

Free open source photogrammetry with MICMAC

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- 1- **What?** (What is photogrammetry ?)
- 2- **Why?** (What is photogrammetry useful to ?)
- 3- **How** (How does it work ?)
- 4- **How** (Free open source solution)

1- **What?** (What is photogrammetry ?)

*The science/art/technical of doing
geometric measurement (3D model)
from photos*

An object you want to measure / modelize :



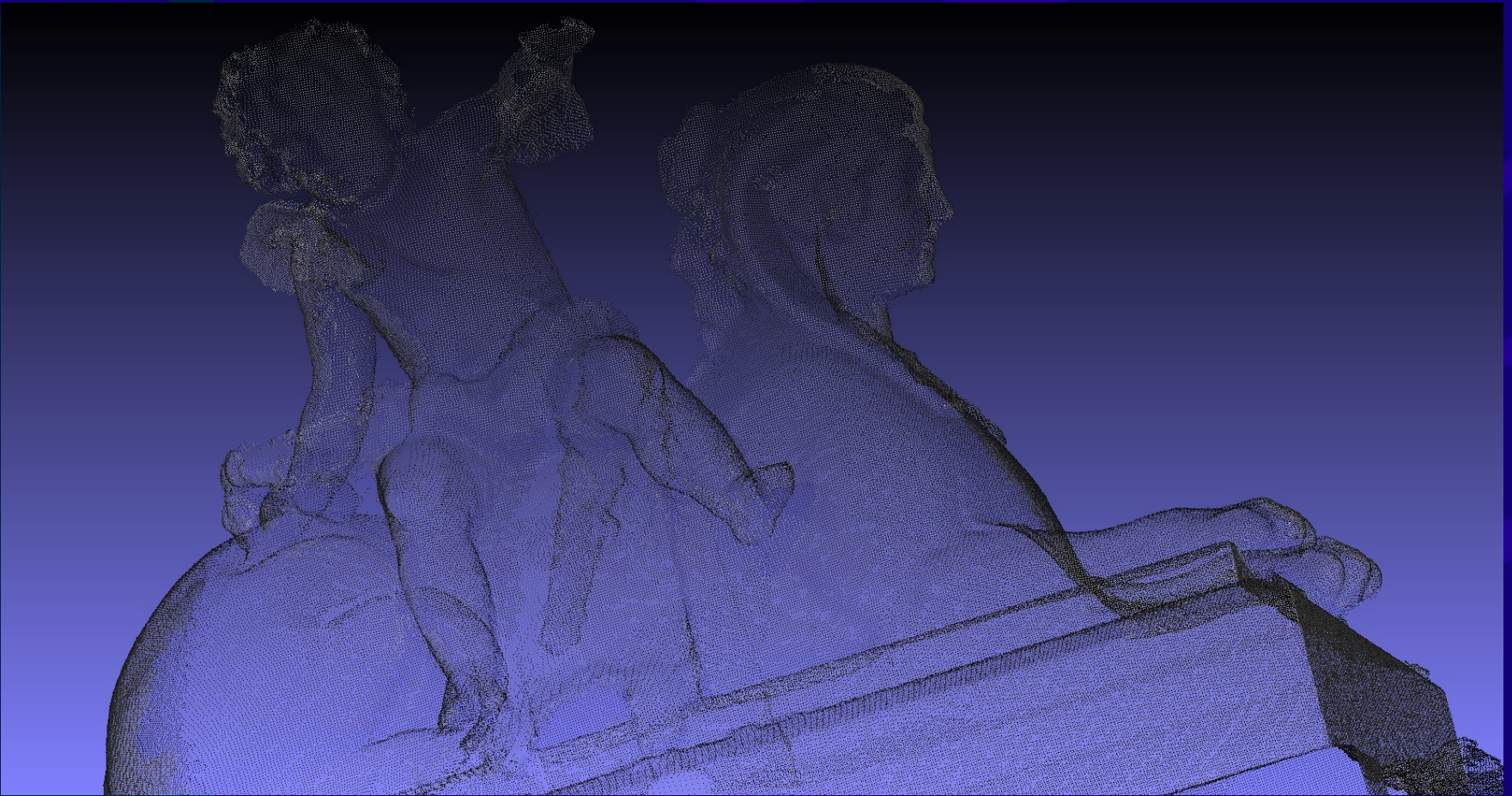
Take many (good) photo



Process the data :



Get the 3D model :



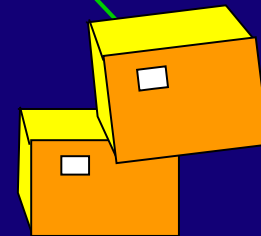
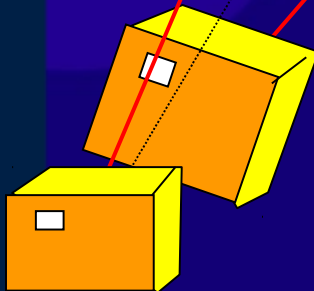
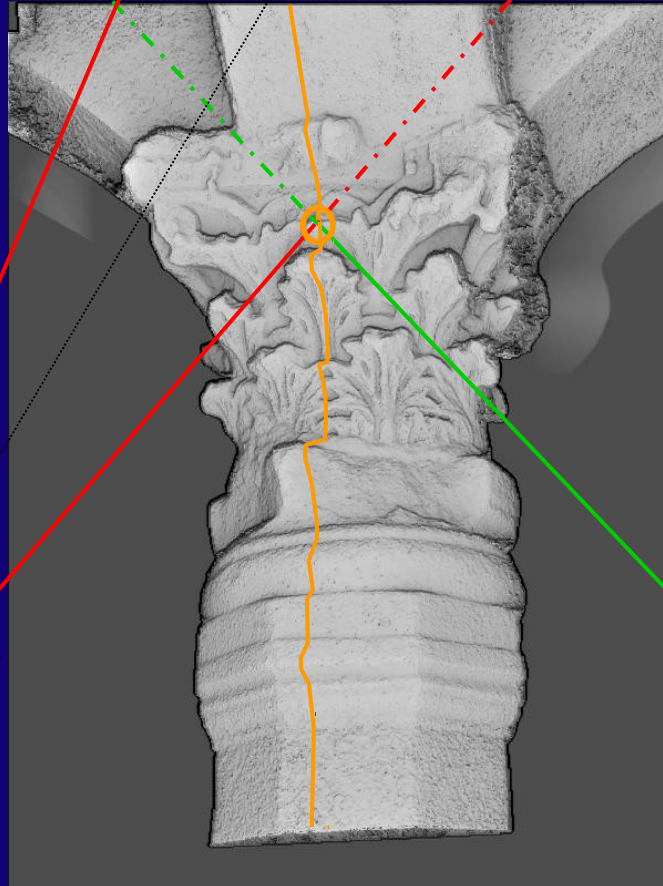
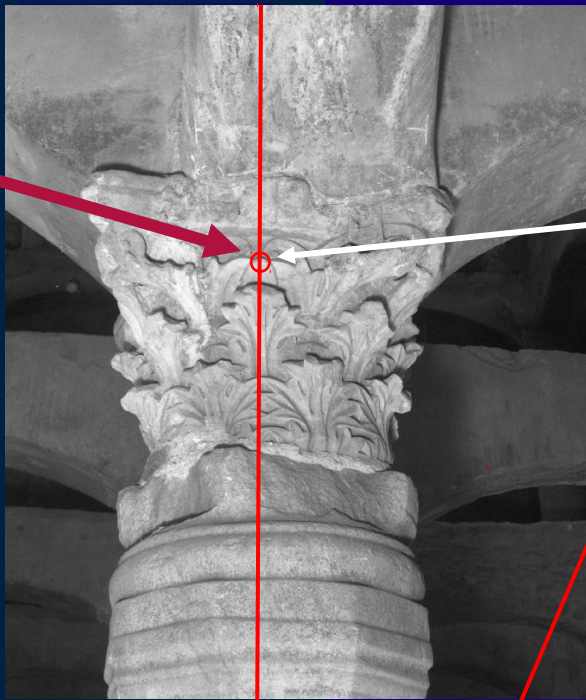
Point cloud



Textured point cloud

How is it feasible ?

3d modelization with photogramm  trie



2- **Why?** (What is photogrammetry useful to ?)

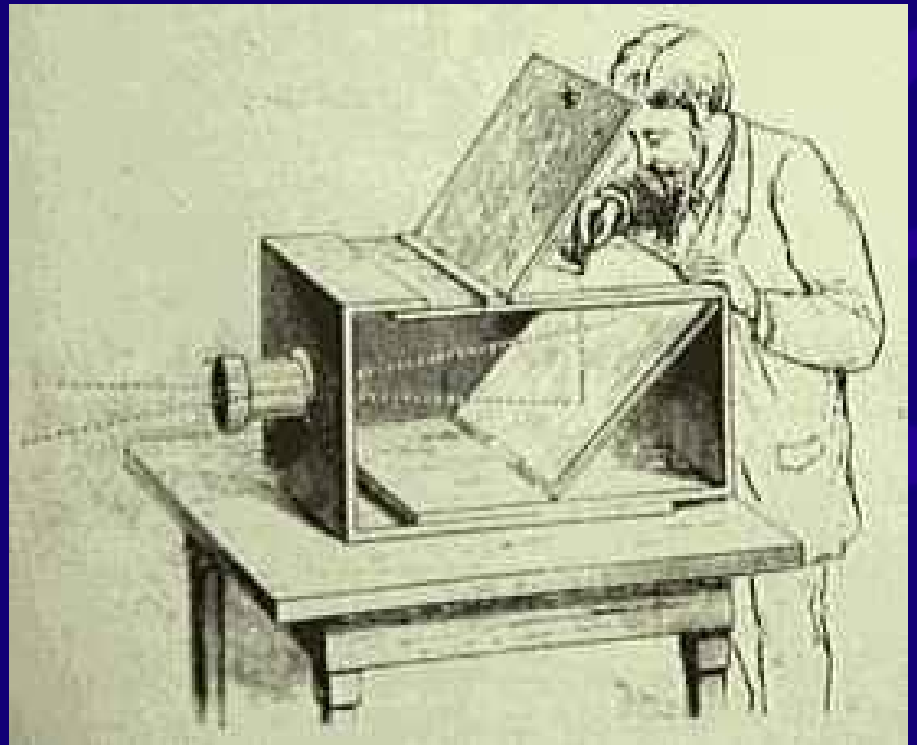
*A technique useful for 3D modelisation
(cost effective and accurate).*

Image based geometric measurement :

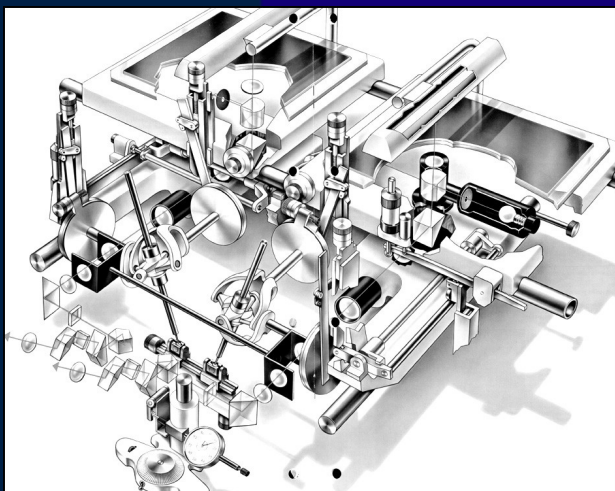
A very old technic
(more than 150 years)



Aymé Laussedat
(1819-1907)



Until beginning of 2000 years,
photogrammetry was seen



An old technic



**Requiring specialized hardware
and operator.**

Less accurate, automatic and complete than LIDAR

Technological context, constant evolution in vector, sensor and processing:

Development of digital camera;

Development of satellites for earth observation

Development of UAV

Développement of computing power (CPU-GPU -Cloud Computing);

Development of processing methods (photogrammetry-computer vision-image processing).

⇒ *Cost effective mean of geometric measurement*

Today, various application domain for
engineer , scientist

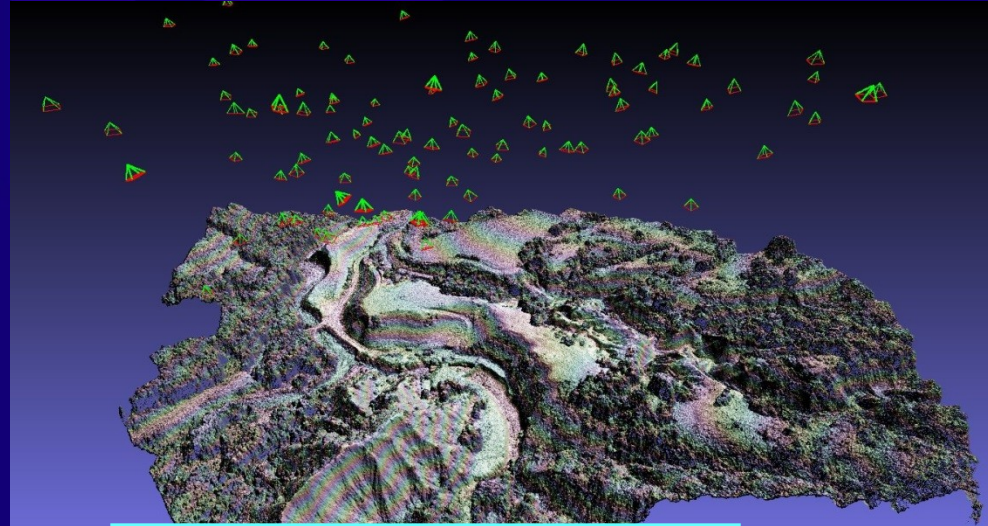
Environnemental

Patrimonial

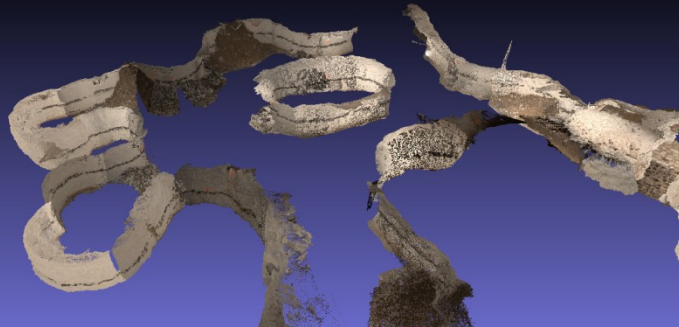
Industrial

Forestry

...



