

# PhotoScan (Agisoft [www.agisoft.ru](http://www.agisoft.ru))

Extracts from the User Manual  
V. 1.04

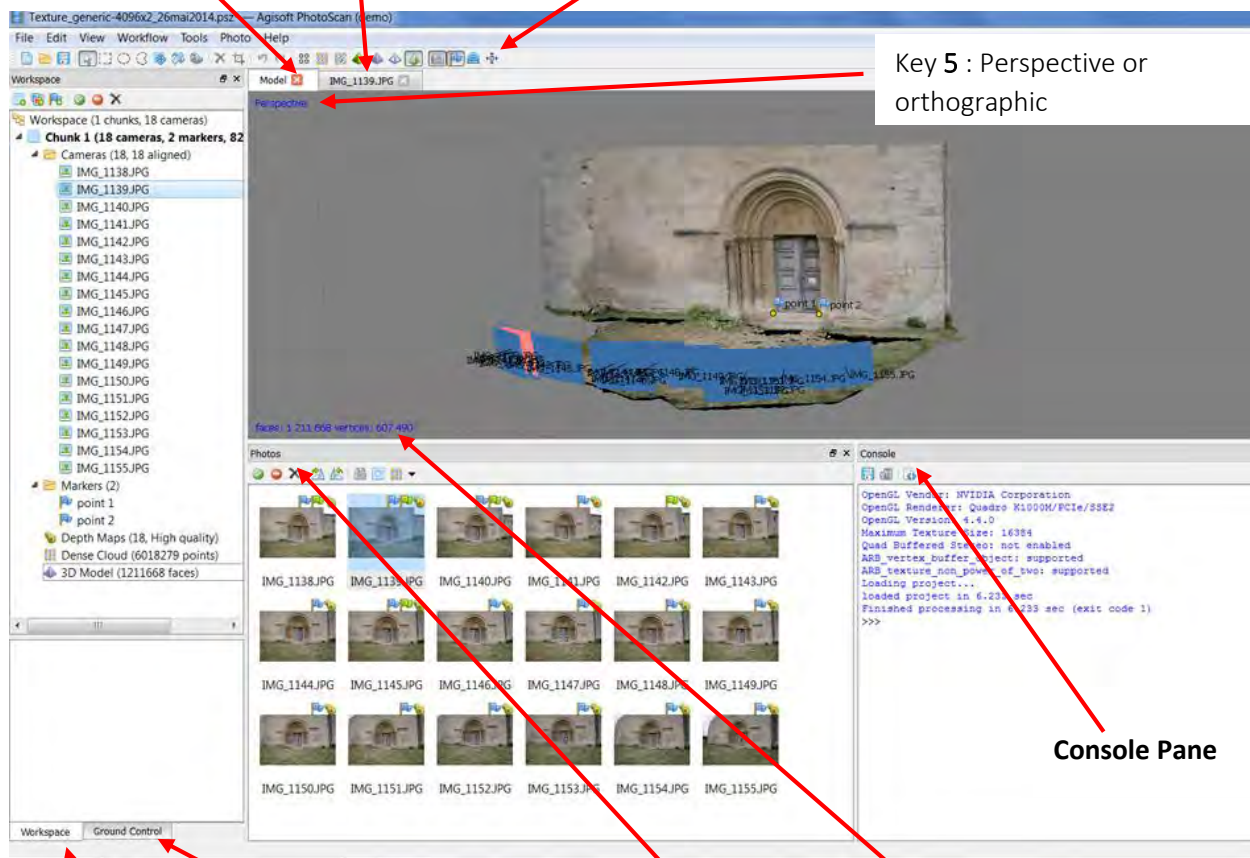


## / Interface

Model view

Photo view

Reset View



Key 5 : Perspective or orthographic

Console Pane

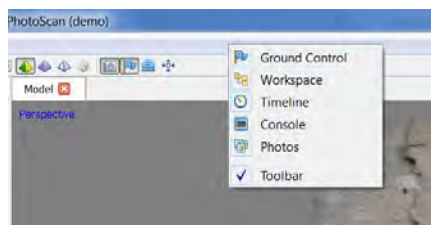
Workspace Pane

Ground Control Pane

Photo Pane

Number of points (cloud) or faces (mesh).

To display on/off the panes **Menu View/Panes/** ground Control, Worspace,... or **right click** on the Menu bar.



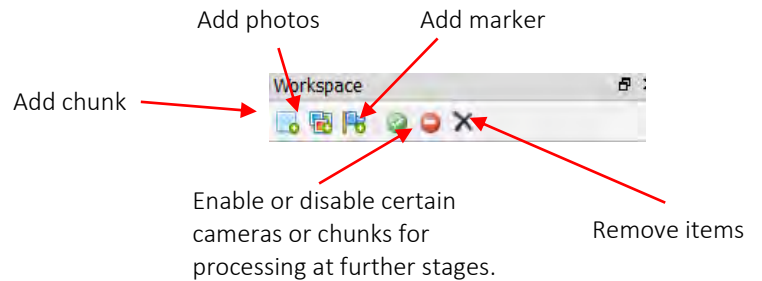
### I.1 / Workspace pane

On the Workspace pane all elements comprising the current project are displayed.

These elements can include:

- List of chunks in the project
- List of cameras in each chunk
- List of markers in each chunk
- List of scale bars in each chunk
- Depth maps is separate chunks
- Dense point clouds is separate chunks
- 3D models in separate chunks

Buttons located on the Workspace pane toolbar allow to:

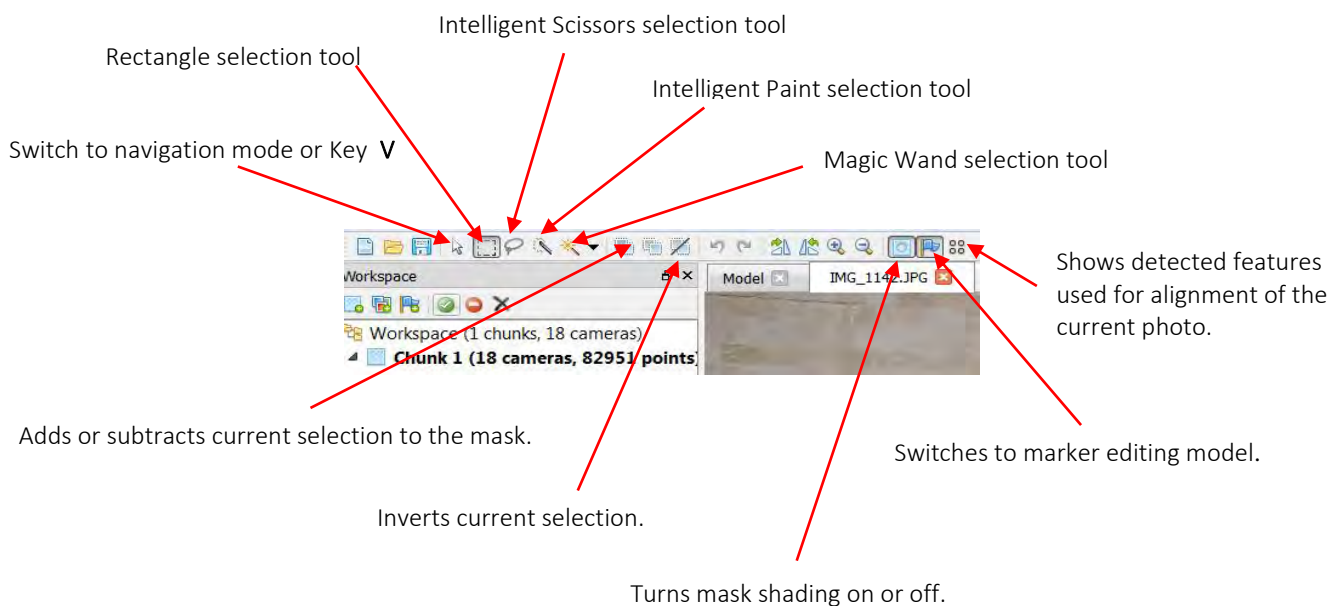


### I.2 / Photo view

Photo view tab is used for displaying individual photos as well as markers and masks on them.

Photo view is visible only if any photo is opened. To open a photo double-click on its name on the Workspace, Ground Control or Photos pane.

The Photo view selection tools are used to design Masks on the current photo. Masks are used in PhotoScan to specify the areas on the photos which can otherwise be confusing to the program or lead to incorrect reconstruction results.

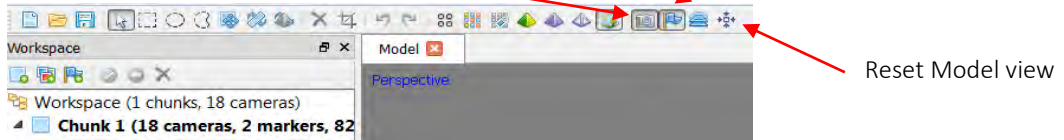


### 1.3/ /Model view

Model view tab is used for displaying 3D data as well as for mesh and point cloud editing. The view of the model depends on the current processing stage and is also controlled by mode selection buttons on the PhotoScan toolbar.

Shows / hides camera positions, reconstructed during image alignment.

Shows / hides positions of markers placed on the model.



