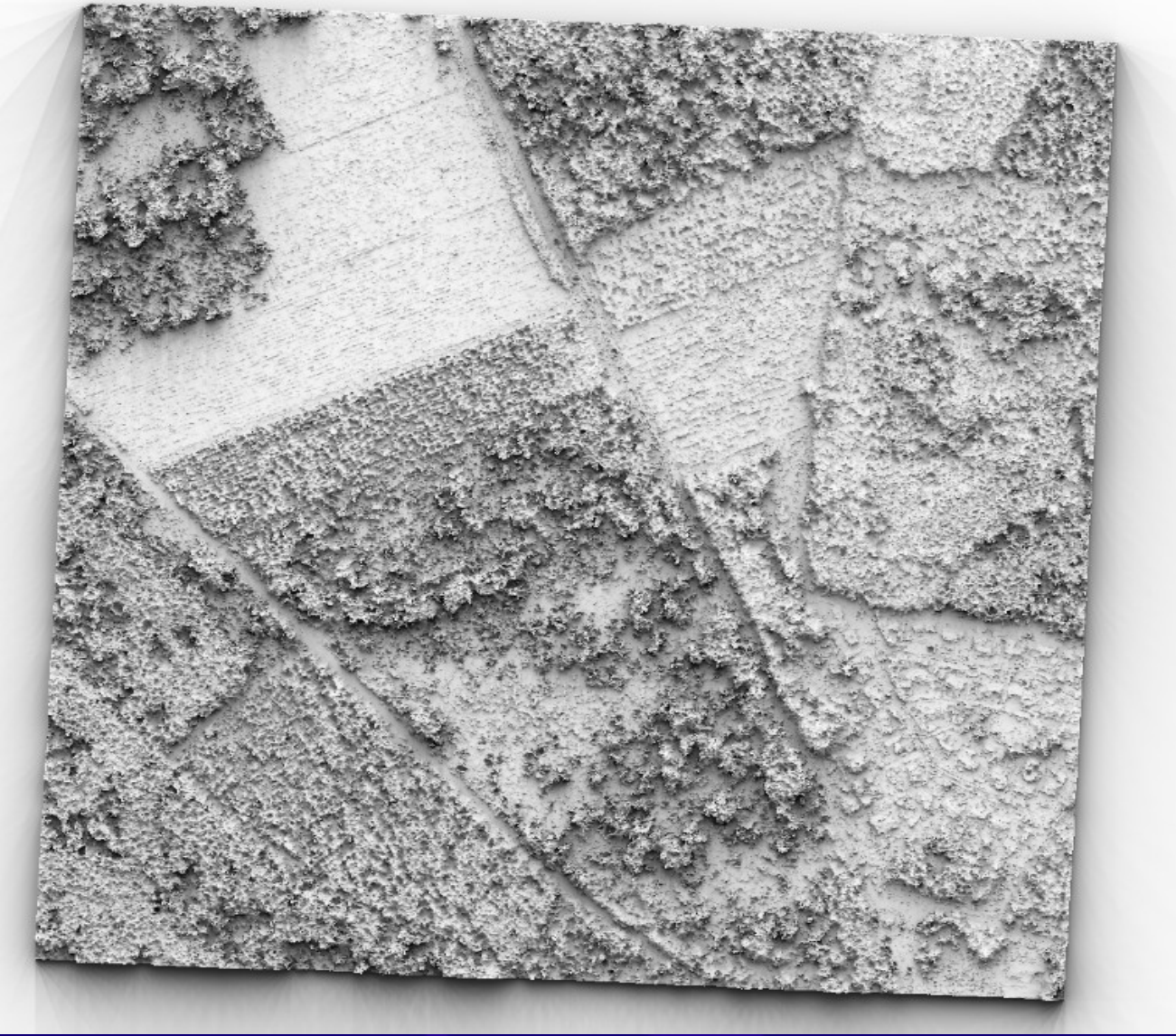
Spatial resolution : 25cm



# Creation of a forest canopy surface model from satellite imagery

Sattelite: Pleiade

Spatial resolution: 70cm



# Difficulties in forest canopy photogrammetric restitution

**(Baltsavias et al., 2008. High-quality image matching and automated generation of 3D tree)**

**(1) little or not texture**
**(2) object discontinuities**
**(3) repetitive objects**
**(4) moving objects (such as shadows)**
**(5) occlusions**
**(6) multi-layered or transparent objects**
**(7) radiometric artifacts**