Measuring soil erosion

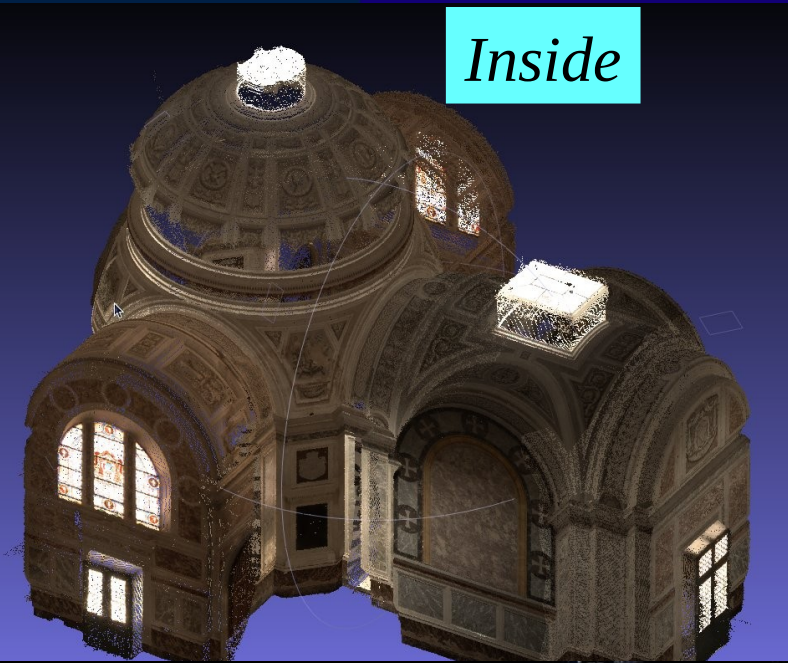


3D models of caverns



Measuring soil rugosity.

Inside



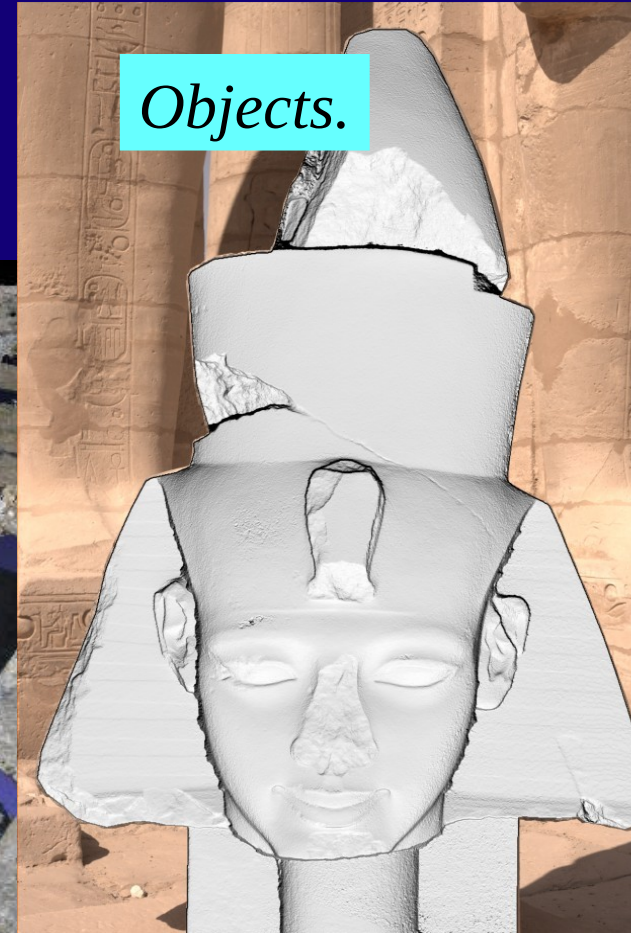
Patrimonial.

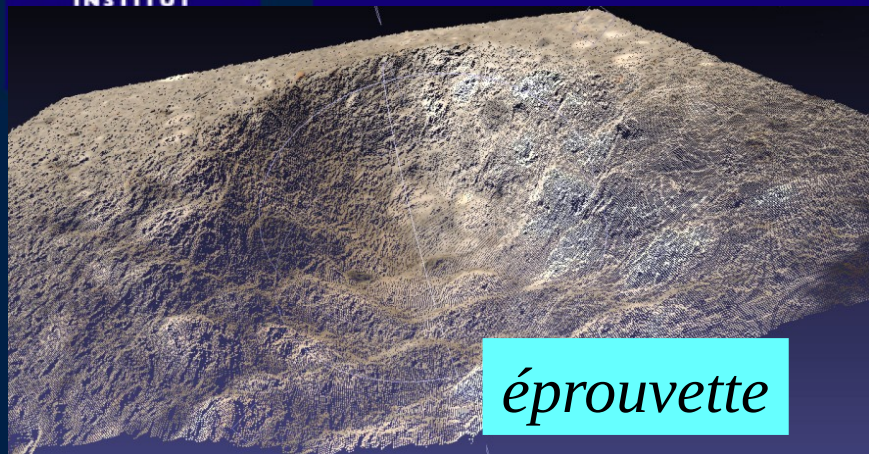
*Scientific measurement.
Communication tools.*

Outside (UAV)

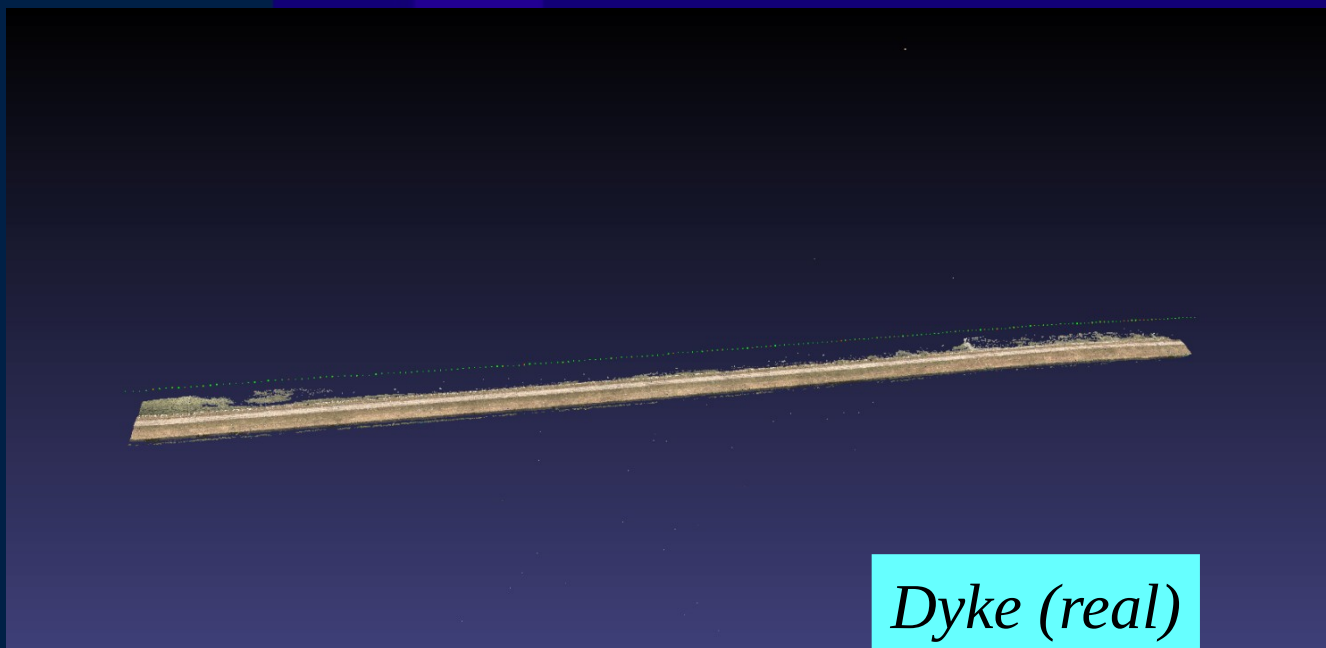
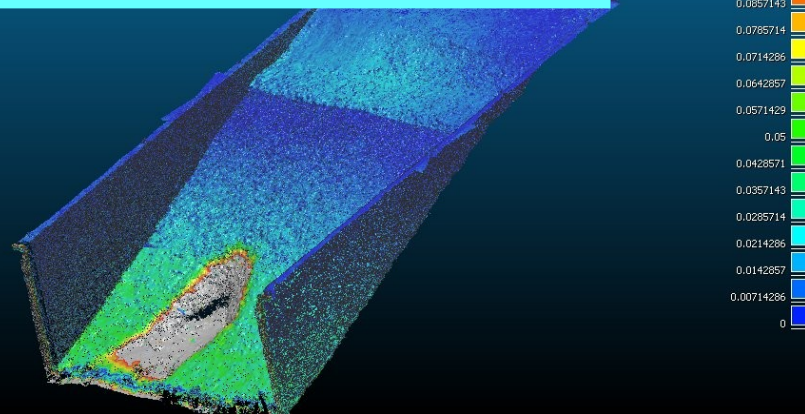


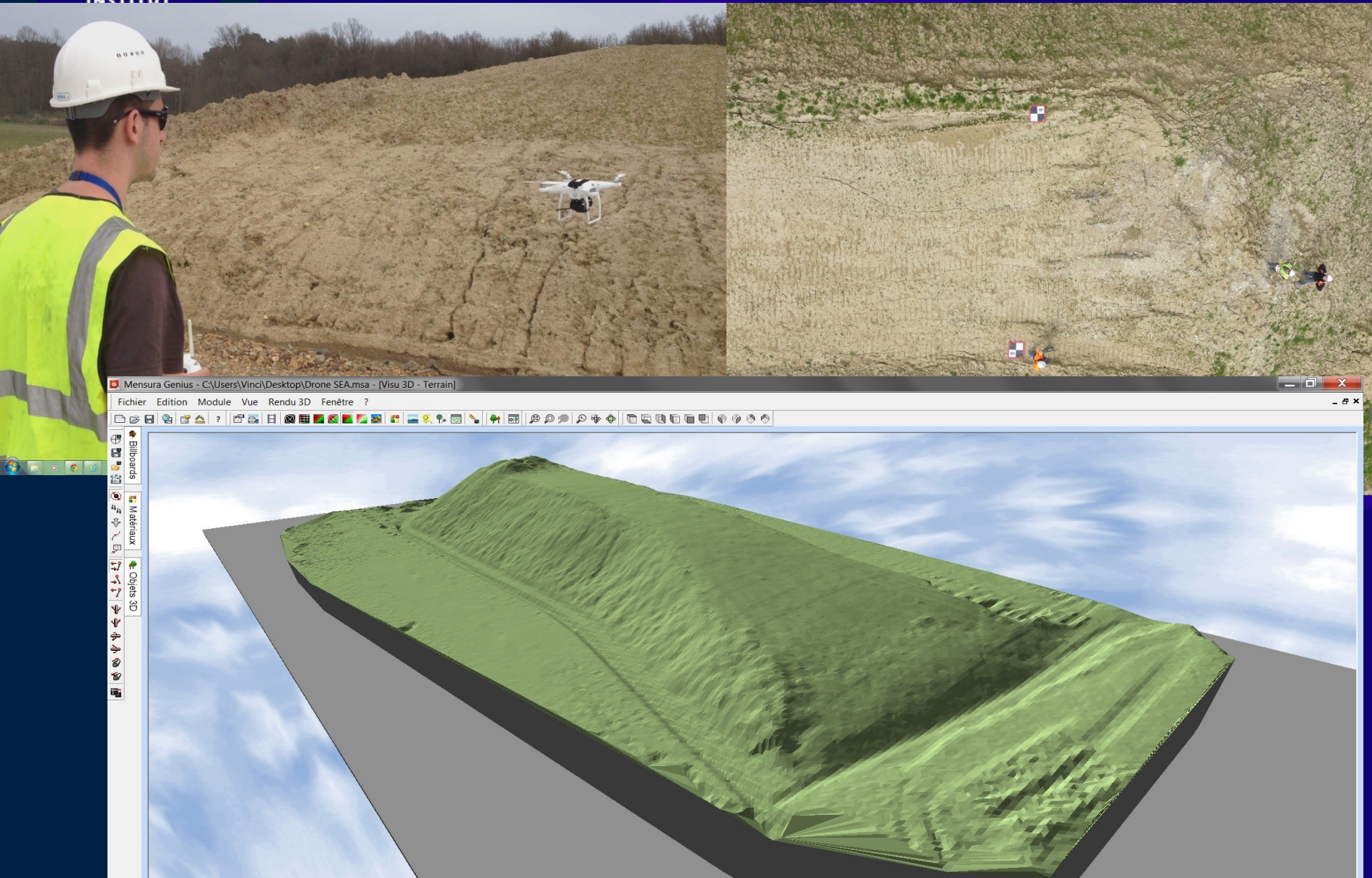
Objects.