Switch to navigation mode or **Key Space**

Selection Tools on sparse, dense points cloud or mesh



Model can be shown as a sparse cloud dense cloud, with class indication or without, or as a mesh in shaded, solid, wireframe or textured mode. Along with the model the results of photo alignment can be displayed. These include sparse point cloud and camera positions visualised data.

**Point Cloud** : Displays sparse point cloud reconstructed during photo alignment.  
**Menu Workflow/Align Photos...** (step 2)

**Dense Cloud**: Displays dense point cloud reconstructed after **Menu Workflow/Build Dense Cloud...** (step 3)

**Dense Cloud Classes**: Displays dense point cloud colored by point Classes made with the **Menu Tools/Dense Cloud/Classify Grounds Points... or Assign Class** (step 3)



**Shaded**: Displays 3D model in the shaded mode computed **after Menu Workflow/Build Mesh...** (step 4)

**Solid**: Displays 3D polygonal model in the surface mode computed after **Menu Workflow/Build Mesh...** (step 4)

**Wireframe** (after **Menu Workflow/Build Mesh...** (step 4)

**Textured**: after **Menu Workflow/Build Texture...** (step 5)

All navigation tools are accessible in the navigation mode only using **Navigation Tool Icon** Or **Key Space** to switch on the Navigation Tool.

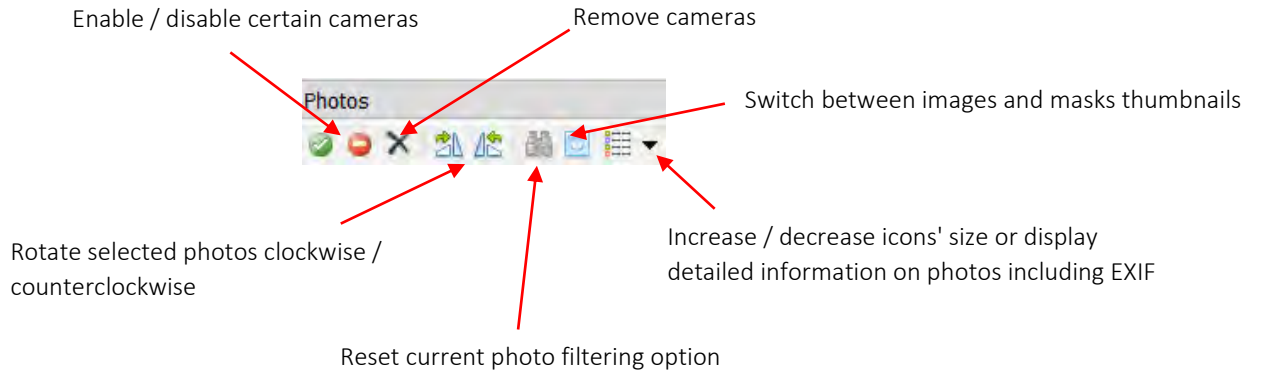


| Tool          | Keyboard modifier  |
|---------------|--|
| Rotation Tool | Press <b>Left</b>  |
| Pan Tool      | Press <b>Left + Ctrl key</b> pressed or Press <b>Right</b>         |
| Zooming Tool  | Press <b>Left + Shift key</b> pressed or by the <b>mouse wheel</b> |



**I.4 / Photos pane**

Photos pane displays the list of photos / masks in the active chunk in the form of thumbnails.  
Buttons located on the Photos pane toolbar allow to:



**I. 5/ Ground Control pane**

- Ground Control pane is designed for:
- Displaying camera and / or marker coordinates
  - Displaying scale bars lengths
  - Displaying camera orientations
  - Displaying estimation errors

| Cameras            | X est     | Y est      |     |
|--------------------|-----------|------------|-----|
| IMG_1138.JPG       | -8.704996 | -14.044998 | 8.3 |
| IMG_1139.JPG       | -8.051243 | -14.331825 | 8.2 |
| IMG_1140.JPG       | -8.030010 | -14.277304 | 7.9 |
| IMG_1141.JPG       | -9.198899 | -14.065844 | 8.0 |
| IMG_1142.JPG       | -5.037684 | -14.343814 | 7.9 |
| IMG_1143.JPG       | -4.559721 | -14.557562 | 7.9 |
| IMG_1144.JPG       | 0.248457  | -15.180525 | 8.2 |
| IMG_1145.JPG       | 1.065750  | -15.145619 | 8.2 |
| IMG_1146.JPG       | 1.066994  | -15.052703 | 7.8 |
| IMG_1147.JPG       | 0.261506  | -14.931822 | 7.8 |
| IMG_1148.JPG       | 3.096524  | -14.916257 | 8.3 |
| IMG_1149.JPG       | 5.806863  | -14.977322 | 8.3 |
| IMG_1150.JPG       | 8.292778  | -15.126802 | 8.3 |
| IMG_1151.JPG       | 9.355156  | -14.996161 | 8.3 |
| IMG_1152.JPG       | 9.358725  | -14.897103 | 7.8 |
| IMG_1153.JPG       | 8.550355  | -15.103770 | 7.8 |
| IMG_1154.JPG       | 11.401942 | -14.285989 | 8.4 |
| IMG_1155.JPG       | 14.772572 | -13.203093 | 8.6 |
| <b>Total Error</b> |           |            |     |

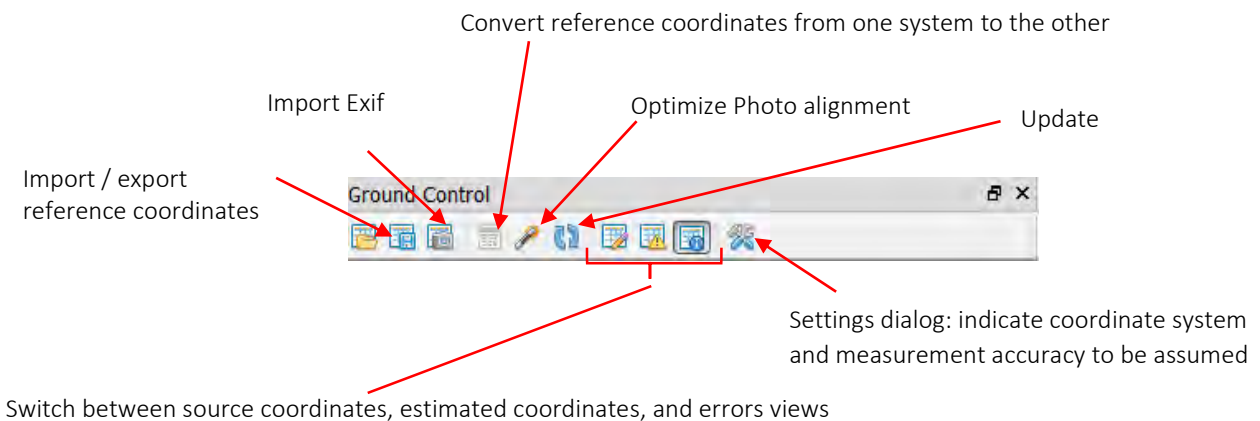
  

| Markers            | X est     | Y est     | Z      |
|--------------------|-----------|-----------|--------|
| Pt_bas-droit       | 4.036269  | 10.566626 | 8.020  |
| Pt_bas-droit       | 3.990256  | 10.433506 | 14.859 |
| Pt_bas-gauche      | -0.451188 | 10.423842 | 7.956  |
| <b>Total Error</b> |           |           |        |

| Scale Bars         | Distance est | Error (m) |
|--------------------|--------------|-----------|
| Hauteur_porch      | 6.839887     |           |
| Largeur_porch      | 4.490186     |           |
| <b>Total Error</b> |              |           |

Buttons located on the pane toolbar allow:

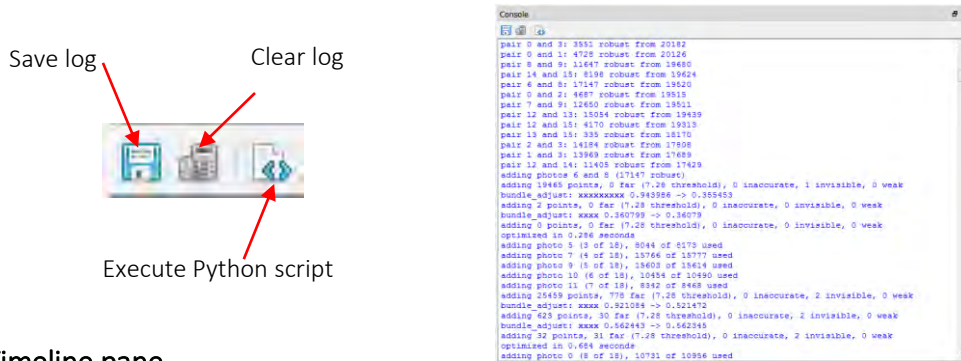


## I.6 / Console pane

Console pane is used for:

- Displaying auxiliary information
- Displaying error messages
- Python commands

Buttons located on the pane toolbar allow:



## I.7 / Timeline pane

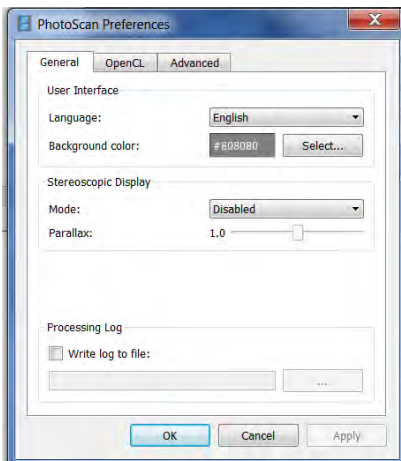
Timeline pane is designed for working with multi-frame chunks

Buttons located on the pane toolbar allow:

- Add / remove frames from chunk
- Play / stop frame sequence
- Adjust frame rate through Settings dialog

# II/ Preferences settings : Menu Tools/Preferences...

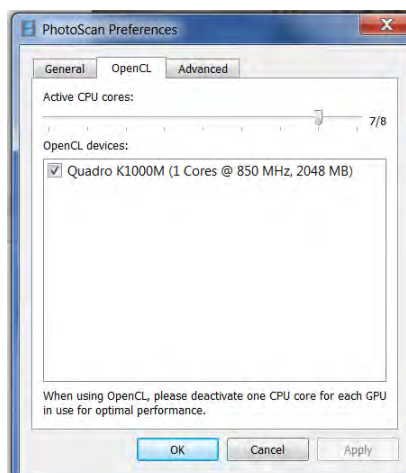
Before starting a project with PhotoScan it is recommended to adjust the program settings for your needs.



