<u>Tutorial (Beginner level):</u> <u>Orthomosaic and DEM Generation with Agisoft PhotoScan Pro 1.2</u> <u>(with Ground Control Points)</u>

Overview

Agisoft PhotoScan Professional allows to generate georeferenced dense point clouds, textured polygonal models, digital elevation models and orthomosaics from a set of overlapping images with the corresponding referencing information. This tutorial describes the main processing steps of DEM/Orthomosaic generation workflow for a set of images with the ground control points.

PhotoScan Preferences

Open PhotoScan Preferences dialog using corresponding command from the Tools menu:

PhotoScan Preferences	PhotoScan Preferences
General OpenCL Advanced Network	General OpenCL Advanced Network
User Interface	Active CPU cores:
Language: English 💌	8/12
Background color: #c2c2c2 Select	OpenCL devices:
Stereoscopic Display	GeForce GTX 680 (8 Cores @ 1137 MHz, 2048 MB) GeForce GTX 680 (8 Cores @ 1137 MHz, 2048 MB)
Mode: Anaglyph	
Parallax: 1.0	
Processing Log	
Write log to file:	
D:\PhotoScan_Pro_1.2.txt	When using OpenCL, please deactivate one CPU core for each GPU
	in use for optimal performance.
OK Cancel Apply	OK Cancel Apply

Set the following values for the parameters on the *General* tab: <u>Stereo Mode:</u> *Anaglyph* (use *Hardware* if your graphic card supports Quad Buffered Stereo) <u>Stereo Parallax:</u> 1.0

Write log to file: specify directory where Agisoft PhotoScan log will be stored

PhotoScan Preferences
General OpenCL Advanced Network
Project Files
Compression level: 6
V Keep depth maps
Store absolute image paths
Miscellaneous
Check for updates on program startup
Switch to model view by default
Enable VBO support
Strip camera extensions during model export
Reset All Settings
OK Cancel Apply

(in case of contacting the software support team it could be required)

Set the parameters in the OpenCL tab as following: Check on any OpenCL devices detected by PhotoScan in the dialog and reduce the number of active CPU cores by one for each OpenCL device enabled. Set the following values for the parameters on the Advanced tab: **Project compression level:** 6 **Keep depth maps:** enabled **Store absolute image paths:** disabled **Check for updates on program startup:** enabled

Enable VBO support: enabled

Add Photos

To add photos select *Add Photos*... command from the *Workflow* menu or **R** click *Add Photos* button located on *Workspace* toolbar.

In the Add Photos dialog browse the source folder and select files to be processed. Click Open button.

Load Camera Positions

At this step coordinate system for the future model is set using camera positions.

Note: If camera positions are unknown this step could be skipped. The align photos procedure, however, will take more time in this case.

Open *Reference* pane using the corresponding command from the *View* menu.

Click *Import* button on the *Reference* pane toolbar and select the file containing camera positions information in the *Open* dialog.

The easiest way is to load simple character-separated file (*.txt) that contains x- and y- coordinates and height for each camera position (camera orientation data, i.e. pitch, roll and yaw values, could also be imported, but the data is not obligatory to reference the model).

In the *Import CSV* dialog indicate the delimiter according to the structure of the file and select the row to start loading from. Note that # character indicates a commented line that is not counted while numbering the rows. Indicate for the program what parameter is specified in each column through setting correct column numbers in the *Columns* section of the dialog. Also it is recommended to specify valid coordinate system in the corresponding field for the values used for camera centers data. Check your settings in the sample data field in *Import CSV* dialog.

Import CSV									X
Coordinate System									
WGS 84 (EPSG::4326	6)								•
Delimiter				Columns					
Delimiter				Columns					
🔘 Tab				Label:	1	÷ A	ccuracy:	5	*
Semicolon				Longitude:	2	÷ Ya	aw:	5	*
Comma				Latitude:	3	🔶 Pi	tch:	6	*
Space				Lautuue.	3		ccn.	0	
Other:				Altitude:	4	≑ R	oll:	7	*
Combine consecu	tive delimiters			Load accura	су		Load orien	tation	
Start import at row: 2	*								
Label	Longitude	Latitude	Altitude	Yaw	Pitch	Roll			
#name	lon	lat	Н	azim	pitch	roll	time		
IMG_0083.JPG	38.78168067	54.898102	631.8068	177.6310762	01.09	-0.19	. May 05 05	5:38:41 201	1
IMG_0084.JPG	38.78174392	54.89721078	632.1584	172.0332889	01.09	-2.70	. May 05 05	5:38:47 201	1
IMG_0085.JPG	38.7819431	54.89639484	635.7408	167.6400869	01.06	-0.11	. May 05 05	5:38:52 201	1
IMG_0086.JPG	38.78227293	54.89552851	636.198	164.9311835	01.05	-0.00	. May 05 05	5:38:57 201	1
IMG_0087.JPG	38.78265655	54.89470755	634.6232	172.676666	01.04	01.03.	. May 05 05	5:39:01 201	1
IMG_0088.JPG	38.78285546	54.89382426	632.0844	180.5663709	01.05	01.02.	. May 05 05	5:39:06 201	1
IMG_0089.JPG	38.78284079	54.89301226	630.6564	183.8578081	01.07	01.01.	. May 05 05	5:39:12 201	1
IMG_0090.JPG	38.78273445	54.89210528	632.834	183.4790956	01.07	0.6668	May 05 05	5:39:17 201	1
IMG_0091.JPG	38.78264004	54.89121207	633.2048	175.013302	01.06	-3.64	. May 05 05	5:39:22 201	1
IMG_0092.JPG	38.78277624	54.89031478	631.7776	174.004961	01.05	0.038	May 05 05	5:39:27 201	1
			ОК	Cancel					

Click OK button. The data will be loaded into the Reference pane.