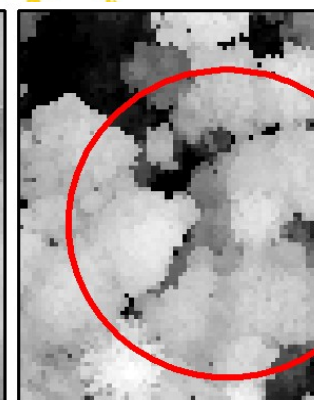
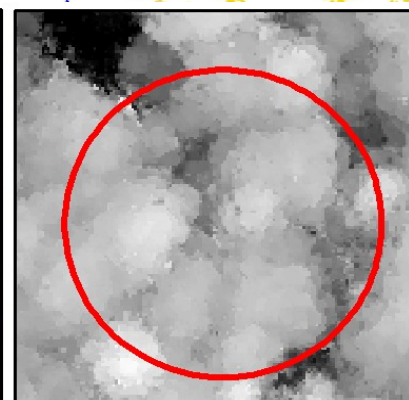
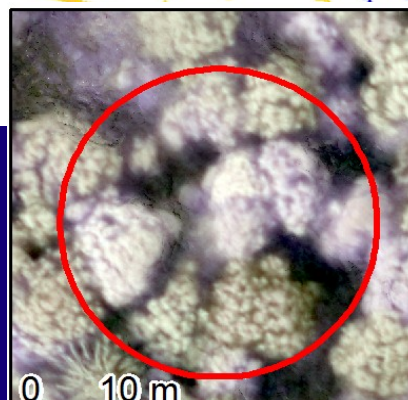
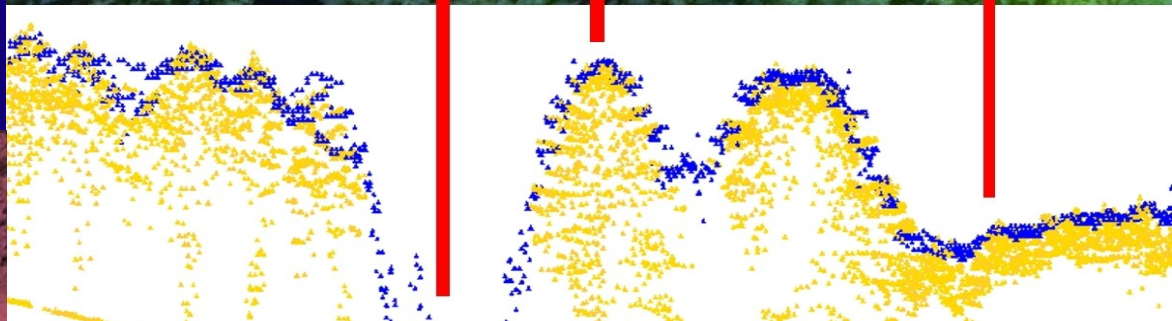


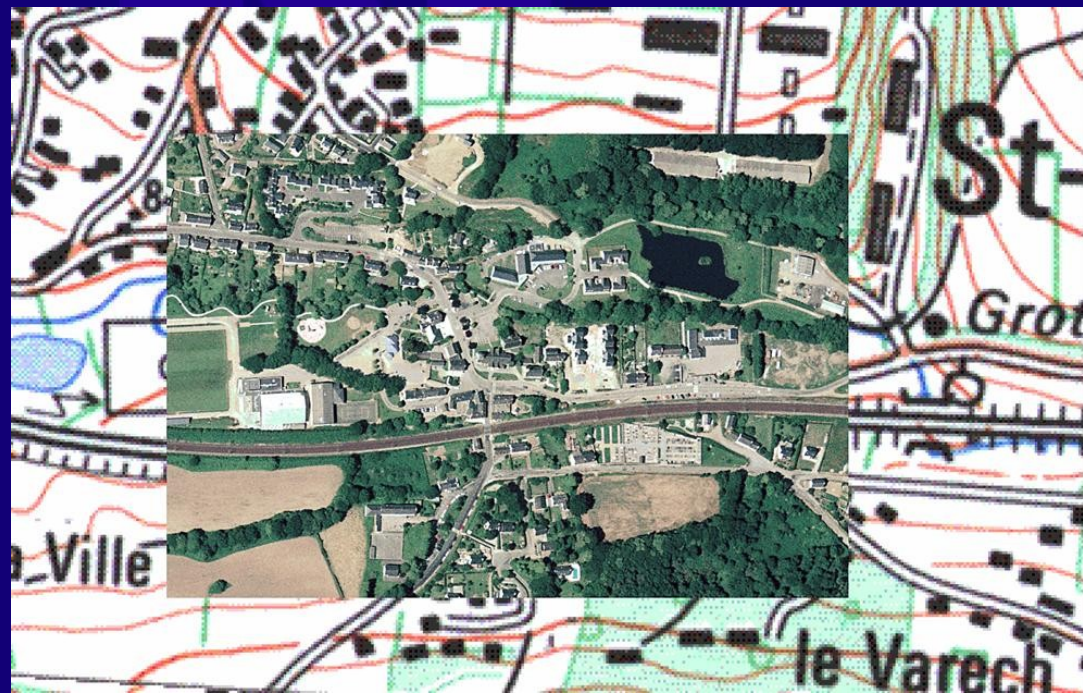
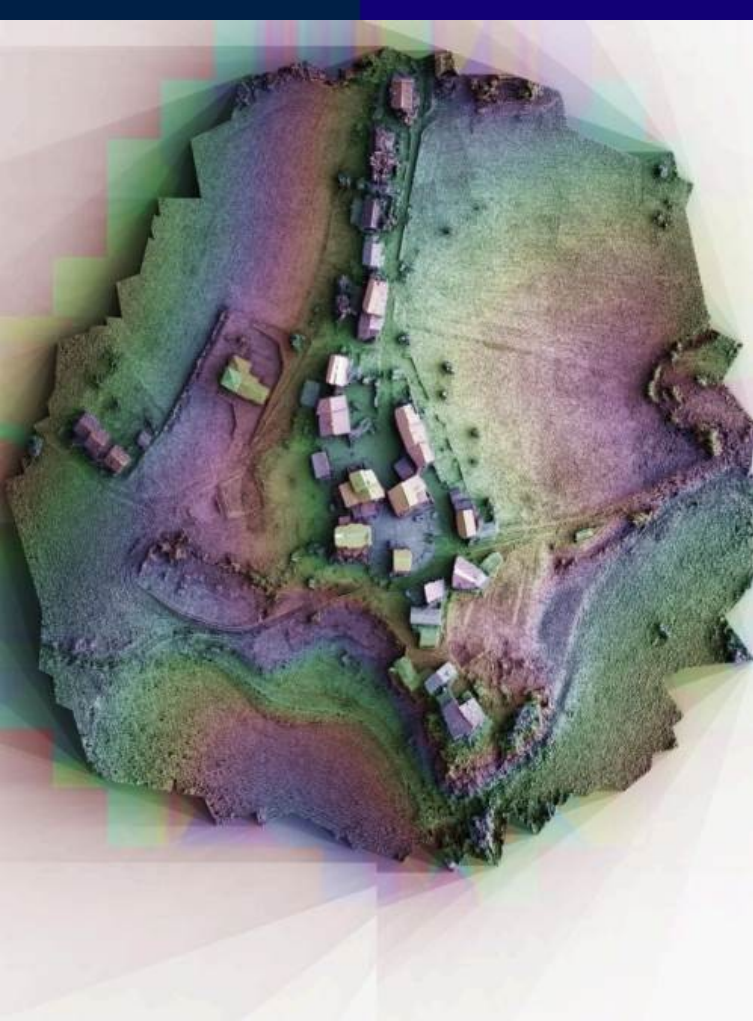


Modèle réduit de digue





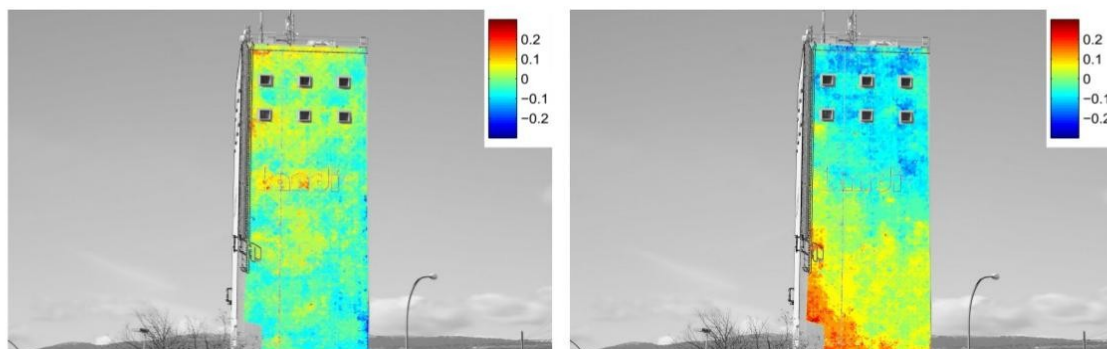




*And of course
cartography....*



Deformation (« optical correlation ») , using a fixed camera on a pod:



(a) Disparités horizontales [px].

(b) Disparités verticales [px].

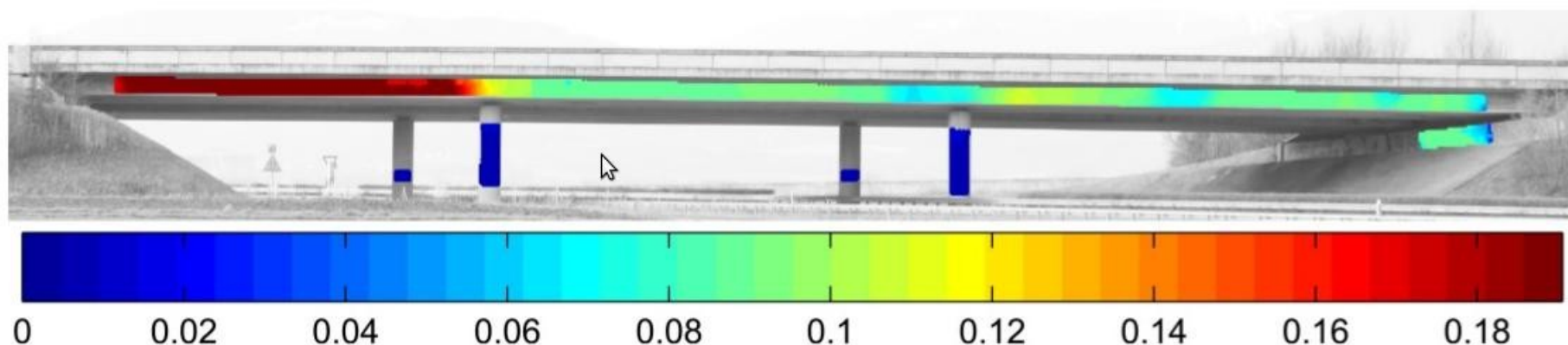
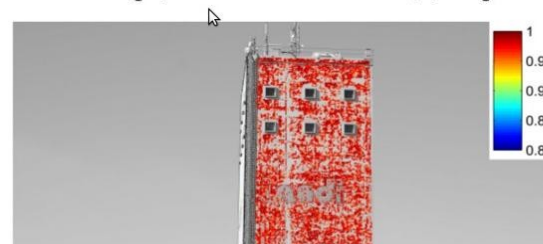


FIGURE 7.6 – Images 75-89 : Disparités verticales [px].

Currently a tool for scientist .

Soon , used by people ?

Soon , used by people ? for :
3D printing

*3D printing,
requires 3D model :*



*Photogrammetry :
a cost effective tools to input 3D models in 3D printers.*

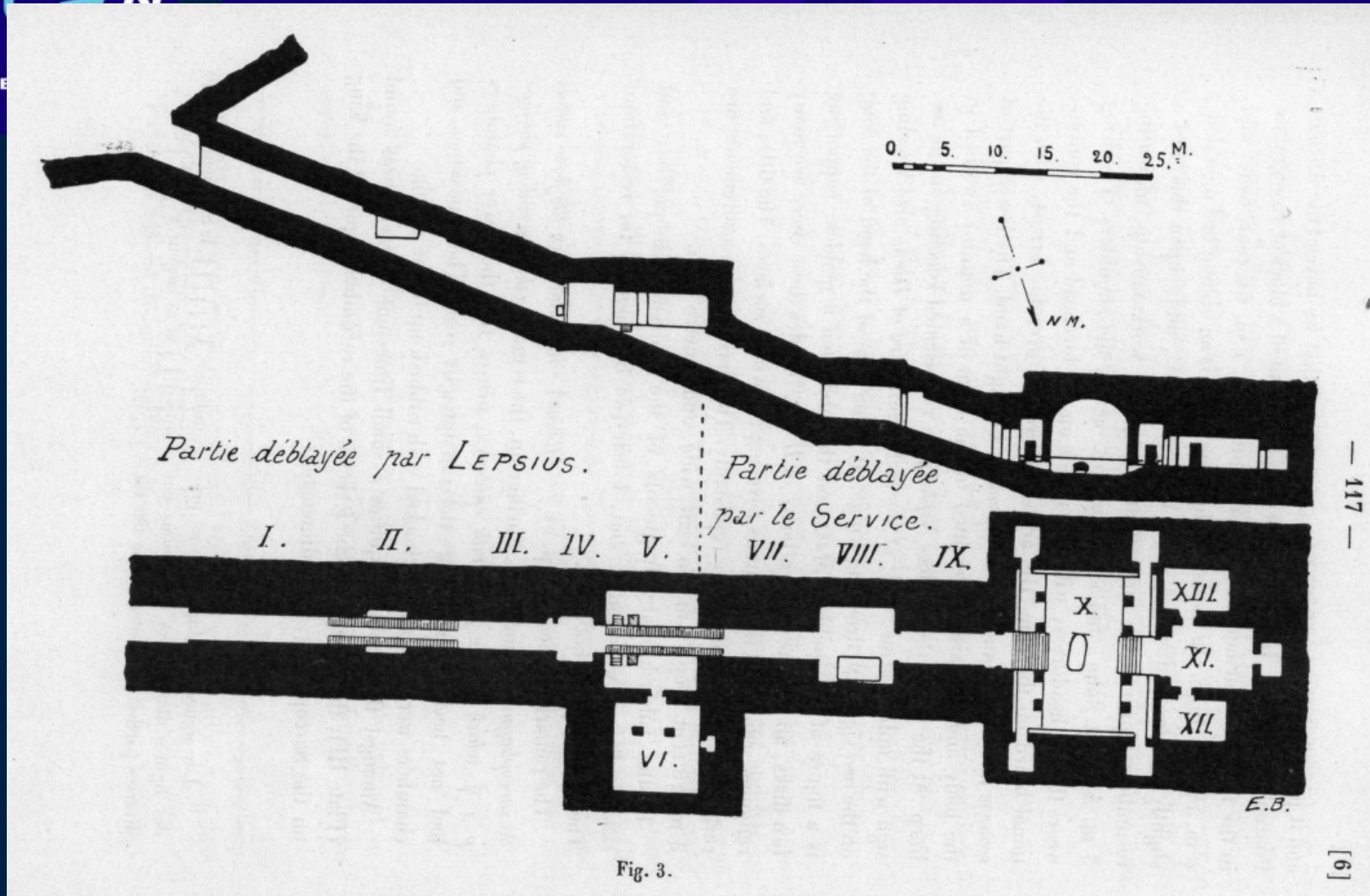
Soon , used by people for :