**Stereo Mode:** Disabled

**Stereo Parallax:** 1.0

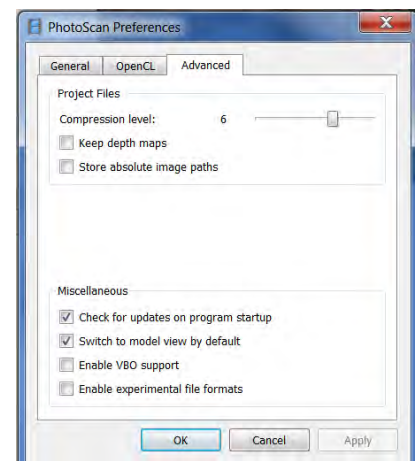
**Write log to file:** specify directory where Agisoft PhotoScan log would be stored (in case of contacting the software support team it could be required)



OpenCL acceleration can be enabled using **OpenCL** tab in the Preferences dialog box.

For each OpenCL device used one CPU core should be disabled for optimal performance.

Using OpenCL acceleration with mobile video chips is not recommended because of the low performance of mobile GPUs.



**Compression Level**

Note that since PhotoScan tends to generate extra dense point clouds and highly detailed polygonal models, project saving procedure can take up quite a long time. So you can decrease compression level to speed up the saving process

It is recommended to free at least one CPU per each active GPU for overall control and resource managing tasks.



## III/ Save intermediate steps results in a project file (\*.psz) Menu File/Save As or Save

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Certain stages of 3D model reconstruction can take a long time. The full chain of operations could easily last for 4-6 hours when building a model from hundreds of photos. It is not always possible to finish all the operations in one run.

PhotoScan allows to save intermediate results in a project file\*.psz. Project files may contain the following information:

- List of loaded photographs with reference paths to the image files.
- Photo alignment data such as information on camera positions, sparse point cloud model and set of refined camera calibration parameters for each calibration group.
- Masks applied to the photos in project.
- Dense point cloud model with information on points classification.
- Reconstructed 3D polygonal model with any changes made by user. This includes mesh and texture if it was built.
- Depth maps for cameras.
- List of added markers as well as of scale-bars and information on their positions.
- Structure of the project, i.e. number of chunks in the project and their content.

You can save the project at the end of any processing stage and return to it later. Project files can also serve as backup files or be used to save different versions of the same model.

Project files use relative paths to reference original photos. **Thus, when moving or copying the project file to another location do not forget to move or copy photographs with all the folder structure involved as well.**

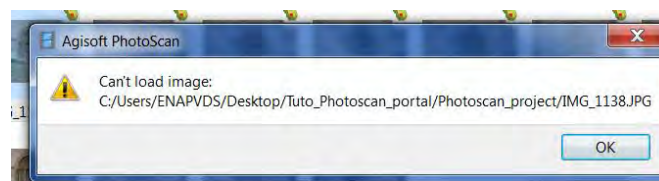
Otherwise, PhotoScan will fail to run any operation requiring source images, although the project file including the reconstructed model will be loaded up correctly.

Alternatively, you can enable Store absolute image paths option on the menu Tools/ Preferences/ Advanced.

## IV/ Photos can't be opened

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Double clicking on a photo in the photo pane gives the message:

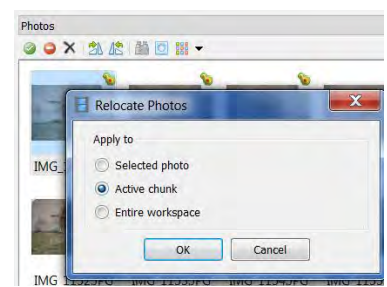
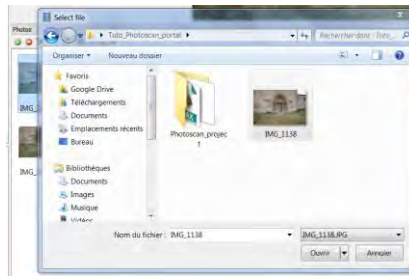
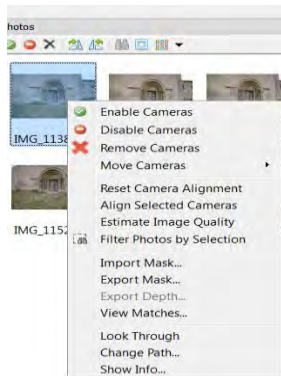


So you have only the Thumbnails in the Photo View. Zoom on the photo is not possible.

Probably the locations of photos have changed in respect to the location of the project file. The references to the original photos are stored in the project files in the form of relative paths. These references become invalid when the project file alone is moved to another location, or when the photos are moved without changing the project file placement.

To change the relative paths to the photos

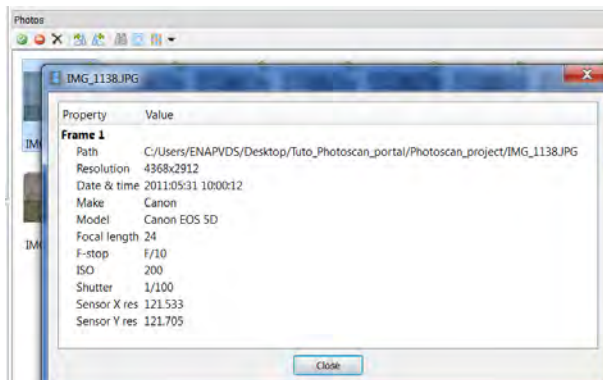
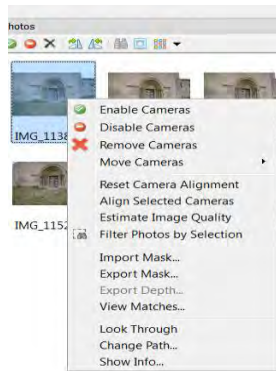
- 1) Right-clicking on the photo in Photo pane.
- 2) Select **Change Path...** command from the **context menu**.
- 3) Browse to the folder containing the photo, select it and click **OK**.
- 4) Apply to the **active chunk** or to the **entire workspace** if all the photos are located in the same folder.



If the relative location of the project file in respect to the photos location must be changed, the project file should be resaved using the command **menu File /Save As...**

To identify the expected photo location

Right-clicking on the photo title and select **Show Info...** command from the **context menu**. A dialog box with information on the selected photo including the path to the image data file will be displayed.



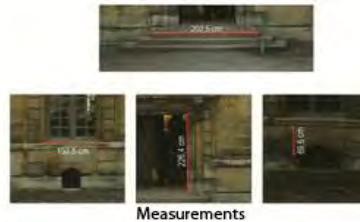
To fix the problem move the photos to the original locations indicated by the data displayed in the information dialog box.

## V/ Processing of images with PhotoScan includes the following main steps

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### Remark :

If the goal of your project is to provide a model or measurements in realworld units, you'll need a scale reference measurement. You must, during the photography process, measure parts (one or more) of features building elements (if you work on a building). This scale measurement can be acquired using simple tools such as a tape measure. This measure will allow to scale the sparse or the dense cloud. Then you will measure any part of the cloud or 3d mesh model to have the real distances (see § VI.3/)



### The process :

- **Step 1** : Loading photos into PhotoScan. Then inspecting loaded images, removing unnecessary images;
- **Step 2** : Aligning photos; Check the alignment, edition of the sparse cloud
- **Step 3** : Building dense point cloud; edition of the dense point cloud;
- **Step 4**: Building mesh (3D polygonal model); editing mesh.
- **Step 5** : Generating texture;
- **Step 6** : Exporting results.

## V. 1 / Step 1: Loading Photos: Menu Workflow /Add Photos... and inspection.

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### I.1/ Menu Workflow/Add Photos or click Add Photos icon located on Workspace toolbar.

In the **Add Photos** dialog browse the source folder and select files to be processed. Click *Open* button. PhotoScan accepts the following image formats: **JPEG, TIFF, PNG, BMP, PPM, OpenEXR and JPEG Multi-Picture Format (MPO)**. To work with other types of photos you will need to convert them in one of the supported formats.

