

# **Grafica 3D per i beni culturali: Multiview stereo matching, the tools**

10-15 Maggio 2018

# Image-based 3D Reconstruction

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## □ Advantages:

- Automatic
- Fast (relatively to manual built)
- Good scalability (both small and huge model can be acquired)
- Non-expert users can create his/her 3D model.
- Cheap!

## □ Disadvantages:

- Accuracy (not so accurate)
  - Not all the objects can be acquired
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# Using the tools

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For the 2017 edition of the course, two tools have been chosen as the «official» ones:

- Regard 3D: local tool for 3D reconstruction and import/export from MeshLab
  - Culture 3D Cloud: web service for remote processing
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# Regard 3D

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The tool can be found in the official website (<http://www.regard3d.org/>) that includes a quite good documentation

The processing of data follows the usual workflow of multi-view stereo matching tools:

- Create a project
  - Matching image features
  - Calibration and orientation of camera
  - Dense matching
  - (Creation of a textured 3D Model)
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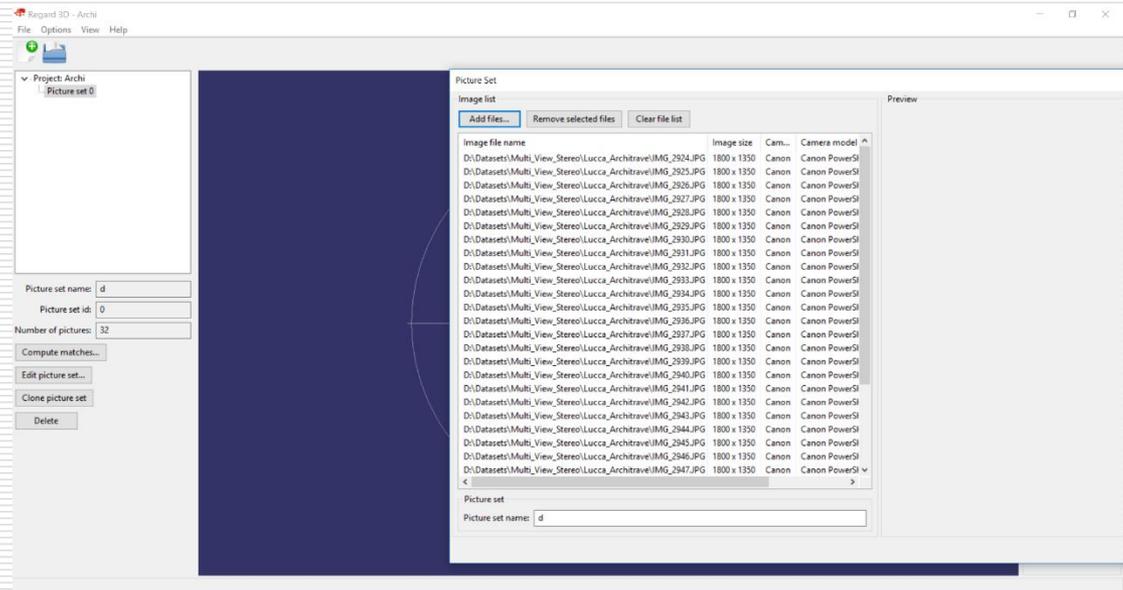
# Regard 3D: create the project

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- Prepare a folder containing only the images you want to use for reconstruction (preserve the exif file if you process the data!)
  - Launch Regard3D
  - Choose «New project»
  - Select the folder where the images are, and choose a project name
  - Choose «Add picture set» and select the images you want to add
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# Regard 3D: create the project

- NOTE: it is crucial that the tool is able to read the camera model and focal, otherwise it won't work.
- Don't remove the EXIF data if you process the images.