3d measuring
tool for DIY



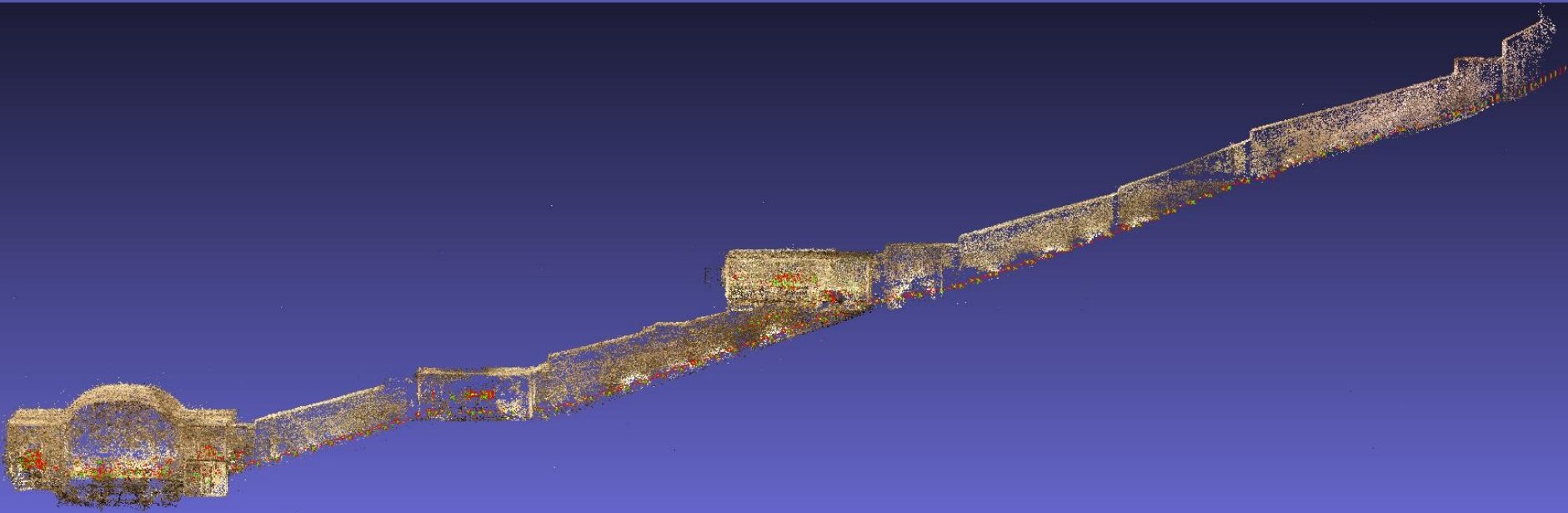
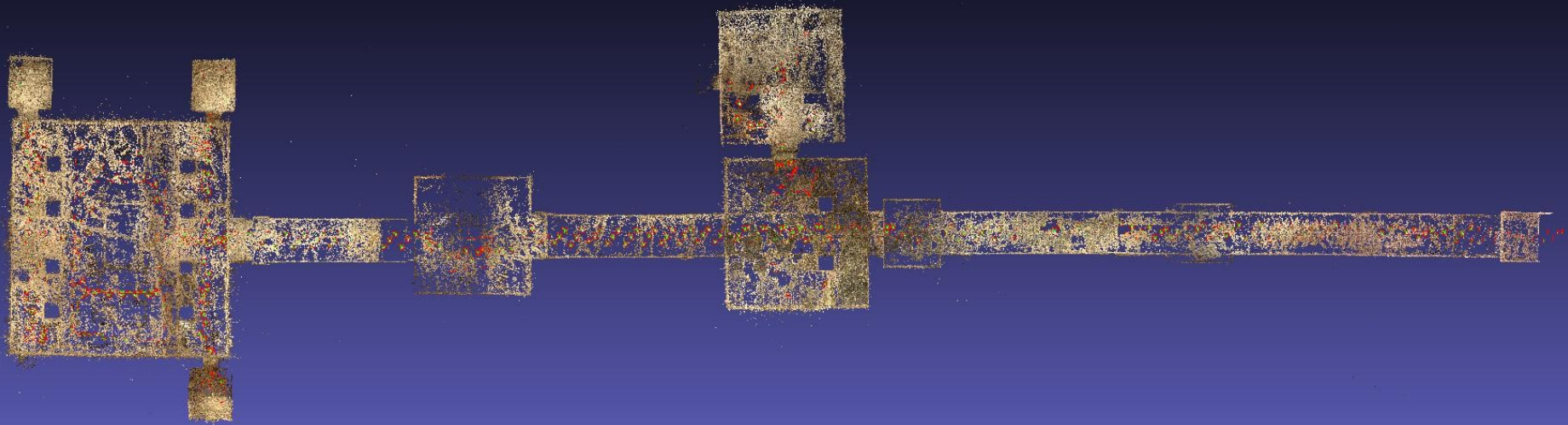
*Photogrammetry & 3D model,
a cost effective tools to take any quotation.*

DIY, need a 3D plan of your flat



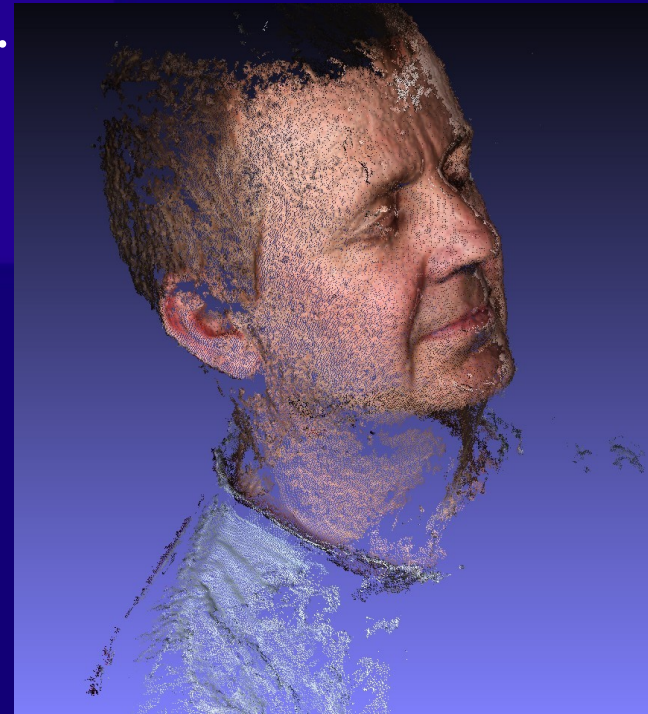
Exemple of a « very big flat », 1000 m², 100 m long.
(Meremphah's tomb, in king valley).

...photogrammetry.



*Photogrammetric « plan » of the tomb, accuracy
2-3 cm (on 100 meter length).*

Soon , used by people ? For fun



3- **How** (How does it work ?)

*The pipeline of 3D modelisation
(a bit of technique ...).*

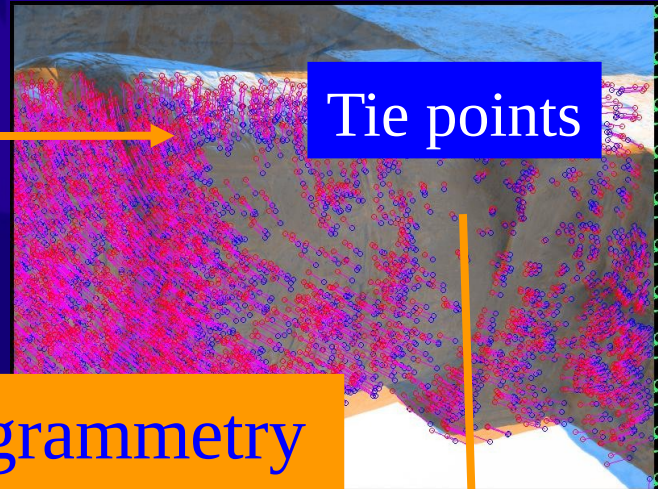
Standard processing flow for image based 3D modelization