### I.2/ Inspecting the loaded photos.

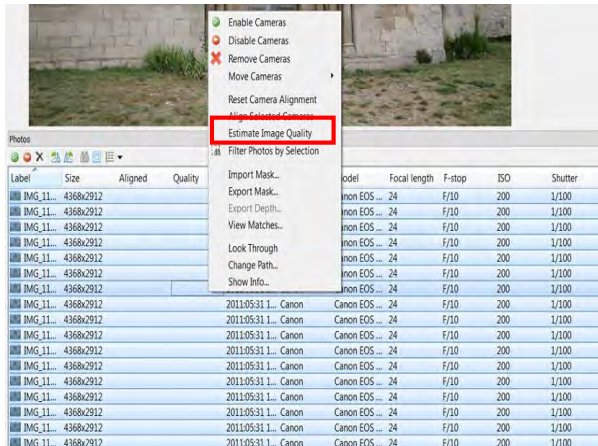
Loaded photos are displayed on the Workspace pane along with flags reflecting their status. The following flags can appear next to the photo name:

- **NC (Not calibrated)**  
Notifies that the EXIF data available is not sufficient to estimate the camera focal length. In this case. PhotoScan assumes that the corresponding photo was taken using 50mm lens (35mm film equivalent).  
If the actual focal length differs significantly from this value, manual calibration may be required. More details on manual camera calibration can be found in the [Camera calibration](#) section.
- **NA (Not aligned)**  
Notifies that external camera orientation parameters were not estimated for the current photo yet.



**To estimate image quality**

- 1) Switch to the detailed view in the Photos pane using **Details** command
- 2) Select all photos to be analyzed on the Photos pane.
- 3) Right button click on the selected photo(s) and choose **Estimate Image Quality** command from the context menu.
- 4) Estimated image quality value will be displayed in the Quality column on the Photos pane. **Images with quality value of less than 0.5 units are recommended to be disabled** and thus excluded from photogrammetric processing, providing that the rest of the photos cover the whole scene to be reconstructed.

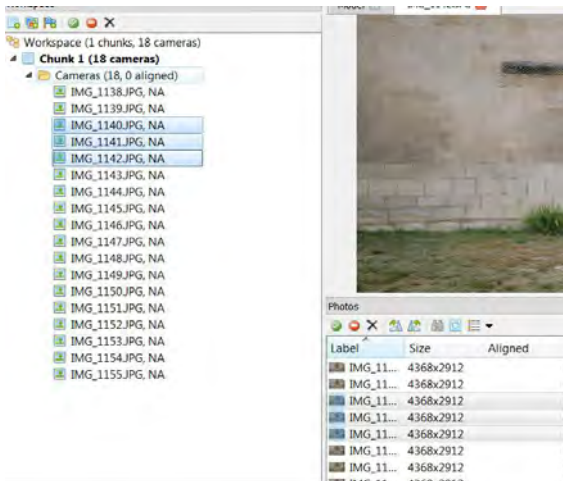


PhotoScan estimates image quality as a relative sharpness of the photo with respect to other images in the data set.

The value of the parameter is calculated based on the sharpness level of the most focused part of the picture.

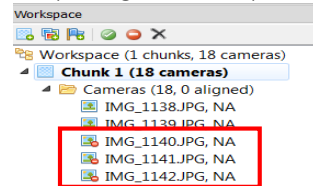
| Label     | Size      | Aligned | Quality  |
|-----------|-----------|---------|----------|
| IMG_11... | 4368x2912 |         | 0.824084 |
| IMG_11... | 4368x2912 |         | 0.839354 |
| IMG_11... | 4368x2912 |         | 0.857123 |
| IMG_11... | 4368x2912 |         | 0.850915 |
| IMG_11... | 4368x2912 |         | 0.855848 |
| IMG_11... | 4368x2912 |         | 0.85351  |
| IMG_11... | 4368x2912 |         | 0.812447 |
| IMG_11... | 4368x2912 |         | 0.800885 |
| IMG_11... | 4368x2912 |         | 0.810622 |

**To disable or to Remove unwanted photos :** Right-click in the Workspace pane or in the Photo pane on the selected photos and choose **Disable** or **Remove Camera** command from the opened context menu, or click **Disable** or **Remove Camera** toolbar button on the Workspace pane or in the Photo pane



- ← Enable camera (if Disable)
- ← Disable camera
- ← Remove camera

Disable cameras are excluded from the photogrammetric processing.



Remove camera are removed from the chunk

## V.2 / Step 2: Menu Workflow /Align Photos..., check alignment and edition of the sparse cloud

### V.2.1/ Menu Workflow/Align Photos

For this first step Photoscan will align the photos. PhotoScan estimates internal and external camera orientation parameters during photo alignment. When the alignment step is completed the results will be a point cloud and the estimated positions camera.

Select the desired reconstruction parameters

#### Accuracy

Higher accuracy setting helps to obtain more accurate camera position estimates. Lower accuracy setting can be used to get the rough camera positions in a shorter period of time.

- **High accuracy** setting the software works with original photos as are,
- **Medium** setting cause image reduction by factor of 4.
- **Low accuracy** source files are reduced by 4 times more.



#### Pair preselection

The alignment process of large photo sets can take a long time. A significant portion of this time period is spent on matching of detected features across the photos.

Image pair preselection option may speed up this process due to selection of a subset of image pairs to be matched.

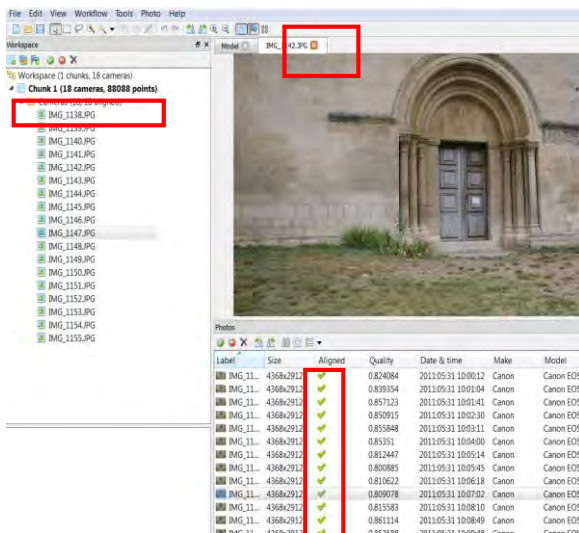
- In the **Disabled** mode Image pair preselection is off.
- In the **Generic** preselection mode the overlapping pairs of photos are selected by matching photos using lower accuracy setting first.
- In the **Ground Control** preselection mode the overlapping pairs of photos are selected basing on the measured camera locations (if present). We must know the camera coordinates.

#### Advanced parameters.

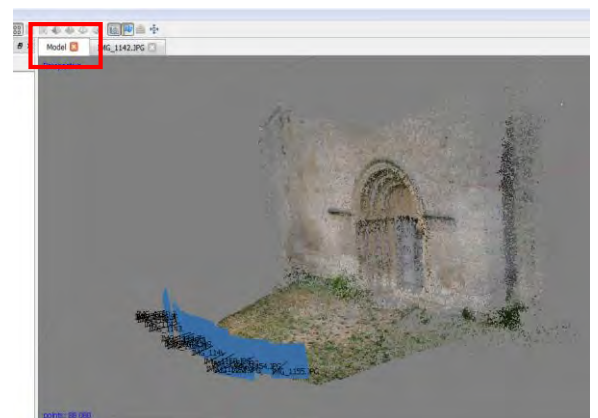
- **Point limit** : The number indicates upper limit of feature points on every image to be taken into account during current processing stage.
- **Constrain features by mask** : When this option is enabled, features detected in the masked image regions are discarded.

## V.2.2 / Check the alignment

Photo View



Model View

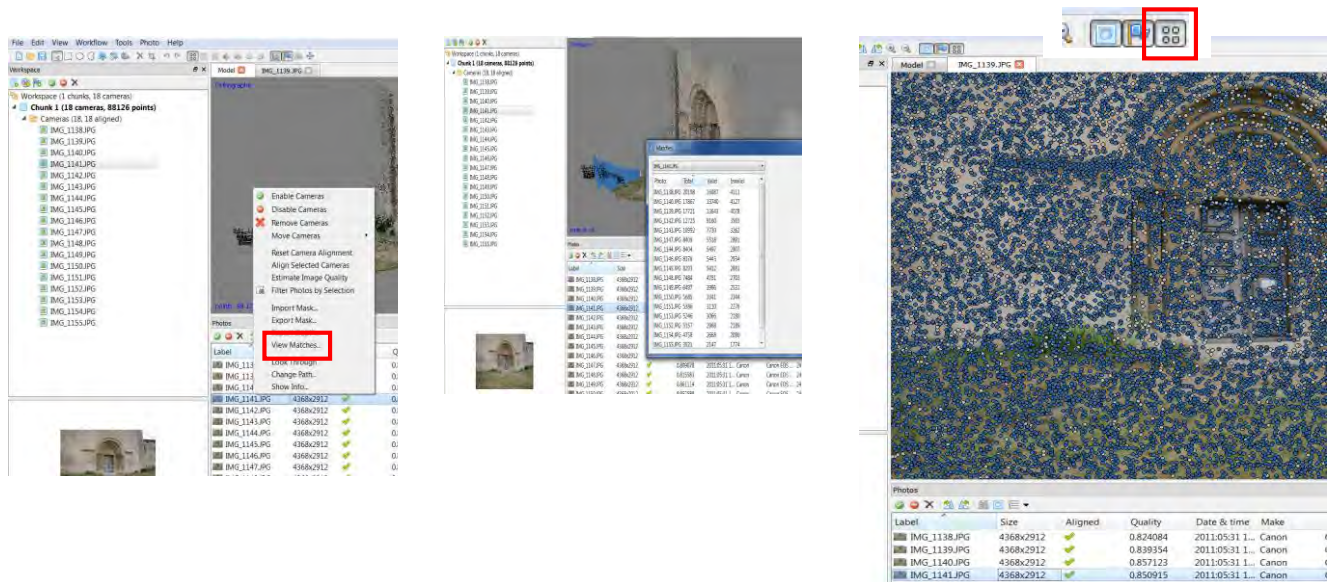


Alignment having been completed, computed camera positions and a sparse point cloud will be displayed.