# Regard 3D: compute matches

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- Choose «compute matches»
  - Two parameters are available: «sensitivity» and «matching ratio»: in the case of difficult dataset you may try to reduce the sensitivity to extract more keypoints
  - At the end, with «show matching results» it's possible to see how much stuff has been matched
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# Regard 3D: triangulation

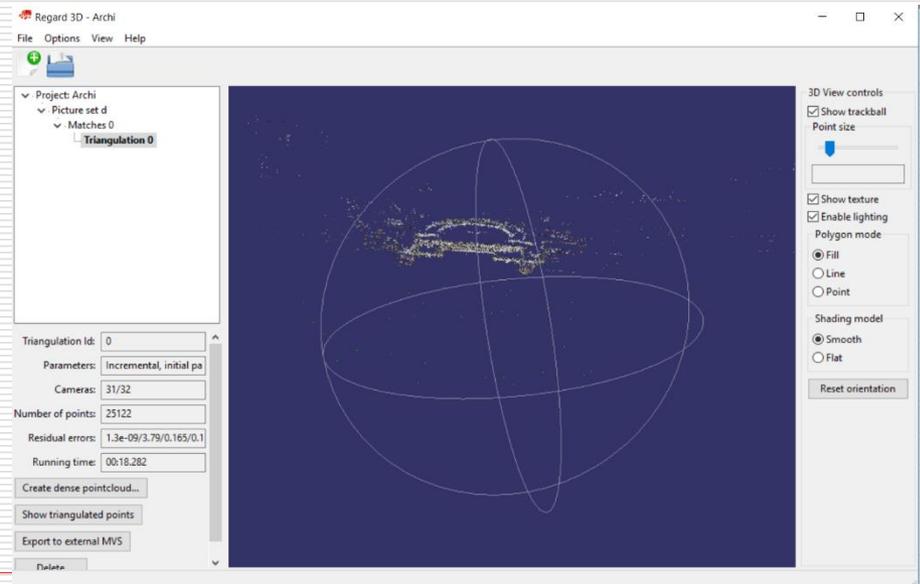
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- Choose «triangulation»
  - Two possible approaches are available: «incremental» and «global»
  - The «incremental» is the classic mode: the only control by user is to define the initial pair, which is by default the one with the highest number of matches
  - The «global» works only when the focal length stayed the same throughout the acquisition
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# Regard 3D: triangulation

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- NOTE: the incremental triangulation usually works, but nobody prevents you from trying both and see if any difference can be seen.
- Every operation in the project is stored independently, so you can decide from which output you can go on.



# Regard 3D: dense matching

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- Choose «create dense point cloud»
  - Two possible approaches are available: «pmvs» and «mve»
  - These are two algorithms that produce dense cloud: in general MVE produces denser clouds, but both reconstruction should be tried
  - In both cases this is the longest step of computation!
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# Regard 3D: dense matching

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- MVE reconstruction can be tuned with two parameters: «scale» and «filter width»
  - «Scale» is related to the detail that is reconstructed. The smaller the better, but the smaller the longer it will take to process
  - «Filter width» is related to the quality of the final reconstruction. The higher the better, but the higher the longer it will take to process
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# Regard 3D: dense matching

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- PMVS reconstruction can be tuned with two parameters: «level» and «cell size»
  - «Level» is related to the detail that is reconstructed. The smaller the better, but the smaller the longer it will take to process
  - «Cell size» is related to the quality of the final reconstruction. The higher the better, but the higher the longer it will take to process
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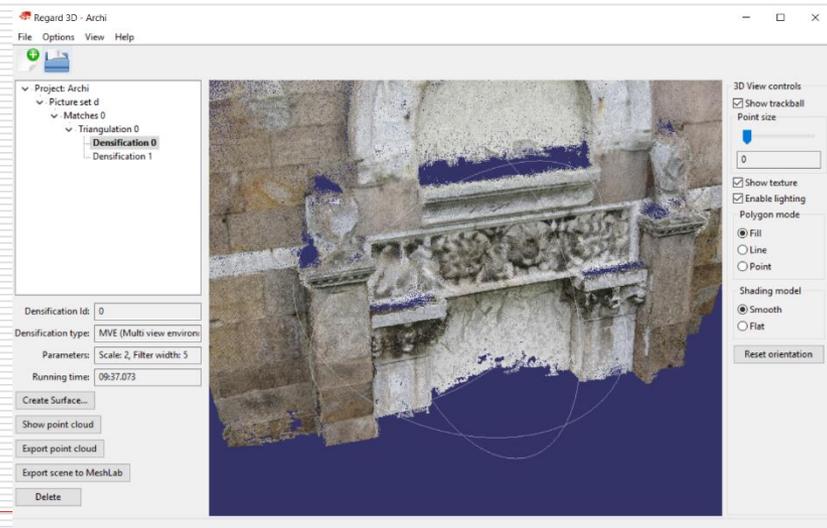
# Regard 3D: exporting data

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- Once that dense reconstruction is finished, two things can be done: export the point cloud or export a MeshLab project
  - In the case of MeshLab export, a sceneMeshLab.mlp file will be created, and two folders (images and model) containing the images and the dense model. The project can be directly loaded in MeshLab
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# Final notes regarding Regard 3D

- Regard 3D contains also an additional step to create a triangulated version of the model, and also a texturing
- In the context of the course, this is demanded to MeshLab, since cleaning and better texturing can be obtained with this tool.