Images processing

Images



Tie points



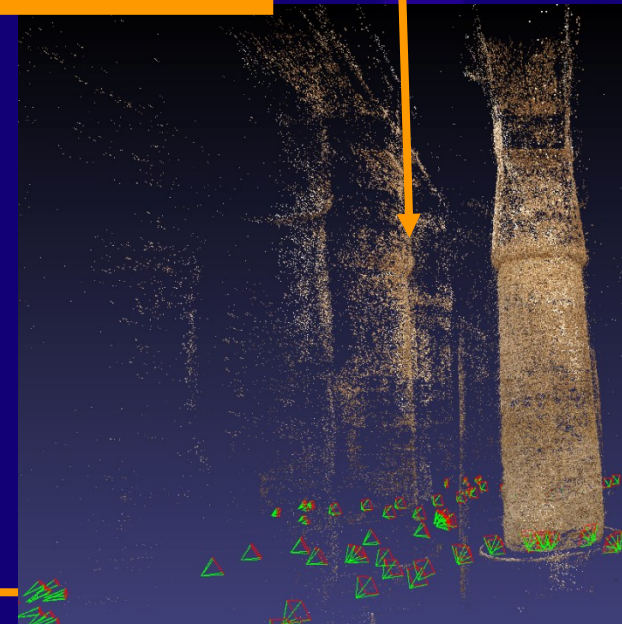
Photogrammetry
Computer vision

Dense matching

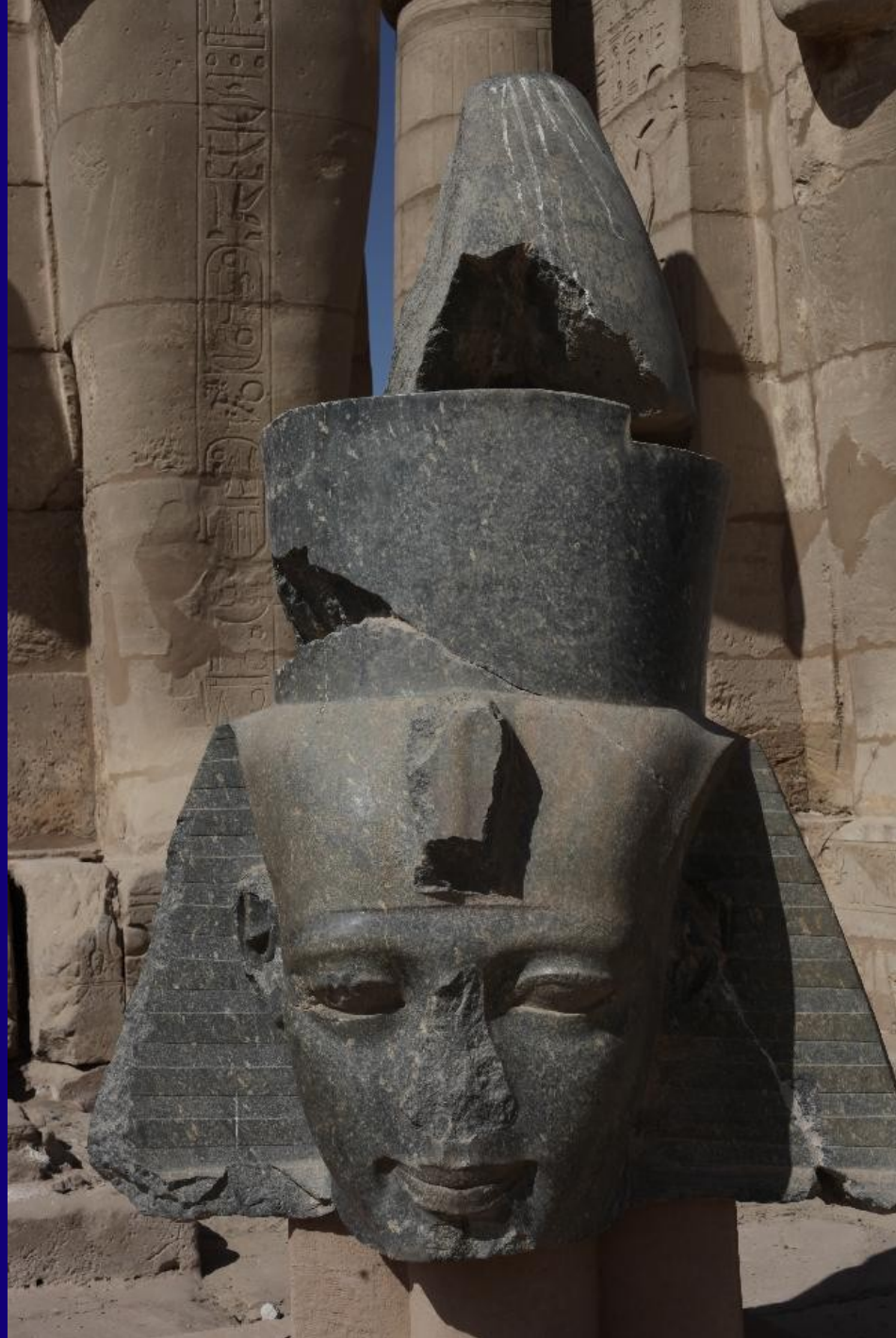
3D Model



Orientation, calibration



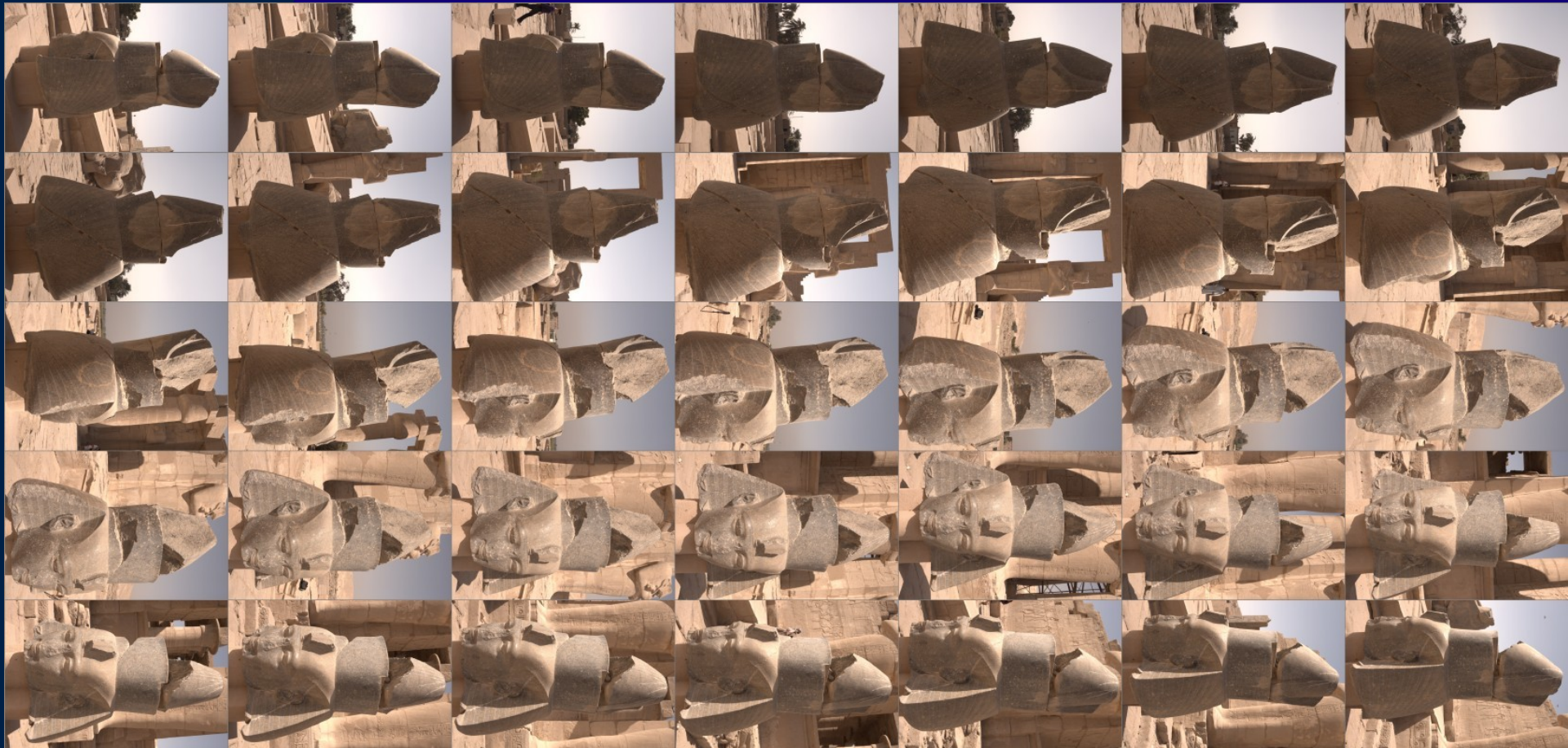
Suppose we want
Ramses II's head
3D model



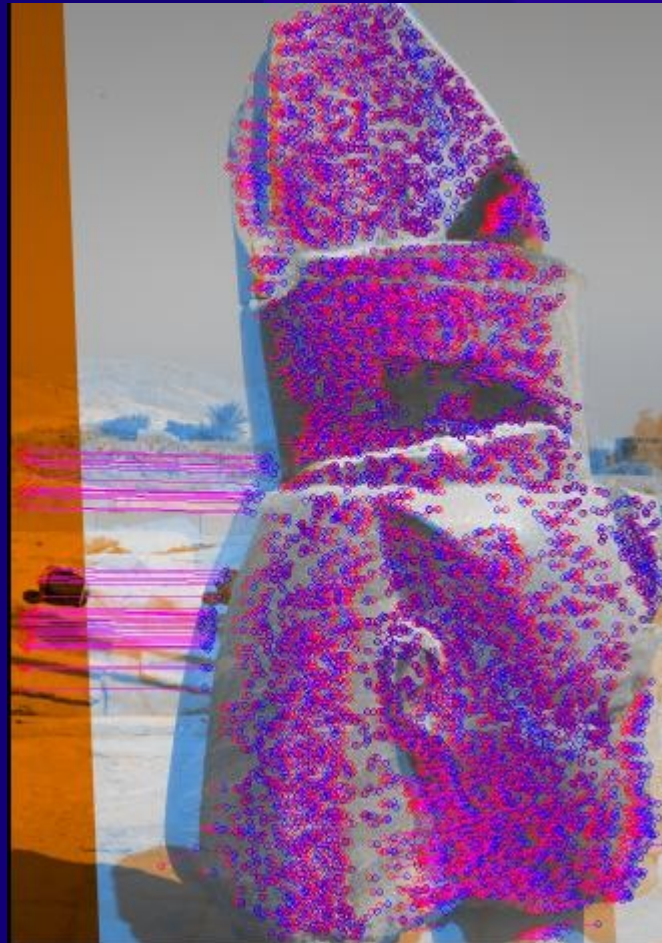
First of all : take photo



Many photos ...” never” too many photos

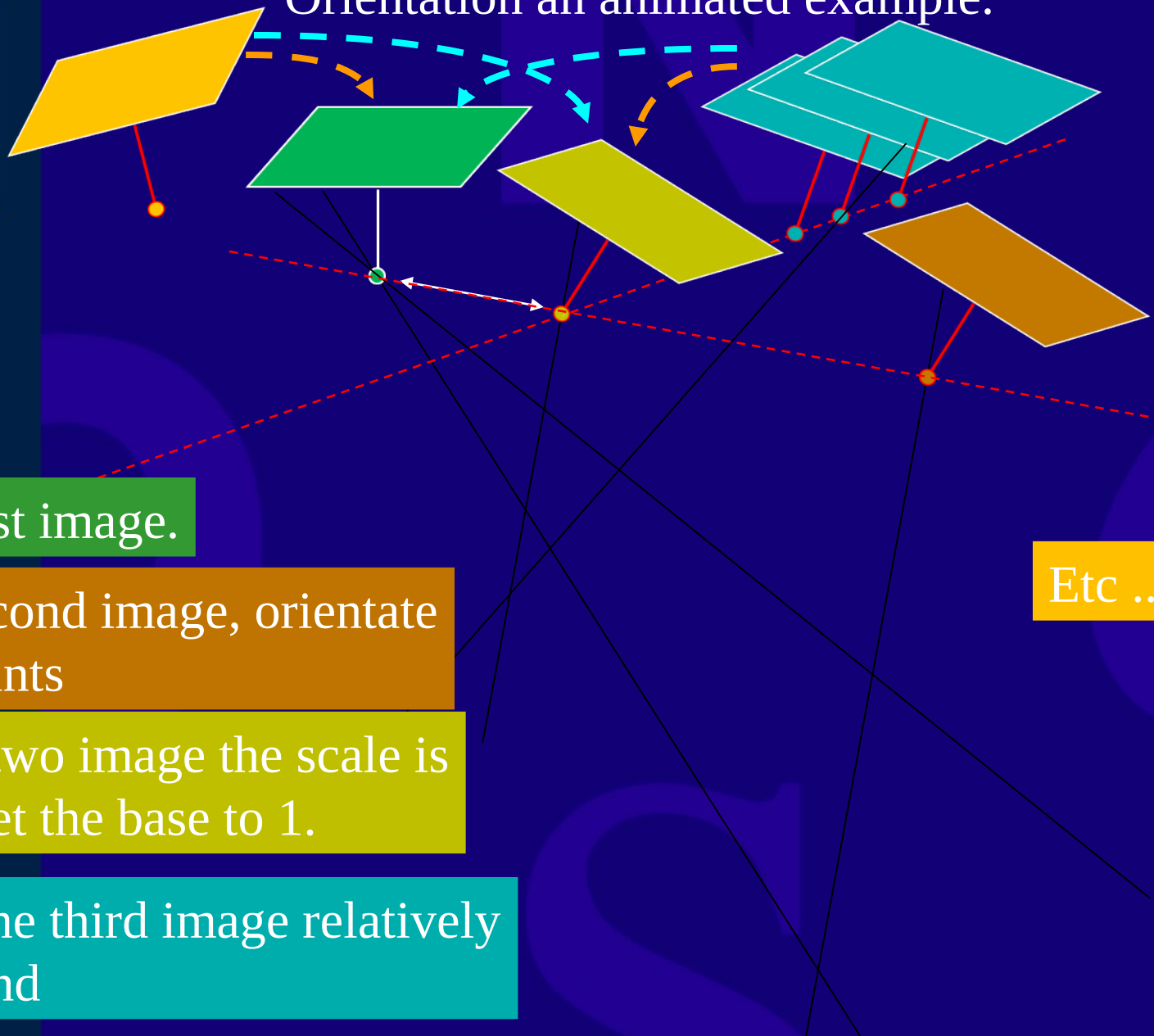


Tie points : example of sifts results with closed point of view



Sift : good invariance to scaling, rotation and contrast.

Orientation an animated example.



Select a first image.

Select a second image, orientate with tie points

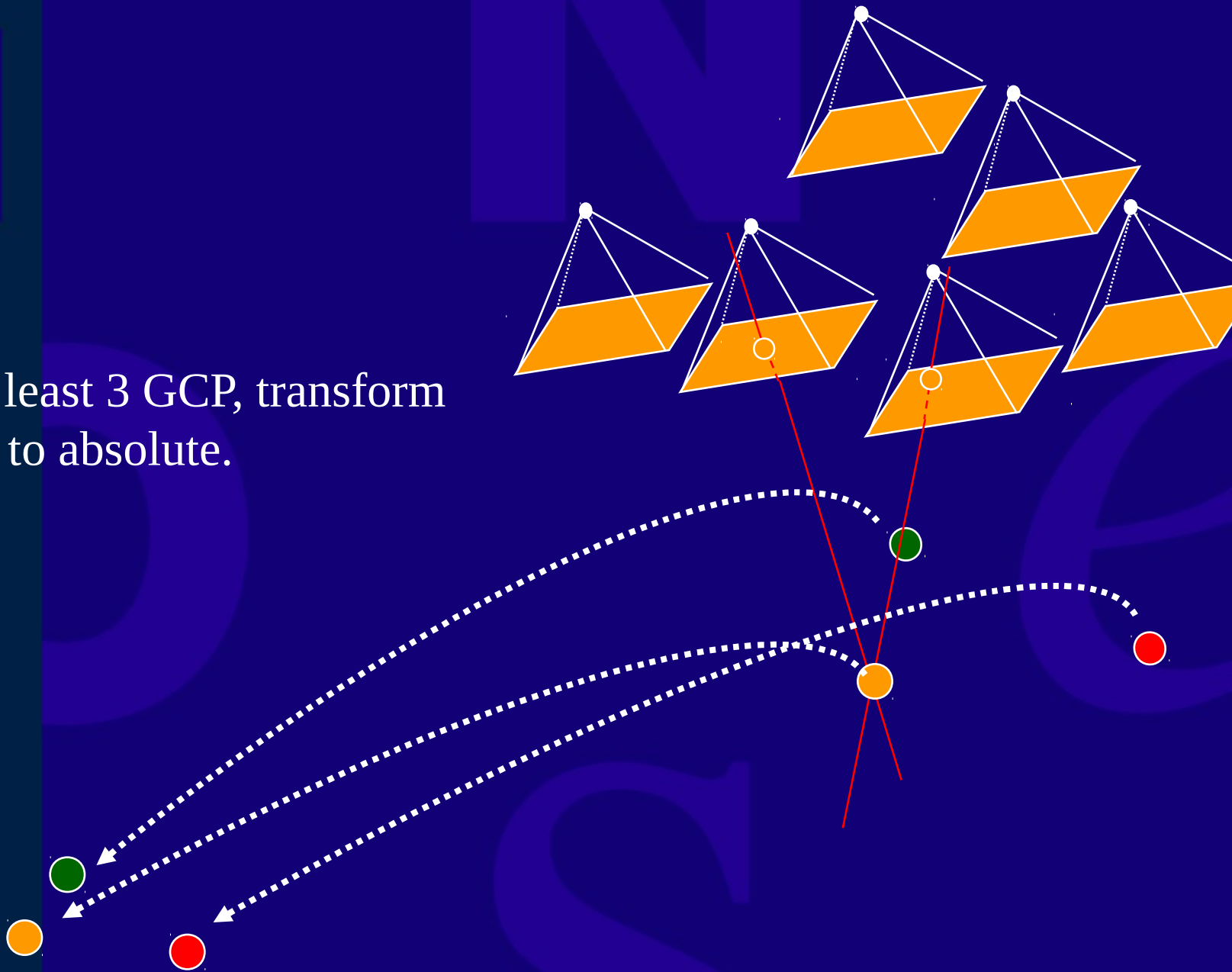
With only two image the scale is arbitrary, set the base to 1.