**Additionaly, when constructing CHM with a lidar DTM :**

**(8) co-registration of photo-DSM and lidar-DTM**

**These problems are even more present in leave-off situation.**

# Case study : Creation of a forest canopy height model from mini-unmanned aerial system imagery

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Where: Felenne (Belgium)

UAS : Gatewing X100

Flight altitude: 225 m

Camera : Ricoh GRIII

Spatial resolution : 8cm

Overlap: 75 %

Surface : 200 ha

**Figure 2.** Elements of orientation of individual areal images are computed by automatic aerotriangulation. Left: one of the 439 images. Right: the aerotriangulated model.

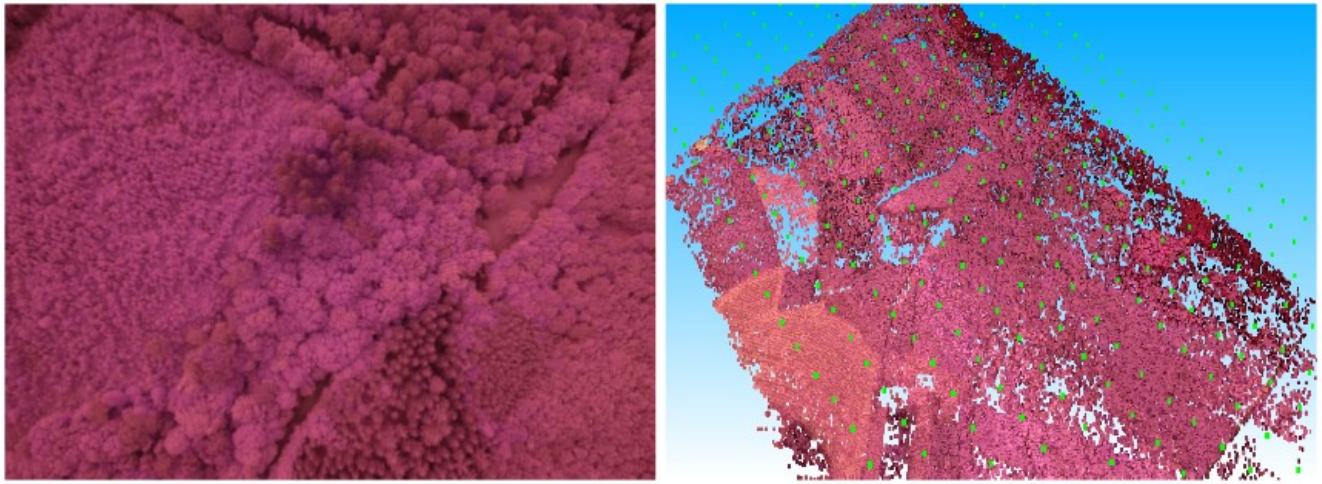
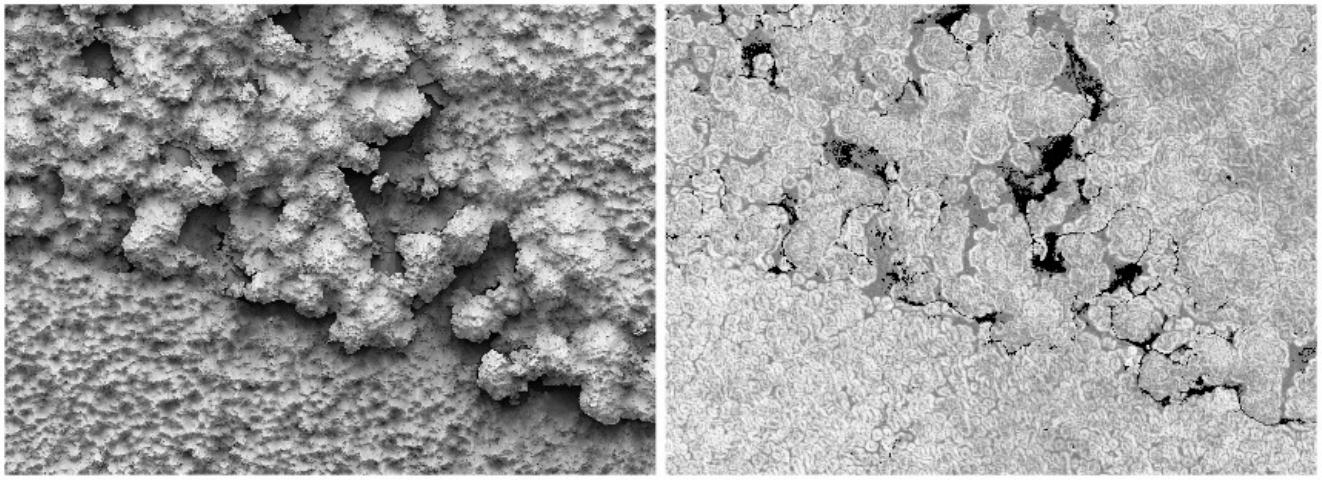
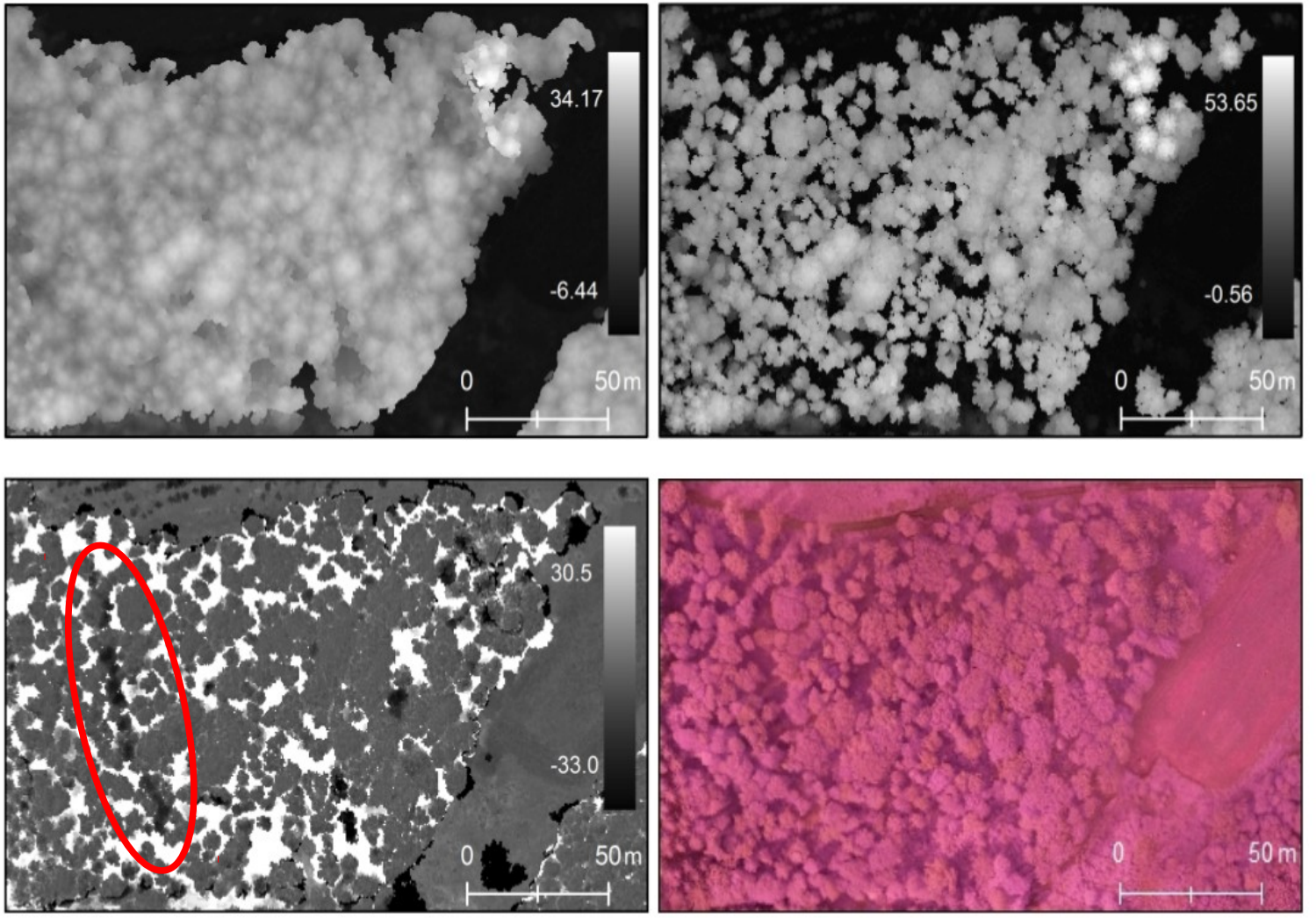