# VisualSfM, install on Windows

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To install it on a Win machine, you need to:

- Download and copy the executable from the website: 32bit and 64bit are available. It is possible to use the CUDA version if you have it on your machine. It's only faster in that case.
  - Copy the CMVS and PMVS executable in the same place where Visualsfm.exe is. You can download the files from [here](#) . If you need a 32bit version send me a mail.
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# VisualSfM, install on Mac

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The installation on Mac seems a bit more tricky, but at least everything needed is installed at once.

Check the installer provided by [Dan Monaghan](#)

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# VisualSfM, basic usage

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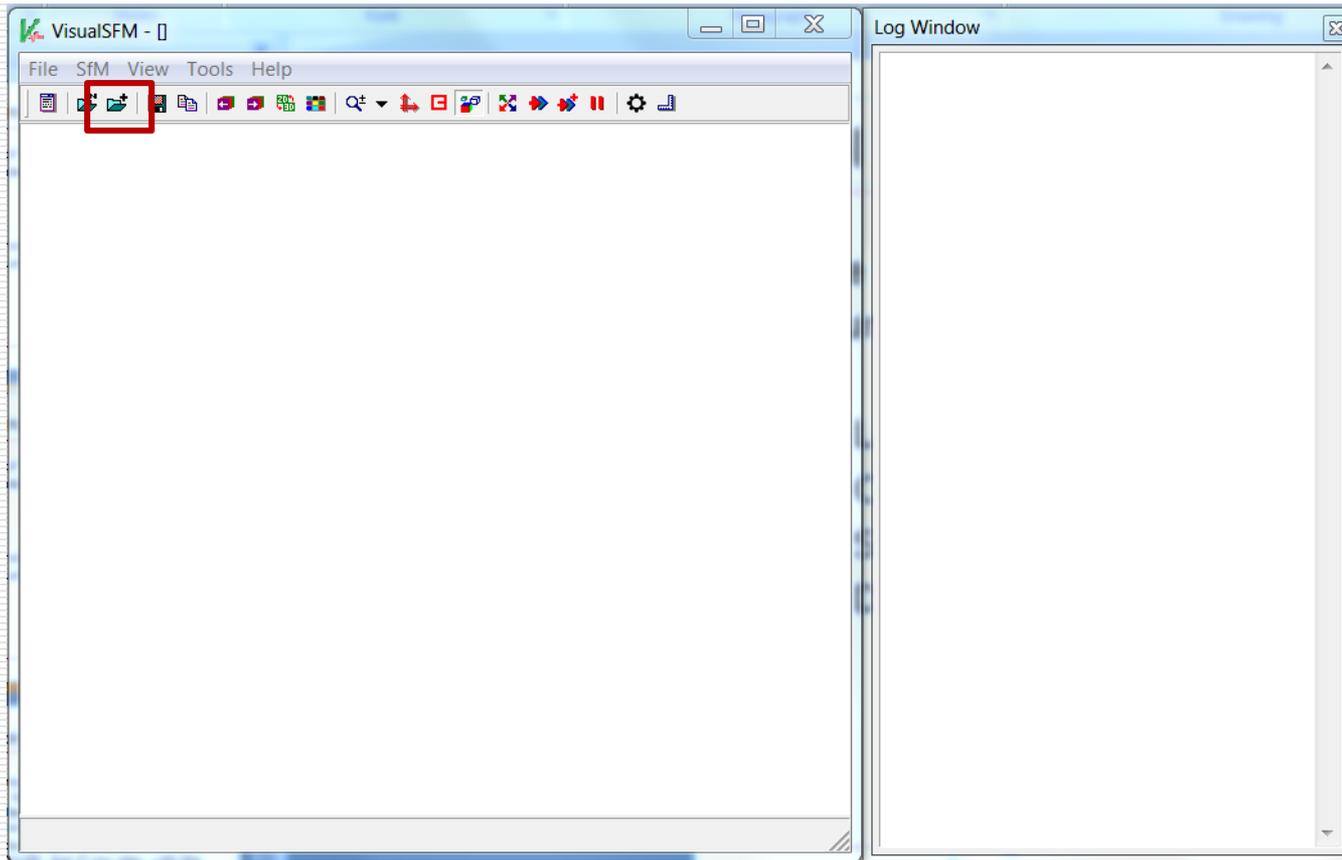
The basic pipeline of VisualSfM is quite simple.  
Four steps are needed