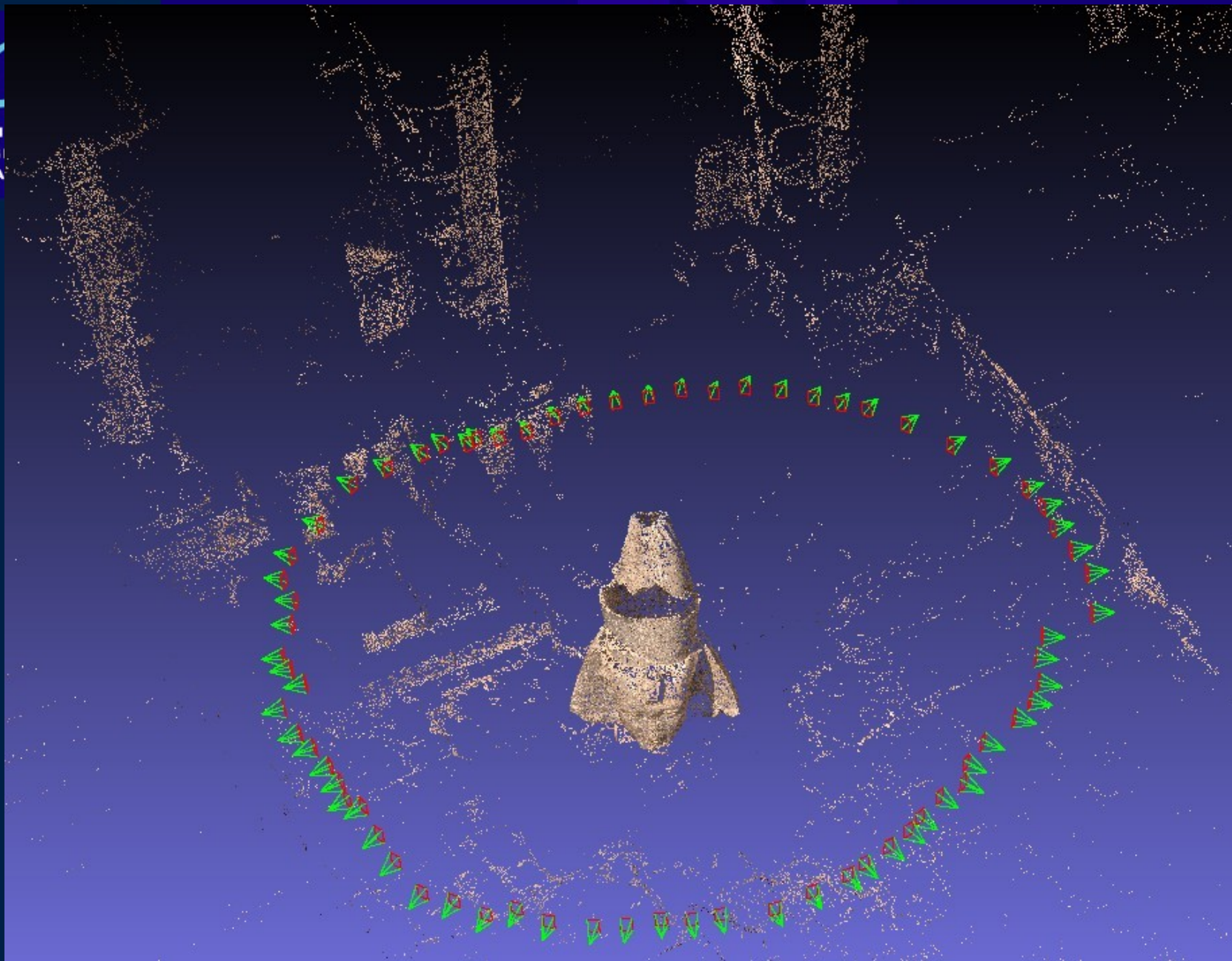
Orientate the third image relatively to the second

Use also the first image to compute the length of the base

Etc

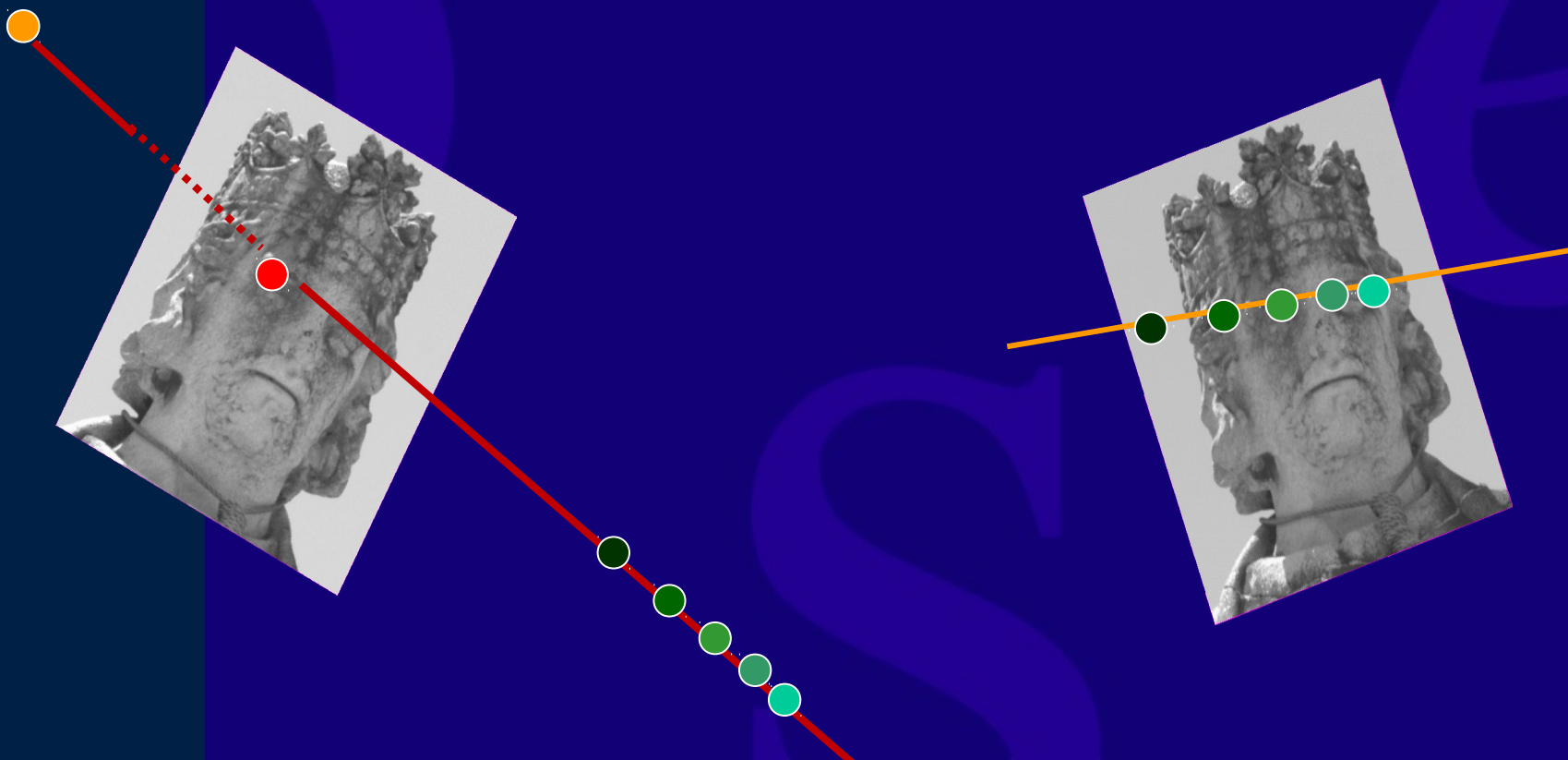
With at least 3 GCP, transform
relative to absolute.



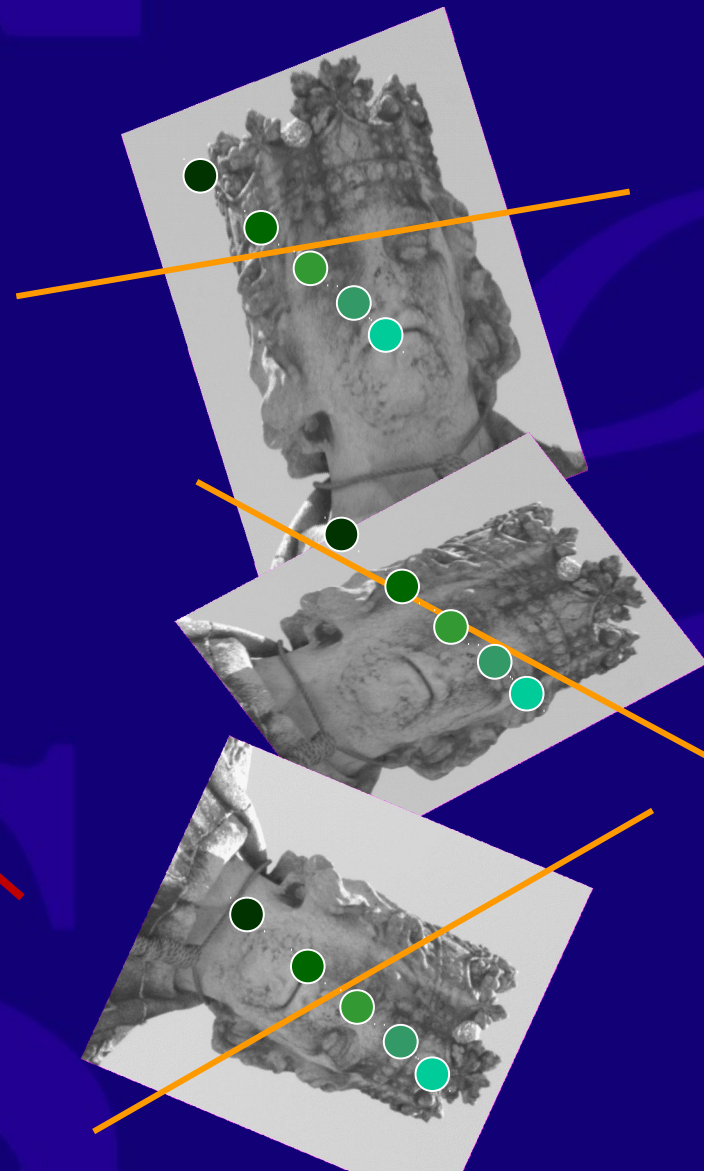
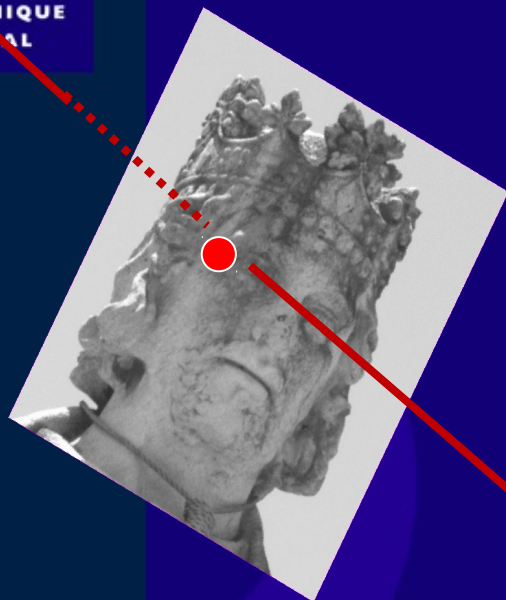


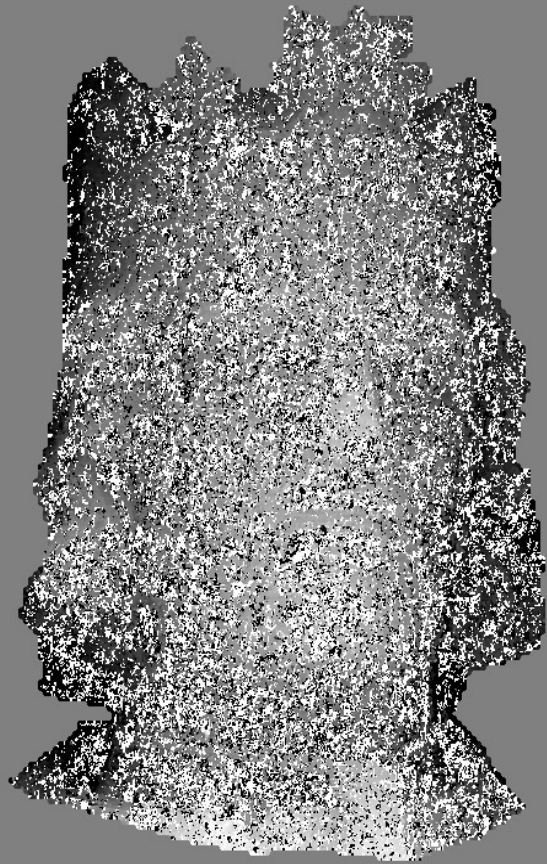
MicMac (and many others) general principle :

Parse the discrete depth and select the depth leading to the best similarity (window correlation).

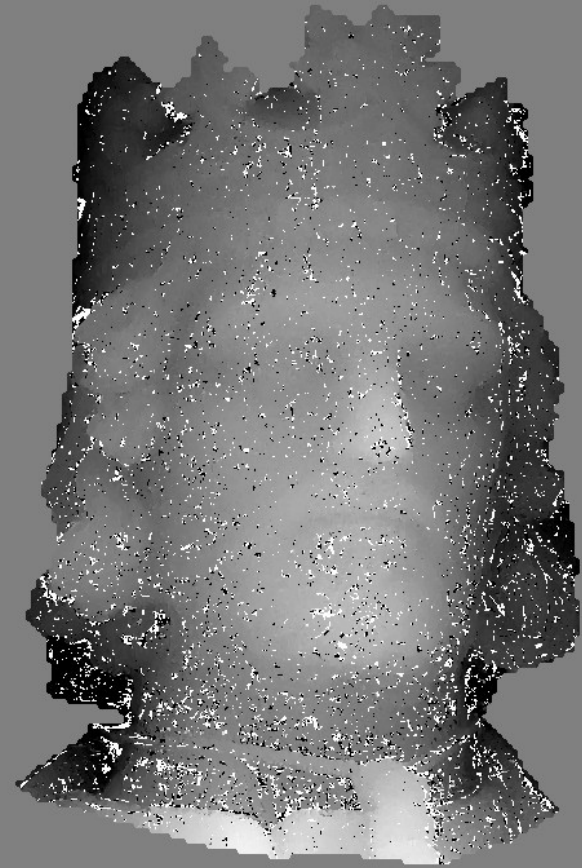


Multiple image matching.