**Figure 3.** Close-up on the canopy surface model. Left: a shaded view of the surface model. Right: Map of normalized cross-correlation score.






Evaluation of lidar and photo Canopy Height Models difference: Top left: photo-CHM (Ground Sampling Distance of 15cm). Top right: lidar-CHM. Bottom left: elevation difference between photo-CHM and lidar-CHM. Bottom right: false color orthophotomosaic.

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# Comparison of photo-CHM with lidar-CHM:

Cloud to cloud distance shows that planimetric standard deviation is about 0.46 m. Altimetric distance reveals the presence of a negative bias of 2.4 cm, attributable to the vegetation growth. Standard deviation in Z distance, for its part, is 0.48 cm.

# Correlation of metrics computed on a 20x20m windows:

**Table 2.** Correlation between photo-CHM and lidar-CHM window metrics.

| | | photo-CHM metrics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | mean | p0 | p25 | p50 | p75 | p90 | p95 | p99 | p100 |
| lidar-CHM metrics | mean | 0.95 | 0.75 | 0.90 | 0.92 | 0.89 | 0.85 | 0.83 | 0.80 | 0.79 |
| | p0 | 0.14 | 0.19 | 0.16 | 0.12 | 0.09 | 0.07 | 0.06 | 0.05 | 0.04 |
| | p25 | 0.82 | 0.75 | 0.86 | 0.78 | 0.69 | 0.62 | 0.60 | 0.57 | 0.55 |
| | p50 | 0.93 | 0.72 | 0.89 | 0.93 | 0.87 | 0.81 | 0.79 | 0.76 | 0.75 |
| | p75 | 0.93 | 0.62 | 0.81 | 0.92 | 0.97 | 0.95 | 0.93 | 0.91 | 0.90 |
| | p90 | 0.89 | 0.56 | 0.74 | 0.85 | 0.95 | **0.98** | **0.98** | 0.97 | 0.96 |
| | p95 | 0.86 | 0.54 | 0.71 | 0.83 | 0.93 | **0.98** | **0.98** | **0.98** | 0.97 |
| | p99 | 0.84 | 0.51 | 0.69 | 0.80 | 0.90 | 0.96 | 0.97 | **0.98** | **0.98** |
| | p100 | 0.80 | 0.49 | 0.66 | 0.76 | 0.87 | 0.92 | 0.94 | 0.95 | 0.96 |