You can inspect alignment results and remove incorrectly positioned photos, if any.

To see the matches between any two photos use View Matches... command from a photo context menu in the Photos pane.

To see the points matches on a photo, in the Image View command, use View Point icone. Blue points are valid matches, white points invalid.



Incorrectly positioned photos can be realigned.

#### To realign a subset of photos


- 1) Reset alignment for incorrectly positioned cameras using **Reset Camera Alignment** command from the photo context menu.
- 2) Set markers (at least 4 per photo) on these photos and indicate their projections on at least two photos from the already aligned subset. PhotoScan will consider these points to be true matches. (For information on markers placement refer to the Setting coordinate system section).
- 3) Select photos to be realigned and use **Align Selected Cameras** command from the photo context menu.
- 4) The progress dialog box will appear displaying the current processing status.

When the alignment step is completed, the point cloud and estimated camera positions can be exported for processing with another software if needed.

### V.2.3. / Edition of the sparse cloud

#### V.2.3.A. / To remove points based on specified criterion

In some cases it may be useful to find out where the points with high reprojection error are located within the sparse cloud, or remove points representing high amount of noise. Point cloud filtering helps to select such points, which usually are supposed to be removed.

- 1) Switch to Point Cloud view mode using Point Cloud toolbar button. 
- 2) Menu **Edit/ Select Gradual Selection...**
- 3) In the Gradual Selection dialog box specify the criterion to be used for filtering.  
Adjust the threshold level using the slider, the selection changes while dragging the slider.  
Click **OK** button to finalize the selection.
- 4) Button **Del** on the keyboard or **Delete Selection** toolbar button

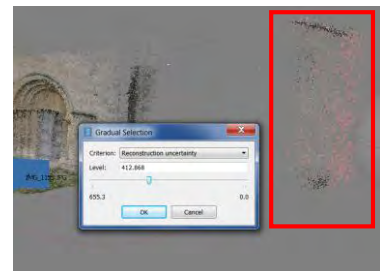
PhotoScan supports the following criteria for point cloud filtering  
Reprojection error

**High reprojection error** usually indicates poor localization accuracy of the corresponding point projections at the point matching step.

#### **Reconstruction uncertainly**

High reconstruction uncertainty is typical for points, reconstructed from nearby photos with small baseline. Such points can noticeably deviate from the object surface, introducing noise in the point cloud. While removal of such points should not affect the accuracy of optimization, it may be useful to remove them before building geometry in Point Cloud mode or for better visual appearance of the point cloud.

**Image count** : PhotoScan reconstruct all the points that are visible at least on two photos.



**Reconstruction uncertainly** is used for this example to remove points of the right side sparse cloud

#### V.2.3.B. / Manual points removal : Incorrect points can be also removed manually.

Switch to **Sparse Cloud** view mode using Point Cloud toolbar button

Select points to be removed using **Rectangle**, **Circle** or **Free-Form** Selection tools.

To add new points to the current selection hold the **Ctrl key**. To remove some points from the current selection hold the **Shift key**.



To delete selected points click the **Delete Selection** toolbar button

To crop selection to the selected points click the **Crop Selection** toolbar button or select Crop Selection command from the Edit menu.



## V.3 / Step 3 : Menu Workflow /Build Dense Clouds...

Based on the estimated camera positions the program calculates depth information for each camera to be combined into a single dense point cloud.

A dense point cloud can be edited and classified within PhotoScan environment or exported to an external tool for further analysis.

### V.3.1. / Orientation of the sparse cloud to build a dense point cloud

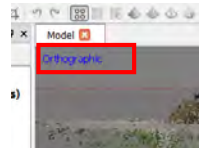
Check and adjust the point cloud with the good orientation. It will be easier to use the cloud to resize the bounding box for the future dense point cloud.

In the model view use the **Rotate Object** icon



Deselect the **Show camera** icon for a better visualization

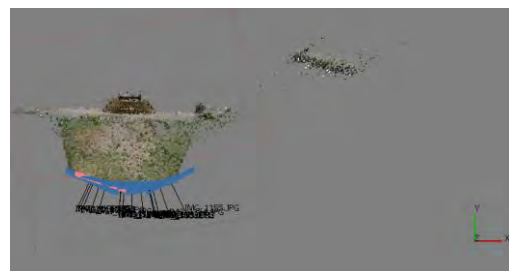
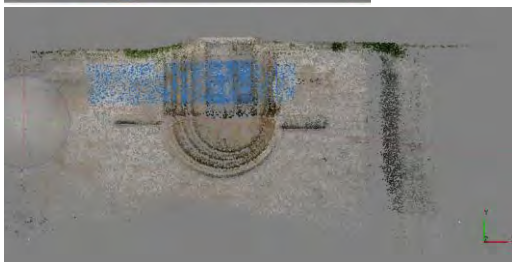
Menu View Perspective/orthographic or use Key 5



Menu View/Predefined View or use the keys 7 (Top), 1 (Front) 3 (Right) to align the object on the Model View axes.

| Predefined Views |          |
|------------------|----------|
| Top              | 7        |
| Bottom           | Ctrl + 7 |
| Right            | 3        |
| Left             | Ctrl + 3 |
| Front            | 1        |
| Back             | Ctrl + 1 |

| Rotate View  |   |
|--------------|---|
| Rotate Up    | 8 |
| Rotate Down  | 2 |
| Rotate Left  | 4 |
| Rotate Right | 6 |



Check the reconstruction volume bounding box: To adjust the bounding box use the **Resize Region** and **Rotate Region** toolbar icons.

First rotate the bounding box and then drag corners of the box to the desired positions.



### V.3.2 / Menu Workflow/ Build Dense Cloud... select the desired reconstruction parameters

Select the desired reconstruction parameters

Reconstruction parameters

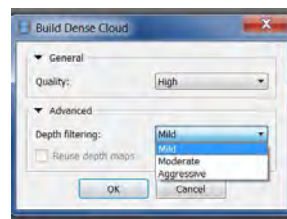
#### Quality

**Higher quality** settings can be used to obtain more detailed and accurate geometry, but require longer time for processing. Interpretation of the quality parameters here is similar to that of accuracy settings given in Photo Alignment section. The only difference is that in this case Ultra High quality setting means processing of original photos, while each following step implies preprocessing image size reduction by factor of 4.

Advanced parameters: Depth Filtering modes

At the stage of dense point cloud generation reconstruction PhotoScan calculates depth maps for every image. Due to some factors, like poor texture of some elements of the scene, noisy or badly focused images, there can be some outliers among the points. To sort out the outliers PhotoScan has several built-in filtering algorithms that answer the challenges of different projects.

- **Mild depth** filtering mode: If the geometry of the scene to be reconstructed is complex with numerous small details on the foreground, then it is recommended to set Mild depth filtering mode, for important features not to be sorted out.
- If the area to be reconstructed does not contain meaningful small details, then it is reasonable to choose **Aggressive depth** filtering mode to sort out most of the outliers.
- **Moderate depth** filtering mode brings results that are in between the Mild and Aggressive approaches. You can experiment with the setting in case you have doubts which mode to choose.



### V.3.3 / Manual dense points cloud removal

Manual points removal: Incorrect points can be also removed manually.

Switch to dense **Cloud view mode** using **Dense Cloud toolbar button**.

Select points to be removed using the selection tools: Crop, Rectangle, Circle or Free-Form Selection tools and the Delete icon.



### V.3.4 / Classifying dense cloud points


PhotoScan allows not only to generate and visualize dense point cloud but also to classify the points within it. There are two options: automatic division of all the points into two classes - ground points and the rest, and manual selection of a group of points to be placed in a certain class from the standard list known for LIDAR data. Dense cloud points classification opens way to customize Build Mesh step: you can choose what type of objects within the scene you would like to be reconstructed and indicate the corresponding point class as a source data for mesh generation. For example, if you build mesh based on ground points only, it will be possible to export DTM (as opposed to DSM) at the next step.

#### Manual classification of dense cloud points

PhotoScan allows to associate all the points within the dense cloud with a certain standard class (see LIDAR data classification). This provides possibility to diversify export of the processing results with respect to different types of objects within the scene, e. g. DTM for ground, mesh for buildings and point cloud for vegetation.