2 images



4 images

Multi Scale/ Multi Resolution / Coarse to fine

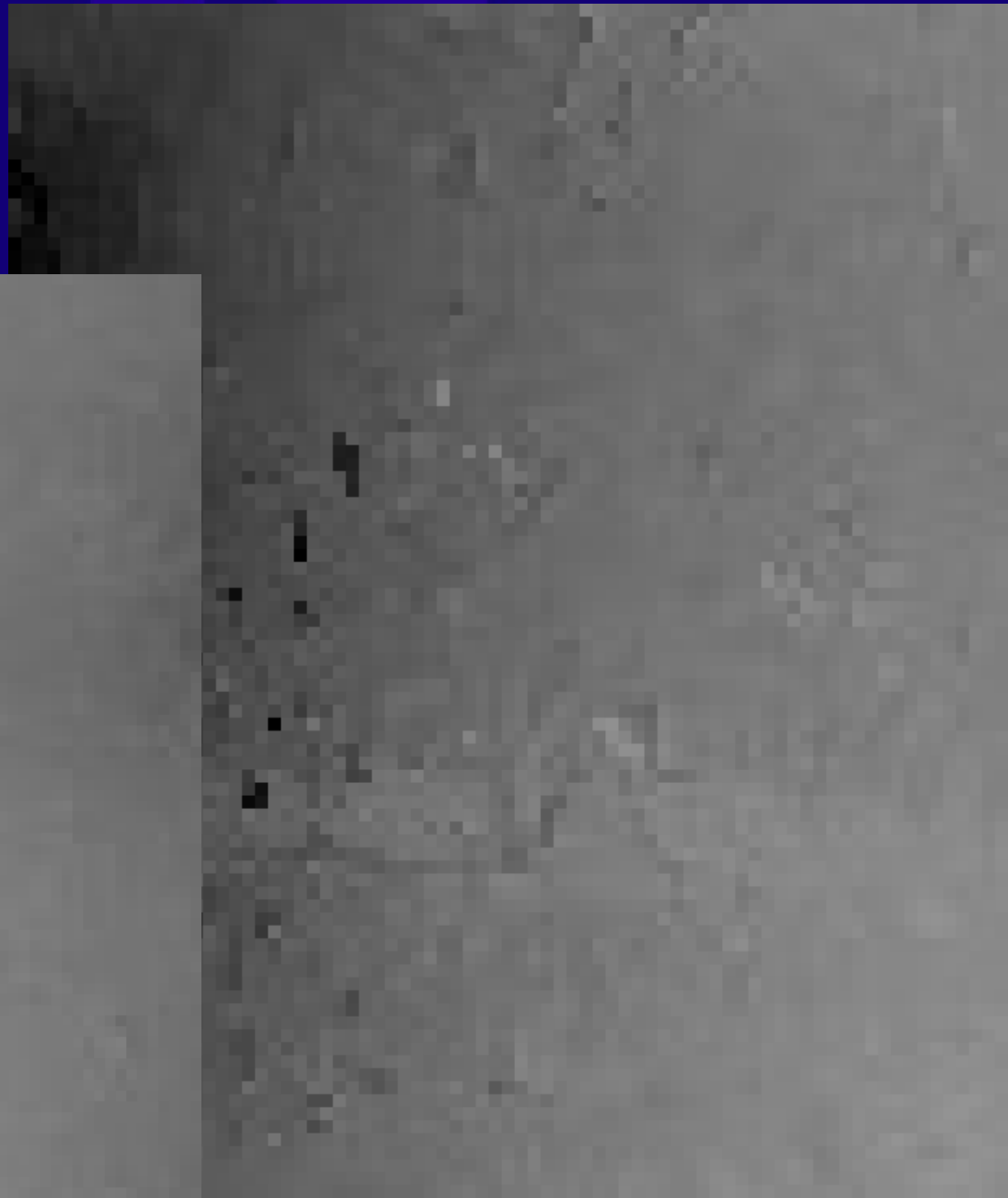
Compute image pyramid.



Solution evolution at different steps.



Remain some noiset:

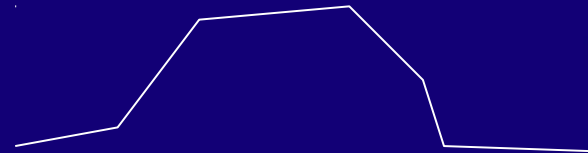


The “ideal” solution should comply with:

- 1-Match points with maximum similarity
- 2- Be regular (a priori knowledge)

We want to specify that :

Likelihood of solution 1



Is greater than likelihood of solution 2



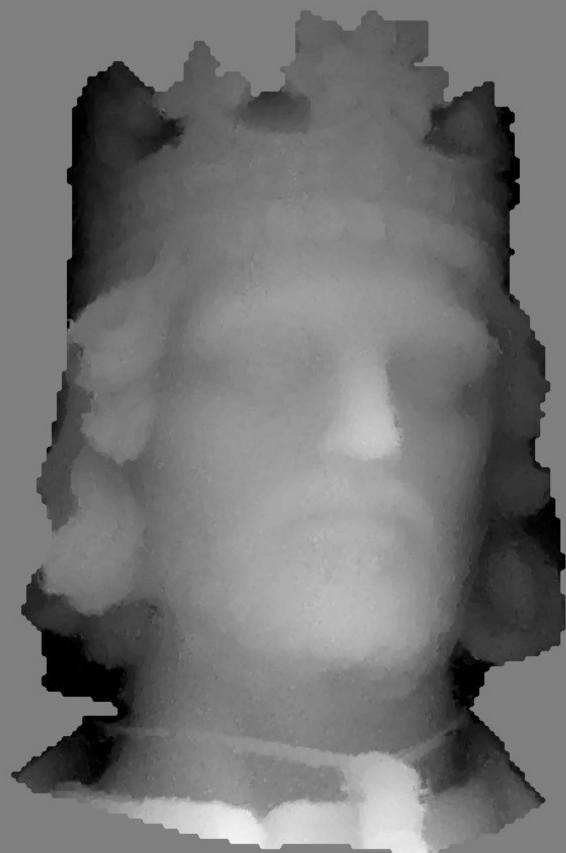
But, prefer solution 2 if image similarity is significantly higher.

Solution with previous techniques



Influence of α parameter :

$\alpha=0.01$



$\alpha=0.1$

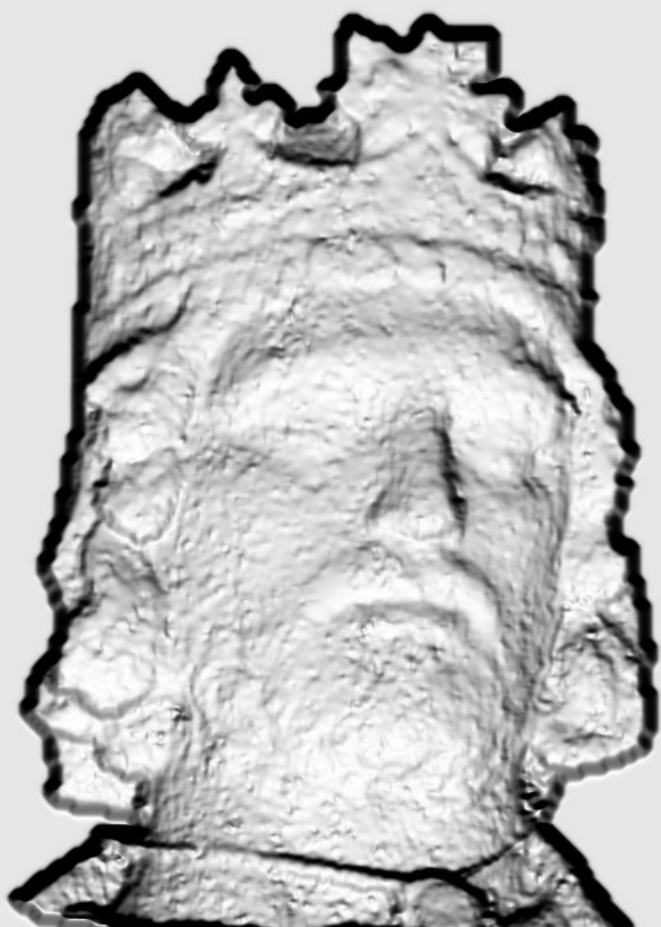


$\alpha=1.0$

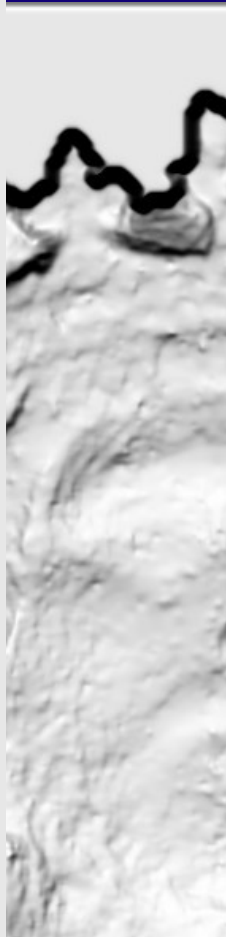


Influence of α parameter (shading visualisation):