Comparison of photo-CHM metrics with forest variables
(Dominant height in decidious stand):

$$Hdom = a + b * p100 + c * p95 + d * p90$$

Residual standard error: 1.531 m, (7.8%)
Multiple R-squared: 0.8599

# Case study : Creation of a forest canopy height model from mini-unmanned aerial system imagery

**Take home messages:**

**Photogrammetric canopy height model equivalent in Smoothed lidar-CHM (mainly due to occlusion)**

**Photogrammetry in vegetation area require specific Tuning of dense-matching algorithm**

**Dominant height may be predicted with an mean Residual of 1.5 m in decidious stand.**

# 3- Tools and proposed actions

# Numerous existing softwares :

| | |
|---|---|
| Open (and free) | Bundler PMVS<br>Visual SFM<br>MicMac-Apero |
| low-cost | Agisoft Photoscan |
| Upload (free) | Solution Arc3D<br>Solution 123DCatch |
| Commercial | Solution acute3D<br>Solution pix4D |

IGN photogrammetry suite characteristics :

Intended for professionnals (GIS experts, archaeologists, architects, geomorphologists ...)

More complex use , no « one bottom press » solution ;

Provide fine tuning opportunity for each steps ;

Handle large amount of data ;

Generate intermediate (and final) results in open format (can be used in separate pieces) ;

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Background :

2003 : developpement of self-calibrating bundle block adjutment and urban DEM dense matching script

2005 : setting up XML user interface, software is called MicMac;

2007 : open source repository;

2008 : developpement of Apero (tool for orientation) ;

2010 : training sessions and developpement of simplified interfaces (without XML);

2012 : “culture 3d” project : Windows port, binaries distribution.

# Why a summer school ?

Importance of photo acquisition :

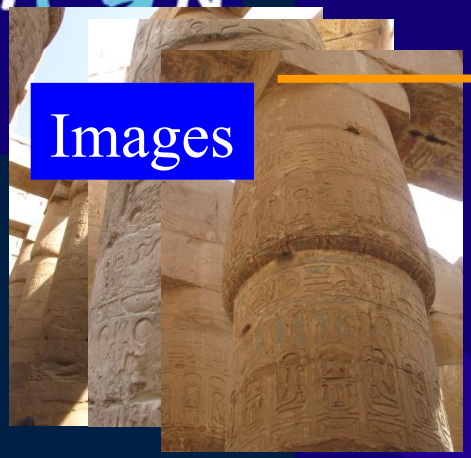
Once you know the process, key stage is acquisition time :

Take “good photo” (contrast, noise, no blur)