- Load images
  - Calculate Match
  - Sparse Reconstruction
  - Dense Reconstruction
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# VisualSfM, load images

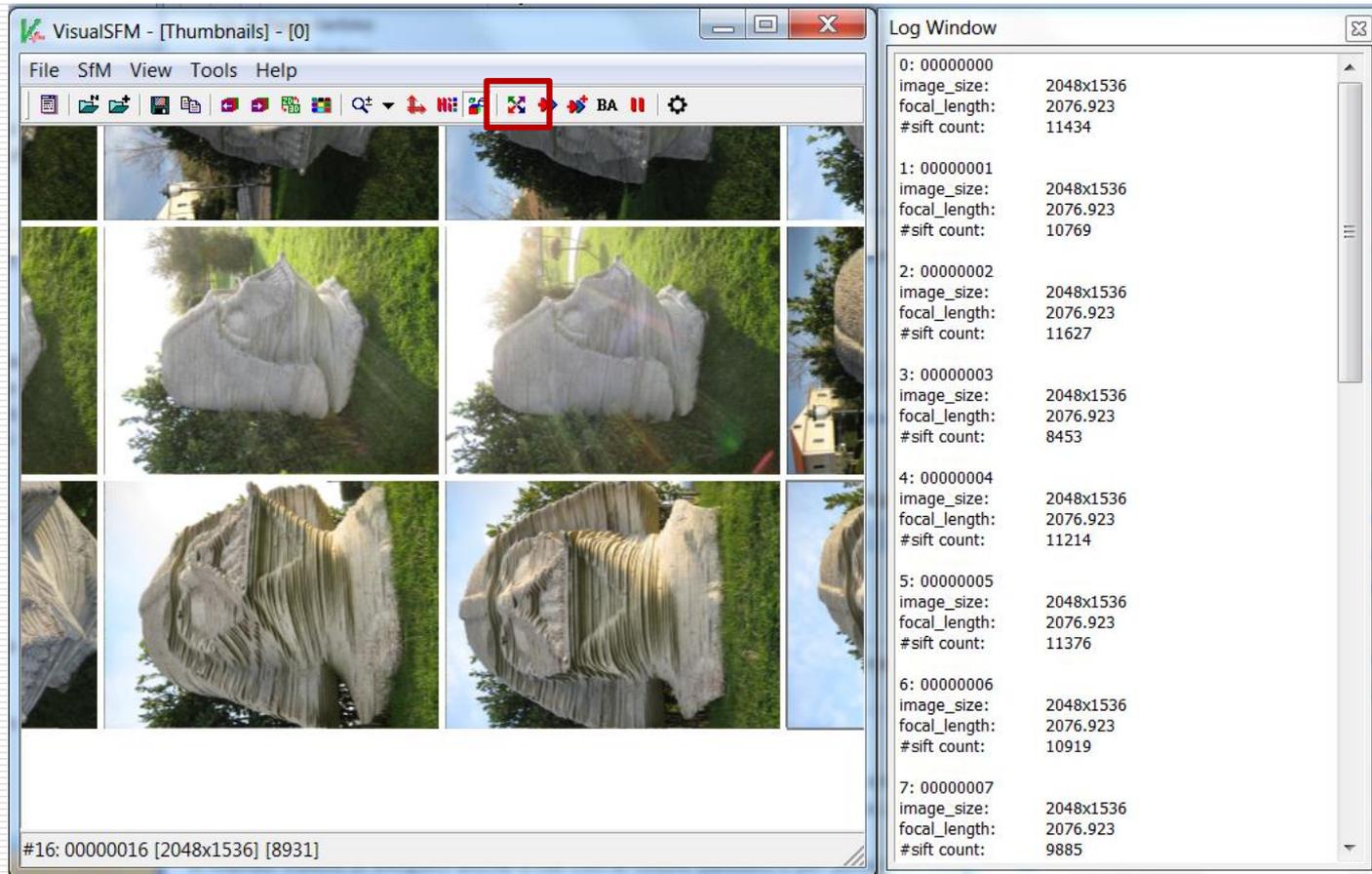
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Select and load the input images