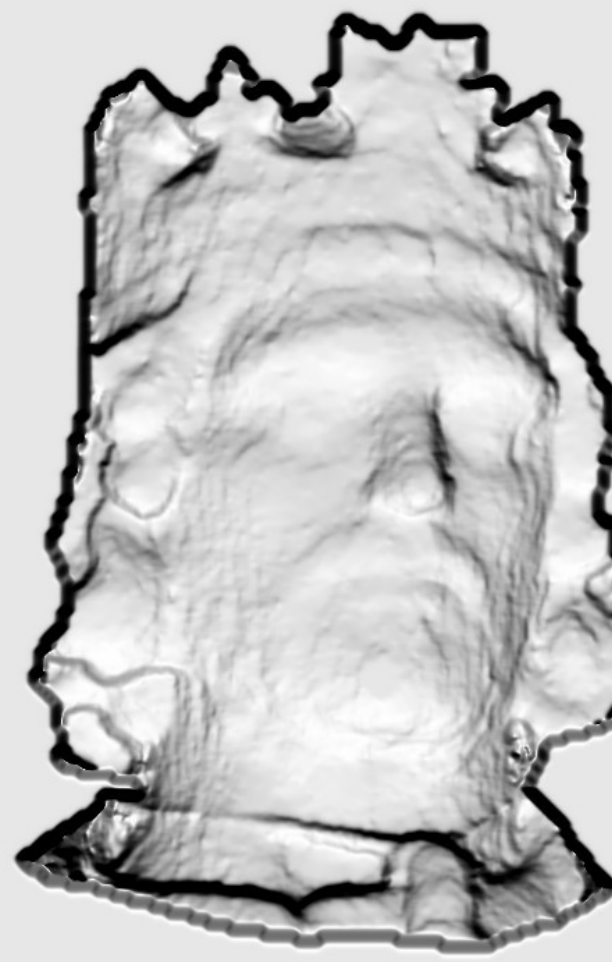
$\alpha = 0.00$

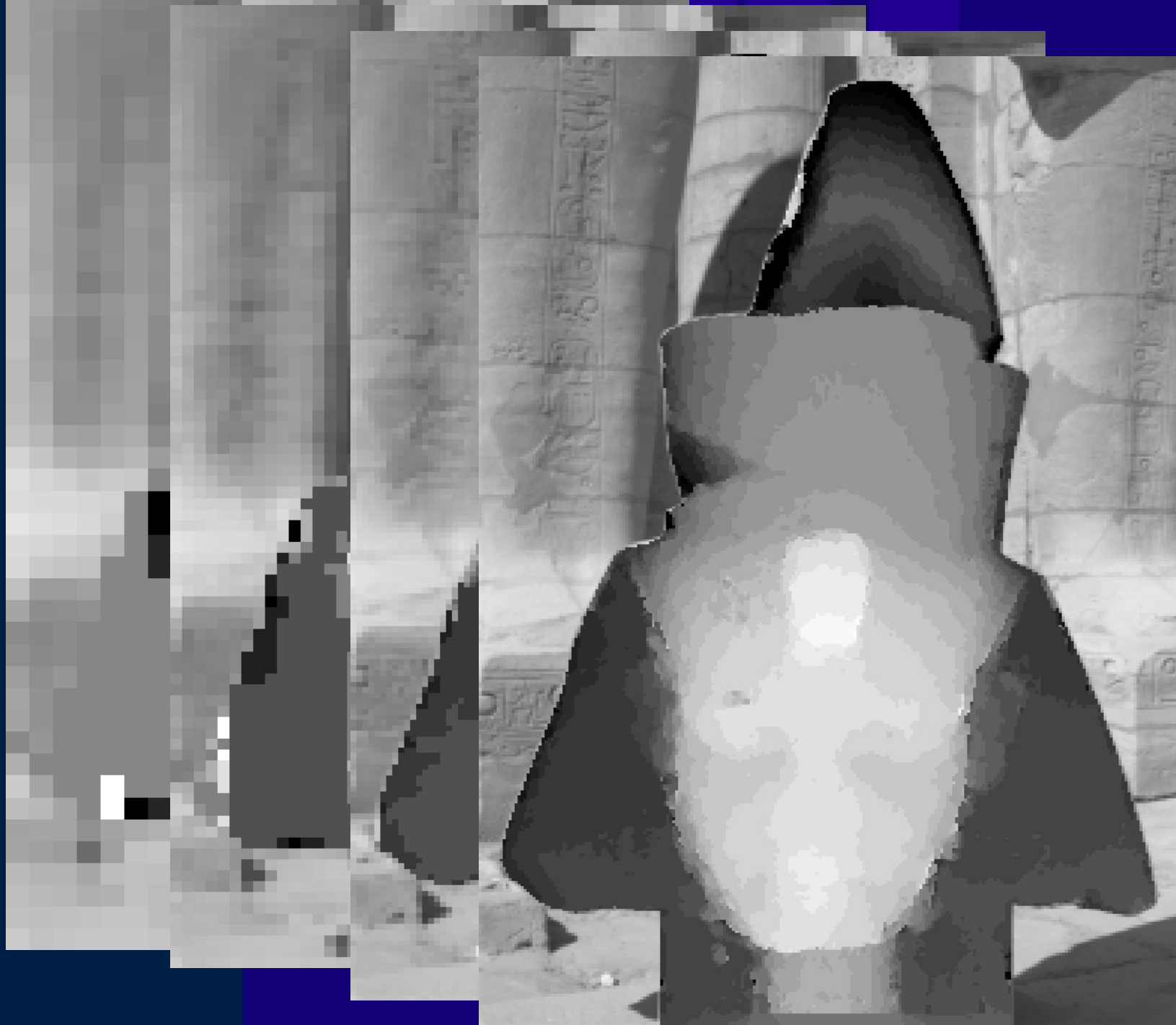


$\alpha = 0.1$

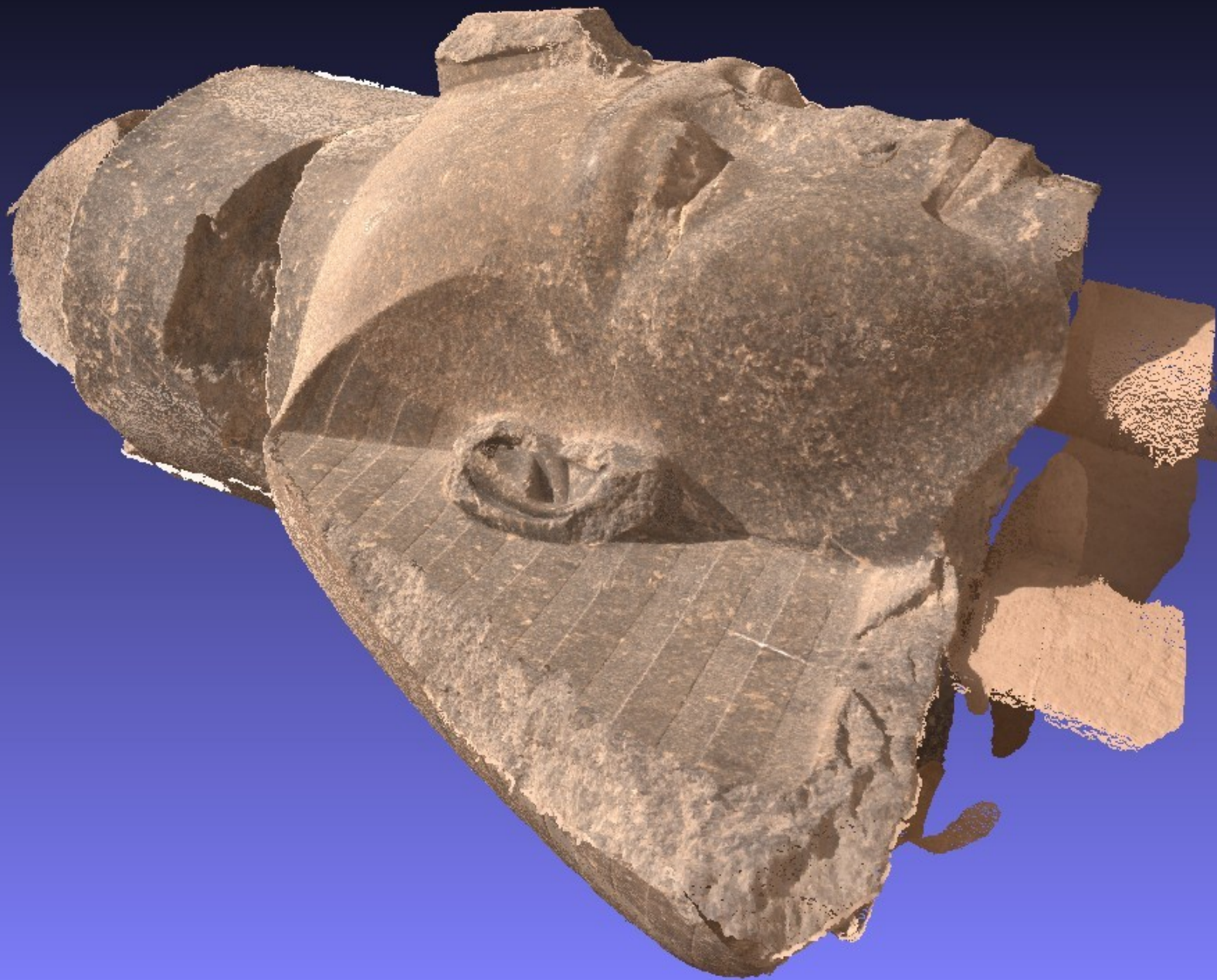


$\alpha = 0.2$









4- **How** (Free open source solution)

MICMAC : IGN's free open source solution.

Many existing software :

Free and opensource	Bundler PMVS Visual SFM MicMac-Apero (Cecill B)
Cheap	Agisoft
Free upload	Arc3D 123DCatch
Paying software	Acute3D (Now Bentley) Pix4D (Now Parrot)



Characteristics of the IGN's software :

Meant for experts (cartographers, archeologists, architects...)

Quite complex, no “push-button” mode ;

Every step may be controlled ;

It can deal with BIG data.

It produces intermediate (and final) results in open formats : it can be used as “spare parts”

History

2003 : development of an image matching software to produce urban DTE and self-calibration

2005 : creation of an XML interface ; the name of the Software is “MicMac”

2007 : open source version of MicMac;

2008 : development of the “Apero” software to orientate the images

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

2012 : “culture 3d” project ; MicMac available on Windows,
Binaries distributions ;

Organization of the software

All the tools are available via one command :

mm3d

It is an input to all processes

Why ?

- Easier to remember

- Some developemnts can be factorized

- Binaries are compact

All the tools are available via one command :

mm3d

mm3d : Allowed commands

AperiCloud Visualisation of camera in ply file

Apero Compute external and internal orientations

AperoChImSecMM Select secondary images for MicMac

Bascule Generate orientations coherent with some physical information on the scene

BatchFDC Tool for batching a set of commands

Campari Interface to Apero, for compensation of heterogenous measures

ChgSysCo Chang coordinate system of orientation

CmpCalib Do some stuff

cod Do some stuff

CreateEpip Tool create epipolar images

Dequant Tool for dequantifying an image

Devlop Do some stuff

ELDcraw Do some stuff

GCPBascule Relative to absolute using GCP

CenterBascule Realtime to absolute using embedded GPS

GCPCovert Convert GCP from Txt 2 XML

OriCovert Convert Orientation from Txt 2 XML

GenXML2Ccpp Do some stuff

GrShade Compute shading from depth image

Gri2Bin Do some stuff

MakeGrid Generate orientations in a grid format

Malt Simplified matching (interface to MicMac)

MapCmd Transforms a command working on a single file in a command working on a set of files

Mascarpone Automatic mask tests

.....

Help to remember a command from a sub-expression :

mm3d Ap

Suggest by Prefix Match

AperiCloud

Apero

AperoChImSecMM

mm3d asc

Suggest by Subex Match

Bascule

GCPBascule

CenterBascule

Mascarpone

NuageBascule

RepLocBascule

SBGlobBascule

SaisieBasc

For (almost) all the commands, use « -help » to know the proper syntax :

```
mm3d SaisieAppuisPredic -help
*****
*   Help for Elise Arg main   *
*****

Unnamed args :
* string :: {Full Name (Dir+Pattern)}
* string :: {Orientation}
* string :: {File for Ground Control Points}
* string :: {File for Image Measurements}

Named args :
* [Name=SzW] Pt2di :: {Size of global window (Def 800 800)}
* [Name=NbF] Pt2di :: {Number of Sub Window (Def 2 2)}
* [Name=WBlur] REAL :: {Size IN GROUND GEOMETRY of blurring for target}
* [Name=Type] string :: {in [MaxLoc,MinLoc,GeoCube]}
```

Here, for instance, 4 compulsory arguments (all the « strings »)
+ optionnal arguments called by their names

```
mm3d TestKey "IMG_.*tif" Nb=1000
```

```
0 IMG_5564-RGB.tif
1 IMG_5564.tif
2 IMG_5564_Masq.tif
3 IMG_5565.tif
4 IMG_5566.tif
5 IMG_5567.tif
6 IMG_5568.tif
7 IMG_5569.tif
8 IMG_5570.tif
9 IMG_5571.tif
10 IMG_5572.tif
11 IMG_5573.tif
12 IMG_5574.tif
13 IMG_5574_Masq.tif
14 IMG_5575.tif
15 IMG_5576.tif
16 IMG_5577.tif
17 IMG_5578.tif
18 IMG_5579.tif
19 IMG_5580.tif
```

... ■

```
mm3d TestKey "IMG_.*8.tif" Nb=1000
```

```
0 IMG_5568.tif
1 IMG_5578.tif
2 IMG_5588.tif
```

```
mm3d TestKey "IMG_.*[68][6-9].tif" Nb=1000
```

```
0 IMG_5566.tif
1 IMG_5567.tif
2 IMG_5568.tif
3 IMG_5569.tif
4 IMG_5588.tif
5 IMG_5589.tif
```

!!! BE CAREFUL !!!!!

MicMac/Apero software uses POSIX regular expression, which are different from shell expressions.

For instance « * » is used as any repetition of the previous expression, thus, it can not be used alone.

```
mm3d TestKey "*.tif" Nb=1000
```

```
EXPR=^*.tif$
```

```
mm3d: /home/marc/MMM/culture3d/src/util/regex.cpp:85: void cElRegex::AssertOk() const: Assertion `IsOk()' failed.  
Abandon
```

MicMac/Apero tools « think » that there is only one project in a directory.

A log file remembers all the commands:

```
cat mm3d-LogFile.txt
```

```
=====
```

```
/home/marc/MMM/culture3d/bin/mm3d Malt Ortho Abbey.*.jpg L93 SzW=1 AffineLast=false DefCor=0.0
```

```
[Beginning at ] Fri Feb 1 18:15:17 2013
```

```
[Failing with code 2 at ] Fri Feb 1 18:15:24 2013
```

```
=====
```

```
/home/marc/MMM/culture3d/bin/mm3d Malt Ortho Abbey.*.jpg L93 SzW=1 AffineLast=false DefCor=0.0
```

```
[Beginning at ] Fri Feb 1 18:15:37 2013
```

```
[Failing with code 2 at ] Fri Feb 1 18:15:44 2013
```

```
=====
```

```
....
```

```
=====
```

```
/home/marc/MMM/culture3d/bin/mm3d GCPBascule Abbey-*.*.jpg All-Rel RTL-Init AppRTL.xml Mesure-BUG-S2D.xml
```

```
[Beginning at ] Fri Feb 1 22:17:40 2013
```

```
[Failing with code 2 at ] Fri Feb 1 22:18:05 2013
```

exif data gives information about the images.

Missing or wrong information in the exif data can be given through the MicMac-LocalChantierDescipteur.xml file.

```
<Global>
<ChantierDescipteur >
  <KeyedNamesAssociations>
    <Calcs>
      <Arrite> 1 1 </Arrite>
      <Direct>
        <PatternTransform> .* </PatternTransform>
        <CalcName> Canon EOS 5D Mark II </CalcName>
      </Direct>
    </Calcs>
    <Key> NKS-Assoc-STD-CAM </Key>
  </KeyedNamesAssociations>
  <KeyedNamesAssociations>
    <Calcs>
      <Arrite> 1 1 </Arrite>
      <Direct>
        <PatternTransform> .* </PatternTransform>
        <CalcName> 50.0 </CalcName>
      </Direct>
    </Calcs>
    <Key> NKS-Assoc-STD-FOC </Key>
  </KeyedNamesAssociations>
</ChantierDescipteur>
</Global>
```

There exist a global camera database, which can be updated.

```
<MMCameraDataBase>
  <CameraEntry>
    <Name> PENTAX K-5 </Name> <!-- 4.807 micron -->
    <SzCaptMm> 16.0 24.0 </SzCaptMm>
    <ShortName> PK5 </ShortName>
  </CameraEntry>
  <CameraEntry>
    <Name> Canon EOS 60D </Name>
    <SzCaptMm> 14.9 22.3 </SzCaptMm>
    <ShortName> C60D </ShortName>
  </CameraEntry>
  <CameraEntry>
    <Name> Canon EOS 7D </Name>
    <SzCaptMm> 16.0 24.0 </SzCaptMm>
    <ShortName> C7D </ShortName>
  </CameraEntry>
.....amera.xml
```

Conclusion - Perspectives

MicMac a tool for people ?



A powerfull and accurate tool (all the results of this presentation done with MicMac)



Free open source (Cecill-B) , open format



Documented (300 pages), a forum of users (enter « *forum micmac* » on your research engine).



Long term support by IGN and several funding (CNES, FUI, ANR, CNR, Vinci).



Used by many scientist, engineer



Now fully automatic in many context

BUT

Complex , no fully sastifying GUI





Some GUI were developped ... but :

A development made at IGN in 2009-2010 .. **but** it was too soon (kernel not stabilized).

Several test using student project, good for prototyping ideas ... **but** no long time support

Devlopment made by private companies ... **but** none free open source.

=> It's probably the good timing to begin a free open source development project of “photogrammetry for people”, based on MicMac kernel.

=> Developer, if you are interested contact :
• marc.pierrot-deseilligny@ensg.eu

**Thank you for your
attention.**