Take enough  photo

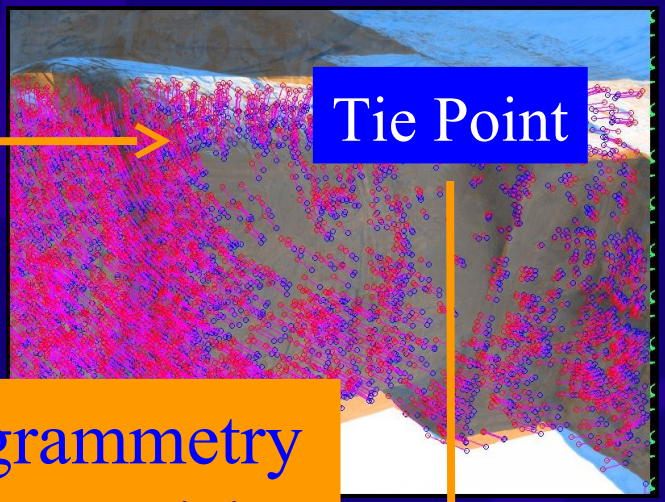
Take the good angles

# Standard Pipeline for 3D photo modelization



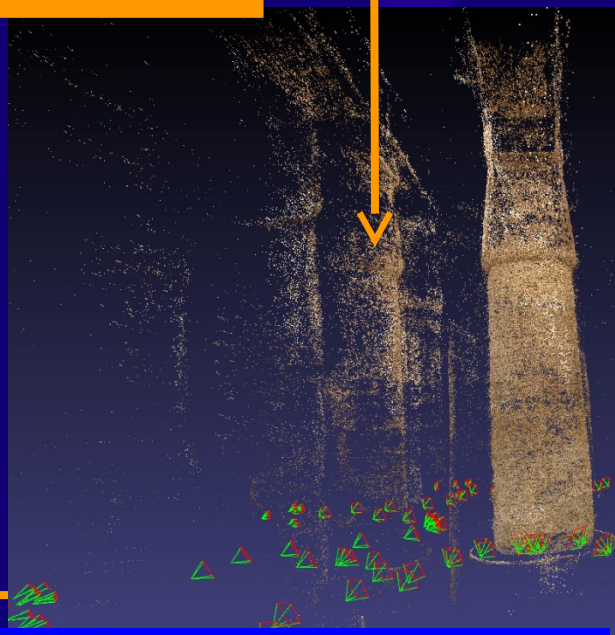
Images

Image processing



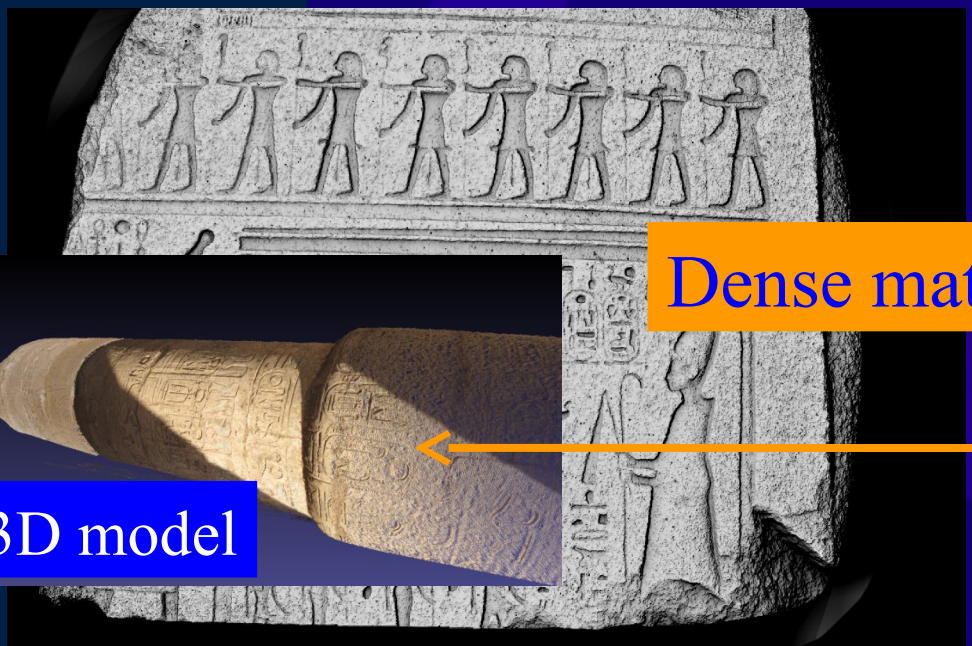
Tie Point

Photogrammetry
Computer Vision



Orientation, calibration

Dense matching



3D model

Proposed summer school :

- 3 to 4 days, week of 19 to 23 August 2013

- In Forcalquiers, south of France (pré Alpes)

- Topics :

  - Fundamental of photogrammetry

  -Learning the IGN's open source suite on simple case;

  -Test cases on forestry (aerial and satellite, UAV, terrestrial);

  -Table ronde and discussion for research and development


Thank you for your attention.