### To assign a class to a group of points

- 1) Switch to Dense Cloud view mode using Dense Cloud toolbar button 
- 2) Select points to be placed to a certain class using the selection tools : **Rectangle, Circle Selection ...**
- 3) **Menu/Tools/Dense Cloud/Assign Class...**
- 4) In the Assign Class dialog box select the source point data for the classification procedure and the targeted class to be assigned to the selected points. Click **OK** button to run the classification procedure.

## V.4 / Step 4 : Menu Workflow /Building mesh

### V.4.1 / Menu Workflow/ Build mesh

In the Model View check the reconstruction volume bounding box.

Menu **Workflow/Build Mesh...** In the Build Mesh dialog box select the desired reconstruction parameters.

#### Reconstruction parameters

PhotoScan supports several reconstruction methods and settings, which help to produce optimal reconstructions for a given data set.

##### Surface type

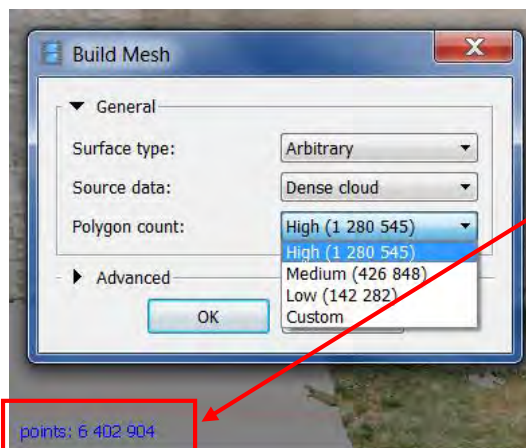
- **Arbitrary surface** type can be used for modeling of any kind of object. It should be selected for closed objects, such as statues, buildings, etc. It doesn't make any assumptions on the type of the object modeled, which comes at a cost of higher memory consumption.
- **Height field surface** type is optimized for modeling of planar surfaces, such as terrains or bas-reliefs. It should be selected for aerial photography processing as it requires lower amount of memory and allows for larger data sets processing.

##### Source data

Specifies the source for the mesh generation procedure. Sparse cloud can be used for fast 3D model generation based solely on the sparse point cloud. Dense cloud setting will result in longer processing time but will generate high quality output based on the previously reconstructed dense point cloud.

##### Polygon count

Specifies the maximum face count in the final mesh. Suggested values (**High, Medium, Low**) are calculated based on the number of points in the previously generated dense point cloud: the ratio is **1/5, 1/15, and 1/45** respectively.



They present optimal number of polygons for a mesh of a corresponding detailisation.

It is still possible for a user to indicate the target number of polygons in the final mesh according to his choice. It could be done through the Custom value of the Polygon count parameter.

Please note that while too small number of polygons is likely to result in too rough mesh, too huge custom number (over 10 million polygons) is likely to cause model visualisation problems in external software.

## Advanced parameters

### Interpolation

If interpolation mode is **Disabled** it leads to accurate reconstruction results since only areas corresponding to dense point cloud points are reconstructed. Manual hole filling is usually required at the post processing step.

- With **Enabled** (default) interpolation mode PhotoScan will interpolate some surface areas within a circle of a certain radius around every dense cloud point. As a result some holes can be automatically covered. Yet some holes can still be present on the model and are to be filled at the post processing step. **Enabled (default) setting is recommended for orthophoto generation.**
- In **Extrapolated mode** the programme generates holeless model with extrapolated geometry. Large areas of extra geometry might be generated with this method, but they could be easily removed later using selection and cropping tools.

### Point classes

Specifies the classes of the dense point cloud to be used for mesh generation. For example, select only "Ground Points" to produce a DTM as opposed to a DSM.

## V.4.2/ Menu Tools/Mesh

### V.4.2.1 / Menu Tools/Mesh/Decimate

Highly detailed models may contain hundreds of thousands polygons.

While it is acceptable to work with such a complex models in 3D editor tools, in most conventional tools like Adobe Reader or Google Earth high complexity of 3D models may noticeably decrease application performance. However, if there are no special **requirements it is recommended to decimate the model down to 100 000 - 200 000 polygons for exporting in PDF, and to 100 000 or even less for displaying in Google Earth and alike tools.**

**Menu Tools/Mesh/ Decimate Mesh...** In the Decimate Mesh dialog box specify the target number of faces, which should remain in the final model.

### V.4.2.2 / Menu Tools/Mesh/Close Holes...

Close Holes tool provides possibility to repair your model if the reconstruction procedure resulted in a mesh with several holes, due to insufficient image overlap for example.

Some tasks require a continuous surface disregarding the fact of information shortage. It is necessary to generate a close model, for instance, to fulfil volume measurement task with PhotoScan.

Menu **Tools/Mesh/ Close Holes...** In the Close Holes dialog box indicate the maximum size of a hole to be covered with the slider. The slider allows to set the size of a hole in relation to the size of the hole model surface.


### V.4.2.3 / Menu Tools/Mesh/ View Mesh Statistics...

Menu **Tools/Mesh/View Mesh Statistics...** collects and displays mesh statistics.

## V.4.3 / Edition of the mesh (faces of the mesh)

### V.4.3.1 / To remove faced based on specified criterion

Mesh filtering based on different criteria helps to select faces, which usually are supposed to be removed.

- 1) Switch to **Shaded Mesh view**. 
- 2) In the Menu **Edit/ Select Gradual Selection...** specify the criterion to be used for filtering. Adjust the threshold level using the slider, the selection changes while dragging the slider.
- 3) Button **Del** on the keyboard or Delete Selection toolbar button.

PhotoScan supports the following criteria for face filtering:

#### Connected component size

This filtering criteria allows to select isolated fragments with a certain number of polygons. The number of polygons in all isolated components to be selected is set with a slider and is indicated in relation to the number of polygons in the whole model. The components are ranged in size, so that the selection proceeds from the smallest component to the largest one.

#### Polygon size

This filtering criteria allows to select polygons up to a certain size. The size of the polygons to be selected is set with a slider and is indicated in relation to the size of the whole model. This function can be useful, for example, in case the geometry was reconstructed in Smooth type and there is a need to remove extra polygons automatically added by PhotoScan to fill the gaps; these polygons are often of a larger size than the rest.

### V.4.3.2 / Manual faces removal

Switch to **Shaded Mesh view** mode using the Shaded Mesh toolbar button.



Select faces to be removed using the selection tools: **Crop**, **Rectangle**, **Circle** or **Free-Form** Selection tools and the **Delete** icon.

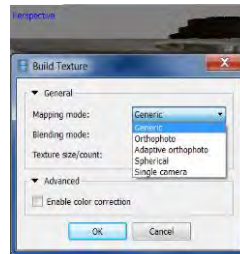
To grow or shrink current selection

- To grow current selection **Menu Edit/Grow Selection...** or press **PageUp** key in the selection mode. To grow selection by even a large amount, press **PageUp + Shift** key pressed.
- To shrink current selection **Menu Edit/Shrink Selection...** or press **PageDown** key in the selection mode. To shrink selection by even a larger amount, press **PageDown + Shift** key pressed.

## V/ Step 5 : Menu Workflow /Build Texture...

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The texture mapping mode determines how the object texture will be packed in the texture atlas. Proper texture mapping mode selection helps to obtain optimal texture packing and, consequently, better visual quality of the final model.



### Mapping Mode

#### Generic

The default mode is the Generic mapping mode; it allows to parametrize texture atlas for arbitrary geometry. No assumptions regarding the type of the scene to be processed are made; program tries to create as uniform texture as possible.

#### Orthophoto

In the Orthophoto mapping mode the whole object surface is textured in the orthographic projection. The Orthophoto mapping mode produces even more compact texture representation than the Adaptive orthophoto mode at the expense of texture quality in vertical regions.

#### Adaptive orthophoto

In the Adaptive orthophoto mapping mode the object surface is split into the flat part and vertical regions. The flat part of the surface is textured using the orthographic projection, while vertical regions are textured separately to maintain accurate texture representation in such regions. When in the Adaptive orthophoto mapping mode, program tends to produce more compact texture representation for nearly planar scenes, while maintaining good texture quality for vertical surfaces, such as walls of the buildings.

#### Spherical

Spherical mapping mode is appropriate only to a certain class of objects that have a ball-like form. It allows for continuous texture atlas being exported for this type of objects, so that it is much easier to edit it later. When generating texture in Spherical mapping mode it is crucial to set the Bounding box properly.

The whole model should be within the Bounding box. The red side of the Bounding box should be under the model; it defines the axis of the spherical projection. The marks on the front side determine the 0 meridian.

#### Single camera

The Single photo mapping mode allows to generate texture from a single photo. The photo to be used for texturing can be selected from 'Texture from' list.

#### Keep uv

The Keep uv mapping mode generates texture atlas using current texture parametrization. It can be used to rebuild texture atlas using different resolution or to generate the atlas for the model parametrized in the external software.

### Blending Mode

The following parameters control various aspects of texture atlas generation:

#### Texture from (Single photo mapping mode only)

Specifies the photo to be used for texturing. Available only in the Single photo mapping mode.