# VisualSfM, compute matches

## Compute the missing matches



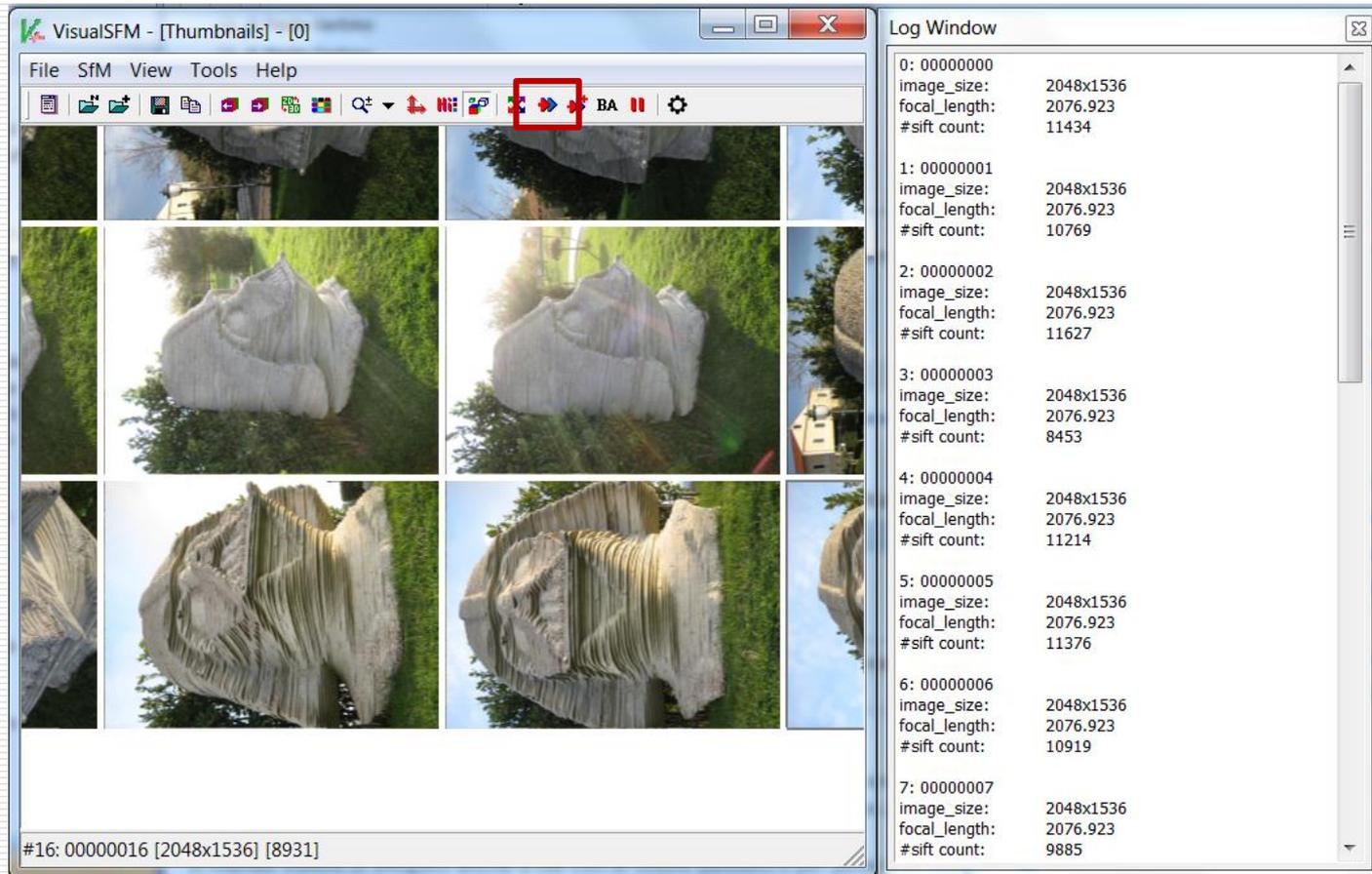
The screenshot displays the VisualSfM software interface. The main window shows a grid of image thumbnails, with a red box highlighting the 'Compute' button (represented by a four-pointed star icon) in the toolbar. The Log Window on the right side of the interface displays the following data:

Image ID	image_size	focal_length	#sift count
0: 00000000	2048x1536	2076.923	11434
1: 00000001	2048x1536	2076.923	10769
2: 00000002	2048x1536	2076.923	11627
3: 00000003	2048x1536	2076.923	8453
4: 00000004	2048x1536	2076.923	11214
5: 00000005	2048x1536	2076.923	11376
6: 00000006	2048x1536	2076.923	10919
7: 00000007	2048x1536	2076.923	9885

At the bottom of the main window, the status bar shows: #16: 00000016 [2048x1536] [8931]

# VisualSfM, sparse reconstruction

## Generate sparse reconstruction



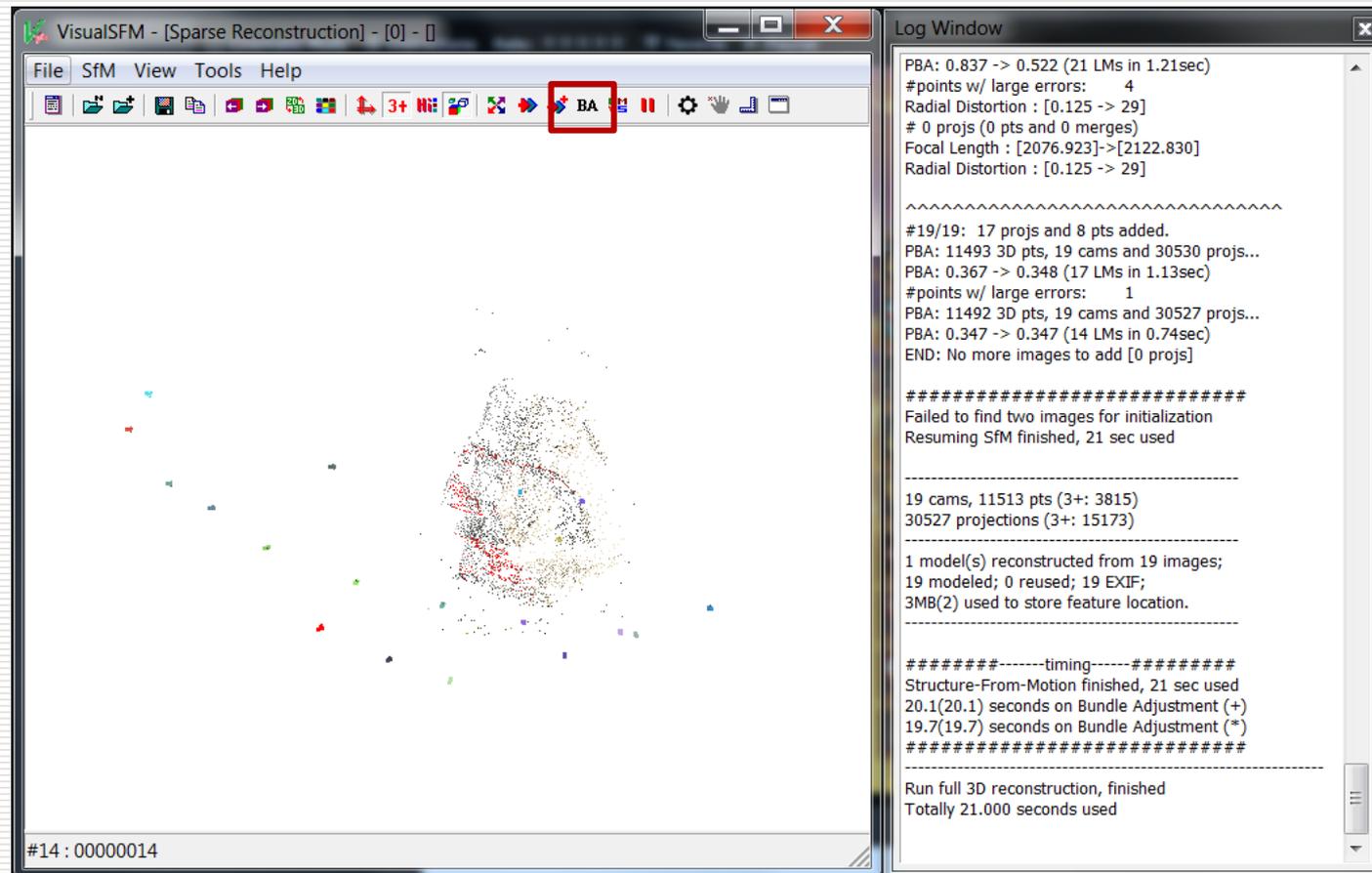
The screenshot displays the VisualSfM interface. The main window shows a grid of image thumbnails, with a red box highlighting the 'Generate Sparse Reconstruction' button (represented by a red double-headed arrow) in the toolbar. The Log Window on the right provides details for the first eight images:

Image ID	image_size	focal_length	#sift count
0: 00000000	2048x1536	2076.923	11434
1: 00000001	2048x1536	2076.923	10769
2: 00000002	2048x1536	2076.923	11627
3: 00000003	2048x1536	2076.923	8453
4: 00000004	2048x1536	2076.923	11214
5: 00000005	2048x1536	2076.923	11376
6: 00000006	2048x1536	2076.923	10919
7: 00000007	2048x1536	2076.923	9885

The status bar at the bottom left of the main window shows: #16: 00000016 [2048x1536] [8931]

# VisualSfM, sparse reconstruction

Run the bundle Adjustment to refine reconstruction



The screenshot displays the VisualSfM interface. The main window shows a 3D point cloud reconstruction of a scene, with a red bounding box highlighting the 'BA' (Bundle Adjustment) button in the toolbar. The 'Log Window' on the right provides detailed statistics for the bundle adjustment process.

```
VisualSfM - [Sparse Reconstruction] - [0] - [X]
File Sfm View Tools Help
[Icons] [BA] [Pause] [Settings] [Hand] [Print]

#14 : 00000014

Log Window
PBA: 0.837 -> 0.522 (21 LMs in 1.21sec)
#points w/ large errors: 4
Radial Distortion : [0.125 -> 29]
# 0 projs (0 pts and 0 merges)
Focal Length : [2076.923]->[2122.830]
Radial Distortion : [0.125 -> 29]

~~~~~
#19/19: 17 projs and 8 pts added.
PBA: 11493 3D pts, 19 cams and 30530 projs...
PBA: 0.367 -> 0.348 (17 LMs in 1.13sec)
#points w/ large errors: 1
PBA: 11492 3D pts, 19 cams and 30527 projs...
PBA: 0.347 -> 0.347 (14 LMs in 0.74sec)
END: No more images to add [0 projs]

#####
Failed to find two images for initialization
Resuming SfM finished, 21 sec used

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19 cams, 11513 pts (3+: 3815)
30527 projections (3+: 15173)

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1 model(s) reconstructed from 19 images;
19 modeled; 0 reused; 19 EXIF;
3MB(2) used to store feature location.

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#####-----timing-----#####
Structure-From-Motion finished, 21 sec used
20.1(20.1) seconds on Bundle Adjustment (+)
19.7(19.7) seconds on Bundle Adjustment (*)
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Run full 3D reconstruction, finished
Totally 21.000 seconds used
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# VisualSfM, sparse reconstruction

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The sparse reconstruction provides an initial feedback about the reconstruction. You can check if:

- All the images have been calibrated (more than one cluster has been created, us PgUp and PgDown)
  - The reconstruction is complete or some part is missing
  - There are wrongly calibrated images
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# VisualSfM, sparse reconstruction