*Slides avalaible on :*
*http://orbi.ulg.ac.be/handle/2268/144562*

# Questions ?

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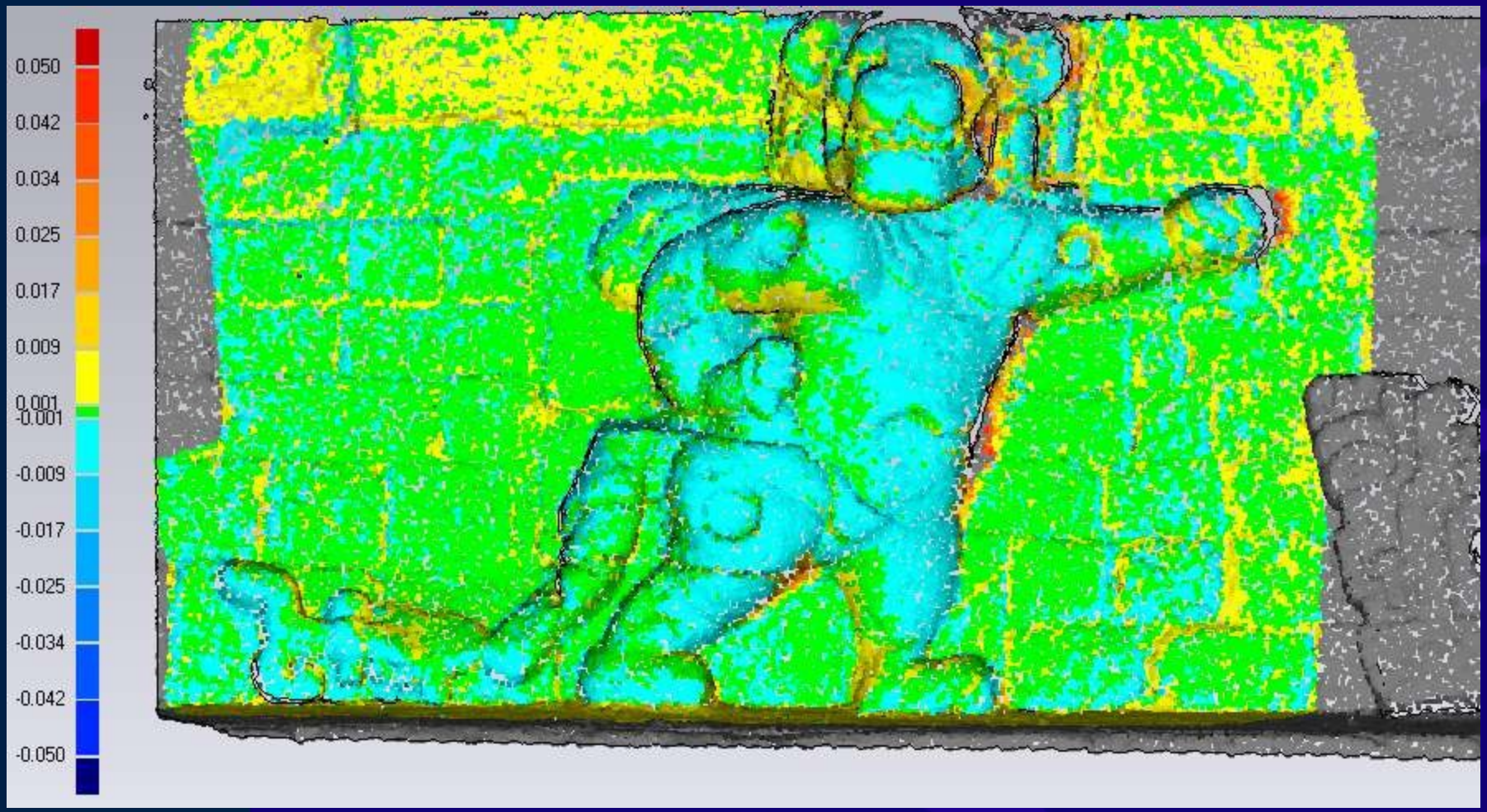
# Précision ?

"Autour du pixel "

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