#### Blending mode (not used in Single photo mode)

Selects the way how pixel values from different photos will be combined in the final texture. Mosaic - gives more quality for orthophoto and texture atlas than Average mode, since it does not mix image details of overlapping photos but uses most appropriate photo (i. e. the one where the pixel in question is located within the shortest distance from the image center).

**Mosaic** texture blending mode is especially useful for orthophoto generation based on approximate geometric model.

**Average** - uses the average value of all pixels from individual photos.

**Max Intensity** - the photo which has maximum intensity of the corresponding pixel is selected.

**Min Intensity** - the photo which has minimum intensity of the corresponding pixel is selected.

#### Texture size / count

Specifies the size (width & height) of the texture atlas in pixels and determines the number of files for texture to be exported to. Exporting texture to several files allows to archive greater resolution of the final model texture, while export of high resolution texture to a single file can fail due to RAM limitations. Additionally the following advanced parameters can be adjusted.

### Advanced

#### Enable color correction

The feature is useful for processing of data sets with extreme brightness variation. However, please note that color correction process takes up quite a long time, so it is recommended to enable the setting only for the data sets that proved to present results of poor quality.

#### Notes:

- HDR texture generation requires HDR photos on input.
- To improve result texture quality it may be reasonable to exclude poorly focused images from processing at this step. PhotoScan suggests automatic image quality estimation feature. Images with quality value of less than 0.5 units are recommended to be disabled and thus excluded from texture generation procedure.

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## V/ Step 6: Exporting results

### V.6.1 /Point cloud export

To export sparse or dense point cloud:

- 1) Menu **File/ Export Points...** In the Export Points dialog box select desired Type of point cloud - Sparse or Dense
- 2) Specify the coordinate system and indicate export parameters applicable to the selected file type.

#### Notes:

Saving color information of the point cloud is supported by the **PLY**, **TXT** and **LAS** file formats.

Saving point normals information is supported by the **OBJ**, **PLY** and **TXT** file formats.

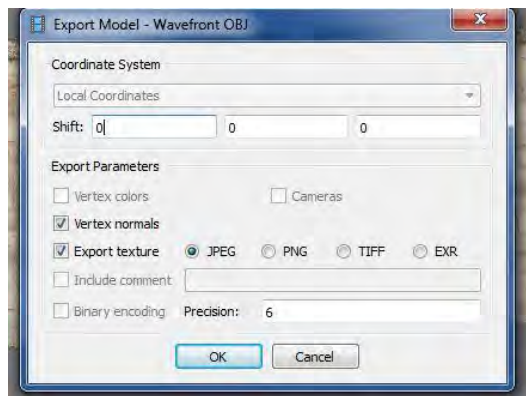
### V.6.2 /3D model export

To export 3D model

- 1) **Menu Files/ Export Model...**
- 2) In the Export Model dialog specify the coordinate system and indicate export parameters applicable to the selected file type.

#### Note

- If the model is exported in local coordinates, PhotoScan can write a KML file for the exported model to be correctly located on Google Earth.
- If a model generated with PhotoScan is to be imported in a 3D editor program for inspection or further editing, it might be helpful to use Shift function while exporting the model. It allows to set the value to be subtracted from the respective coordinate value for every vertex in the mesh. Essentially, this means translation of the model coordinate system origin, which may be useful since some 3D editors, for example, truncate the coordinates values up to 8 or so digits, while in some projects they are decimals that make sense with respect to model positioning task. So it can be recommended to subtract a value equal to the whole part of a certain coordinate value (see Ground Control pane, Camera coordinates values) before exporting the model, thus providing for a reasonable scale for the model to be processed in a 3D editor program.



PhotoScan supports model export in the following formats: **Wavefront OBJ, 3DS file format, VRML, COLLADA, Stanford PLY, Autodesk FBX, Autodesk DXF, Google Earth KMZ, U3D, Adobe PDF.**

Some file formats (**OBJ, 3DS, VRML, COLLADA, PLY, FBX**) save texture image in a separate file. **The texture file should be kept in the same directory as the main file describing the geometry.** If the texture atlas was not built only the model geometry is exported.

### V.6.3 /Orthophoto export

Orthophoto export is normally used for generation of high resolution imagery based on the source photos and reconstructed geometry. The most common application is aerial photographic survey processing, but it may be also useful when a detailed view of the object is required. Orthophoto is often accompanied by the digital elevation model.

In order to export orthophoto in the correct orientation it is necessary to set the coordinate system for the model first. **Since PhotoScan uses original images to build an orthophoto, there is no need to build a texture atlas.**

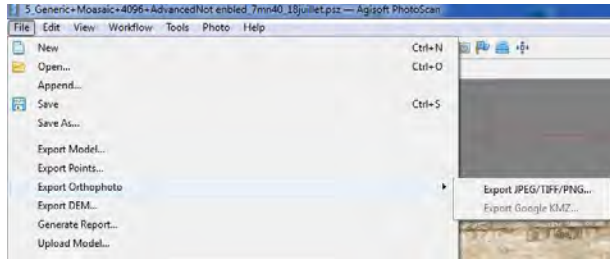
To export Orthophoto

- 1) **Menu/ Export Orthophoto...**
- 2) In the Export Orthophoto dialog box specify coordinate system to georeference the Orthophoto.
- 3) Select **Blending mode** to be used for texture mapping (see Mapping Mode Step 5).
- 4) Check Write KML file and / or Write World file options to create files needed to georeference the orthophoto in the Google Earth and / or a GIS.
- 5) Click **Export button** to start export.

#### Note

- Write KML file option is available only if the model is georeferenced in WGS84 coordinate system due to the fact that Google Earth supports only this coordinate system.

- World file specifies coordinates of the four angle vertices of the exporting orthophoto. This information is already included in GeoTIFF file, however, you could duplicate it for some reason. If you need to export orthophoto in JPEG or PNG file formats and would like to have georeferencing data this informations could be useful.



Following formats are supported for orthophoto export: **JPEG, PNG, TIFF, GeoTIFF**, Multiresolution Google Earth **KML** mosaic.

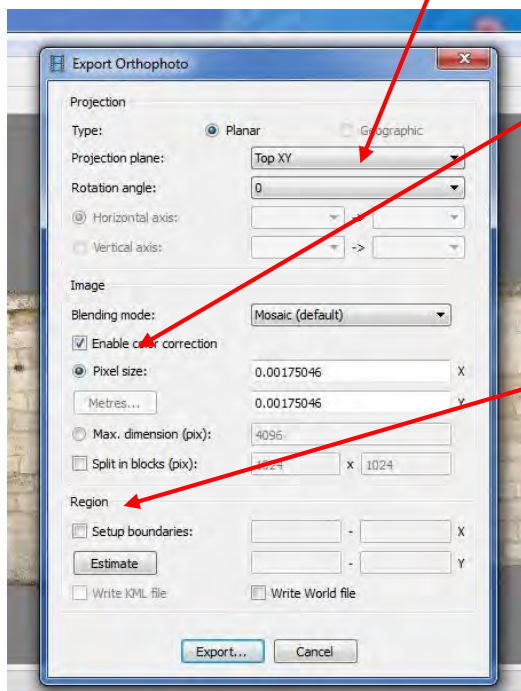
PhotoScan allows to export Orthophoto in different planar projections as well. To export Orthophoto in a planar projection choose **Planar Projection Type** in **Export Orthophoto dialog**. You can select projection plane and orientation of the Orthophoto. PhotoScan provides an option to project the model to a plane determined by a set of markers (if there are no 3 markers in a desired projection plane it can be specified with 2 vectors, i. e. 4 markers).

If the export file of a fixed size is needed, it is possible to set the length of the longer side of the export file in Max. dimension (pix) parameter. The length should be indicated in pixels.

Split in blocks option in the Export Orthophoto dialog can be useful for exporting large projects. You can indicate the size of the blocks (in pix) for the orthophoto to be divided into. The whole area will split in equal blocks starting from the point with maximum x and y values. Note that empty blocks will not be saved.

#### Note

- Default value for pixel size in Export Orthophoto dialog refers to ground sampling resolution, thus, it is useless to set a smaller value: the number of pixels would increase, but the effective resolution would not.



- **Colour correction** feature is useful for processing of data sets with extreme brightness variation. Note that color correction process takes up quite a long time, so it is recommended to enable the setting only for the data sets that proved to present results of poor quality before.

- To export a particular part of the project use **Region section** of the Export Orthophoto dialog. Indicate coordinates of the top left and bottom right corners of the region to be exported in the left and right columns of the textboxes respectively.

Estimate button allows you to see the coordinates of the top left and bottom right corners of the whole area



## VI/ Model Measurements (Markers and Rulers)

PhotoScan uses markers to specify locations within the scene. Markers are used for setting up a coordinate, photo alignment optimization, measuring distances and volumes within the scene as well as for marker based chunk alignment. Marker positions are defined by their projections on the source photos.


PhotoScan supports two approaches to marker placement: manual marker placement and guided marker placement:

- Manual marker placement does not require 3D model and can be performed even before photo alignment. Within the manual approach the marker projections should be indicated manually on each photo where the marker is visible.
- Reconstructed 3D model surface is required for the guided approach  
Guided marker placement usually speeds up the procedure of marker placement significantly and also reduces the chance of incorrect marker placement. It is recommended in most cases.  
In the guided approach marker projection is specified for a single photo only. PhotoScan automatically projects the corresponding ray onto the model surface and calculates marker projections on the rest of the photos where marker is visible. Marker projections defined automatically on individual photos can be further refined manually.