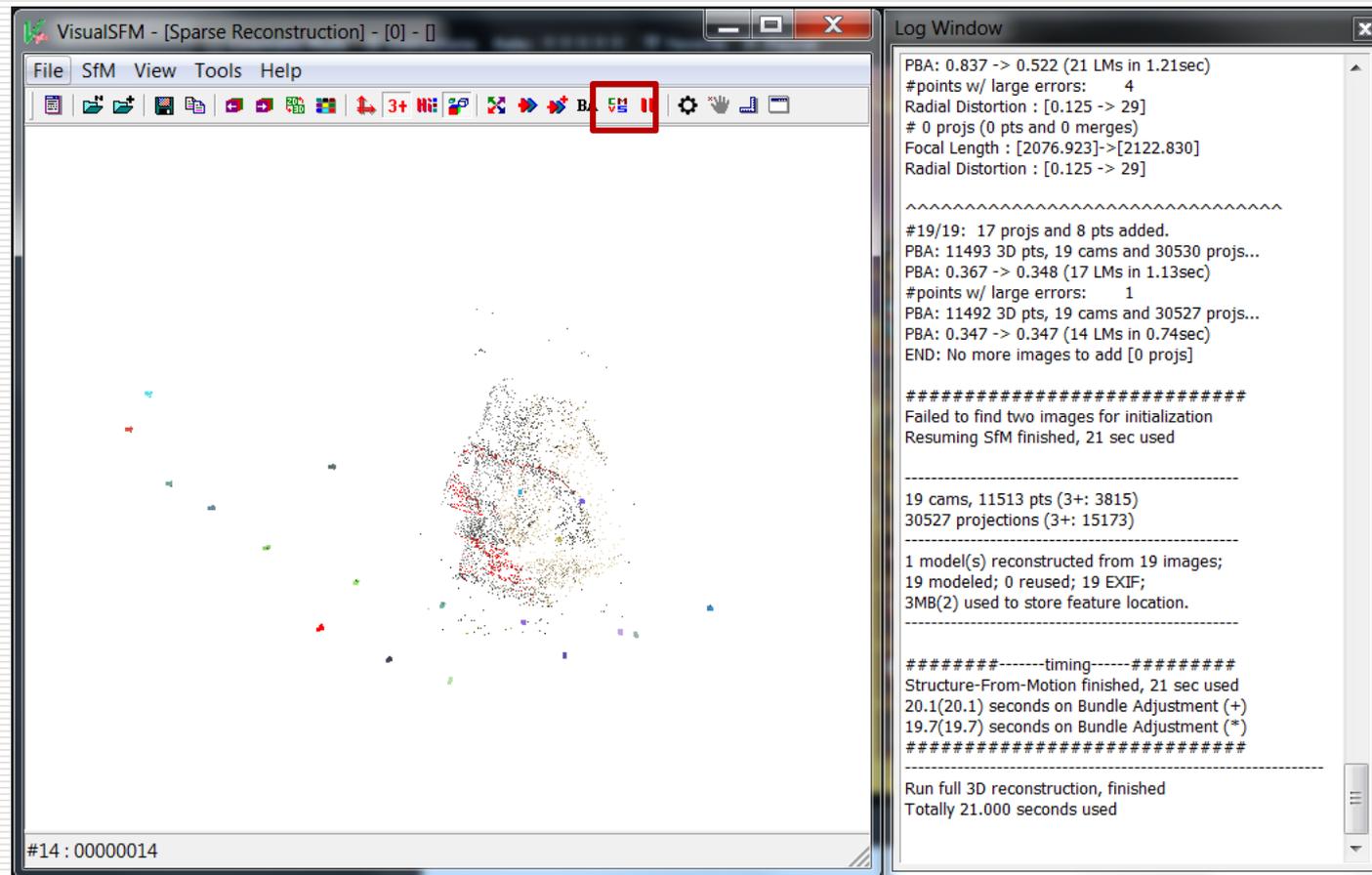
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If the sparse reconstruction has problems you can:

- Change the input dataset (start from scratch, most of the matches will be kept in memory)
  - Remove the wrong cameras (re-launch BA, or try to add them in reconstruction again)
  - There are other ways to control the reconstruction, check the tool!
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# VisualSfM, dense reconstruction

## Run the CMVS for Dense Reconstruction



# VisualSfM, dense reconstruction

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The Dense reconstruction ask you to create a new folder (save it where the images are!)

The final Dense reconstruction will be saved in this folder, inside the 00/models folder.  
It will be called option-0000.ply

This will be the dense cloud that you will load in MeshLab to create the model!

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# Next in line...

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Next lesson:

- Making the model in MeshLab

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