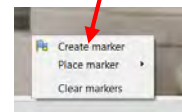
### VI.1 / Place a marker using guided approach

#### VI.1.1 / Place a marker using guided approach

##### On a photo

- 1) Open a photo where the marker is visible by double clicking on its name.
- 2) Switch to the marker editing mode  using **Edit Markers** toolbar button.

Photo



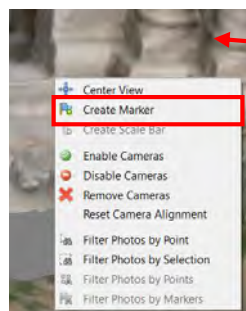
- 3) Right click on the photo at the point corresponding to the marker location.
- 4) Select **Create Marker** command from the context menu.

New marker will be created and its projections on the other photos will be automatically defined.

##### On the 3D Model

Guided marker placement can be performed in the same way from the 3D view by right clicking on the corresponding point on the model surface and using **Create Marker command** from the context menu.

Guided marker placement can be performed in the same way from the 3D view by right clicking on the corresponding point on the model surface and using **Create Marker command** from the context menu.

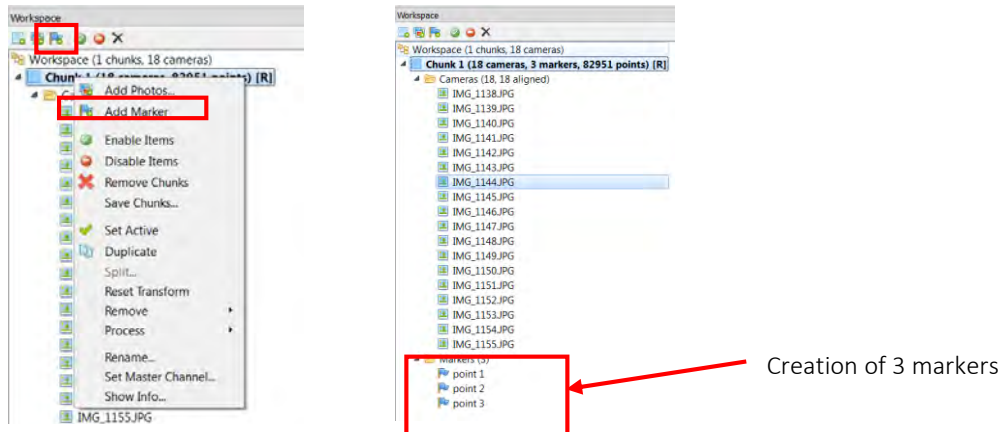


3D Model

While the accuracy of marker placement in the 3D view is usually much lower, it may be still useful for quickly locating the photos observing the specified location on the model.

### VI.1.2 / Place a marker using manual approach

- 1) Create marker instance using **Add marker button** on the **Workspace pane** or by **Add Marker command** from the **Chunk context menu** (available by right clicking on the chunk title on the Workspace pane).



- 2) Open the photo where the marker projection needs to be added by double clicking on the photos name.
- 3) Switch to the marker editing mode using **Edit Markers toolbar button**.
- 4) Right click at the point on the photo where the marker projection needs to be placed. From the context menu open **Place Marker submenu** and select the marker instance previously created. The marker projection will be added to the current photo.



- 5) Repeat the previous step to place marker projections on other photos if needed.

### VI.2 / Distance measurement

In the **Ground Control Pane**

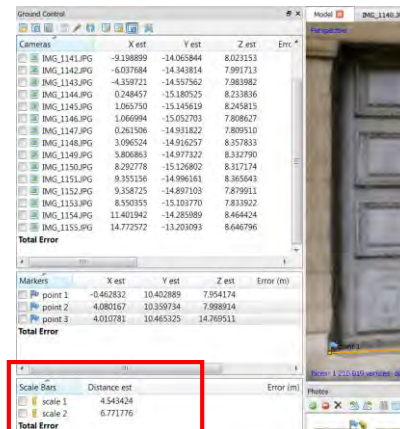
- 1) Select both markers to be used for distance measurements on the Ground Control pane using **Ctrl** button.
- 2) Select **Create Scale Bar** command from the **3D view context menu**. The scale bar will be created and an instant added to the Scale Bar list on the Ground Control pane.



- 3) Switch to the estimated values mode using **View Estimated button** from the Ground Control pane toolbar.




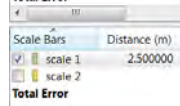
- 4) The estimated distance for the newly created scale bar equals to the distance that should have been measured.







### VI.3 / Scale the sparse and dense clouds with a known distance measured on the object.

Please see the beginning remark of the [§V Processing of images with PhotoScan...](#)

- 1) Switch to the **View Source mode**  using the Ground Control pane toolbar button.
- 2) Double click on the **Distance (m) box** next to the newly created scale bar name and enter the known length of the bar in meters (2.5 for example).



- 3) Click on the Update button  then View Estimated .
- 4) On the Ground Control pane check all scale bars (the bars using the real distance measurement) to be used in optimization procedure.
- 5) Click **Settings toolbar** button  on the Ground Control pane. In the Ground Control Settings dialog box specify the assumed accuracy of scale bars measurements. Click **OK** button.
- 6) Click Optimize toolbar button . In Optimize Photo Alignment dialog box check additional camera parameters to be optimized if needed. Click **OK** button to start optimization.

After the optimization is complete, cameras and markers estimated coordinates will be updated as well as all the georeferencing errors. To analyze optimization results switch to the View Estimated mode using the Ground Control pane toolbar button. In scale bar section of the Ground Control pane estimated scale bar distance will be displayed.

The result is the sparse cloud. You must recalculate the dense cloud, then the mesh if you want to place new markers using guided approach.

### VI.4 / What does the errors in the Ground Control pane mean?

#### Cameras section

- Error (m) - distance between the input (source) and estimated positions of the camera.
- Error (deg) - root mean square error calculated over all three orientation angles.
- Error (pix) - root mean square reprojection error calculated over all feature points detected on the photo.

#### Markers section

- Error (m) - distance between the input (source) and estimated positions of the marker.
- Error (pix) - root mean square reprojection error for the marker calculated over all photos where marker is visible.

#### Scale Bars section

- Error (m) - difference between the input (source) scale bar length and the measured distance between two markers representing start and end points of the scale bar.

## VII/ Working with coded and non-coded targets

Coded and non-coded targets are specially prepared, yet quite simple, real world markers that can add up to successful 3D model reconstruction of a scene. The difference between coded and non-coded targets is that while a non-coded target looks like an ordinary full circle, the coded target has a ring parted in black and white segments around the central full circle.

### Coded targets advantages and limitations

Coded targets (CTs) can be used as markers to define local coordinate system and scale of the model or as true matches to improve photo alignment procedure. PhotoScan functionality includes automatic detection and matching of CTs on source photos, which allows to benefit from marker implementation in the project while saving time on manual marker placement. Moreover, automatic CTs detection and marker placement is more precise than manual marker placement.

PhotoScan supports two types of circle CTs: 12 bit and 16 bit. While 12 bit pattern is considered to be decoded more precisely, 16 bit pattern allows for a greater number of CTs to be used within the same project.

To be detected successfully CTs must take up a significant number of pixels on the original photos. This leads to a natural limitation of CTs implementation: while they generally prove to be useful in close-range imagery projects, aerial photography projects will demand too huge CTs to be placed on the ground, for the CTs to be detected correctly.

### VII.1. /Coded targets in workflow

Sets of both patterns of CTs supported by PhotoScan can be generated by the program itself.

#### VII.1.1 / To create a printable PDF with coded targets

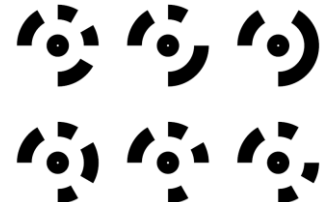
- 1) Menu **Tools / Markers/Print Markers...**
- 2) Specify the CTs type and desired print parameters in Print markers dialog.

#### **Place Coded Targets in Scene and Take Photos :**

Coded targets should be flat, any deformations should be avoided.

Any changes in the coded target pattern must be avoided.

Place Coded targets in the scene or around the object of interest so that they could be clearly seen from at least of couple of images



When the images with CTs seen on them are uploaded to the program, PhotoScan can detect and match the CTs automatically.

#### VII.1.2 / To detect coded targets on source images

- 1) Menu **Tools/Select Detect Markers...**
  - 2) Specify parameters of detector in Detect markers dialog according to the CTs type.
- PhotoScan will detect and match CTs and add corresponding markers to the Ground Control pane.

### VII.1.2 /Non-coded targets implementation

Non-coded targets (NCTs) cannot be matched automatically, however, they are helpful from the marker location accuracy point of view. Once the NCTs are matched manually, PhotoScan can refine marker location, placing the marker instant precisely in the center of the circle.

To refine marker (based on non-coded target) location:

- 1) Select markers to be refined on the Ground Control pane
- 2) Menu **Tools/ Refine Markers...**