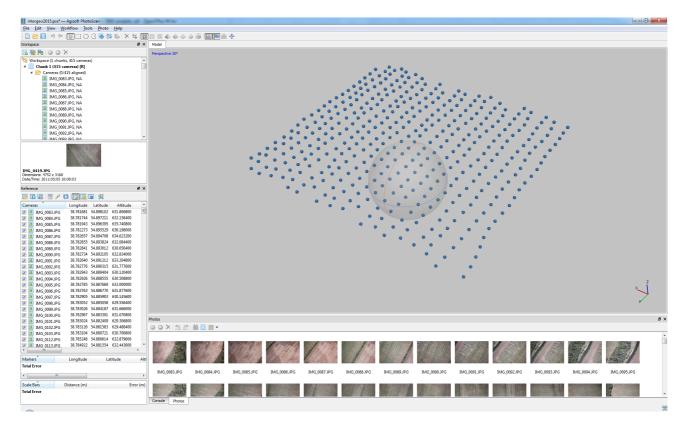
Import EXIF button located on the *Reference* pane can also be used to load camera positions information if EXIF meta-data is available.

Then click on the *Settings* button in the *Reference* pane and in the *Reference Settings* dialog select corresponding coordinate system from the list, if you have not selected it in the *Import CSV* dialog yet. Set up *Camera Accuracy* in meters and degrees according to the measurement accuracy:

Reference Settings			×
Coordinate System			
WGS 84 (EPSG::4326)			•
Measurement accuracy		Image coordinates accura	асу
Camera accuracy (m):	10		
Camera accuracy (deg):	2		
Marker accuracy (m):	0.005	Marker accuracy (pix):	0.1
Scale bar accuracy (m):	0.001	Tie point accuracy (pix):	4
Miscellaneous			
Ground altitude (m):			
	ОК	Cancel	

Ground Altitude should be specified in case of very oblique shooting.

Click OK and camera positions will be marked in *Model View* using their geographic coordinates:



If you do not see anything in the Model view, even though valid camera coordinates have been imported, please check that Show Cameras button is pressed on the Toolbar. Then click Reset View button also located on the Toolbar.

Check Camera Calibration

Open Tools Menu \rightarrow Camera Calibration window.

By default PhotoScan estimates intrinsic camera parameters during the camera alignment and optimization steps based on the Initial values derived from EXIF. In case *pixel size* and *focal length* (both in mm) are missing in the image EXIF and therefore in the camera calibration window, they can be input manually prior to the processing according to the data derived from the camera and lens specifications.

If precalibrated camera is used, it is possible to load calibration data in one of the supported formats using Load button in the window. To prevent the precalibrated values from being adjusted by PhotoScan during processing, it is necessary to check on *Fix Calibration* flag.

PhotoScan can process the images taken by different cameras in the same project. In this case in the left frame of the *Camera Calibration* window multiple camera groups will appear, split by default according to the image resolution, focal length and pixel size. Calibration groups may also be split manually if it is necessary.

In case ultra-wide or fisheye angle lens is used, it is recommended to switch camera type from *Frame* (default) to *Fisheye* value prior to processing.

Camera Calibration						x
Canon EOS 500D (28 mm) 415 images, 4752x3168 pix	Camera type: Pixel size (mm):		Frame	Frame 0.00476651 × 0.004		•
	Focal length (mm):		28	,		
	Initial Adjusted	GPS/INS Offse	et			
	Type: Auto		•			
	fx: 5874.32		cx:	2376		
	fy: 5874.32		cy:	1584		
	k1: 0		p1:	0		
	k2: 0		p2:	0		
	k3: 0		p3:	0		
	k4: 0		p4:	0		
	skew: 0			Fix calibration		
	Image	Resolution	Camera model	Focal length	Date & time	
	IMG_0083.JPG		Canon EOS 500D		2011:05:05 09:39:55	
	IMG_0084.JPG		Canon EOS 500D		2011:05:05 09:40:00	
	IMG_0085.JPG		Canon EOS 500E		2011:05:05 09:40:05	
	IMG_0086.JPG IMG_0087.JPG		Canon EOS 500D Canon EOS 500D		2011:05:05 09:40:10 2011:05:05 09:40:15	
						T
		ОКС	ancel			

Align Photos

At this stage PhotoScan finds matching points between overlapping images, estimates camera position for each photo and builds sparse point cloud model.

Select Align Photos command from the Workflow menu.

Align Photos	×	
General		
Accuracy:	High	
Pair preselection:	Reference 🔻	
▼ Advanced		
Key point limit:	40000	
Tie point limit:	10000	
Constrain features by mask		
ОК	Cancel	

Set the following recommended values for the parameters in the Align Photos dialog:

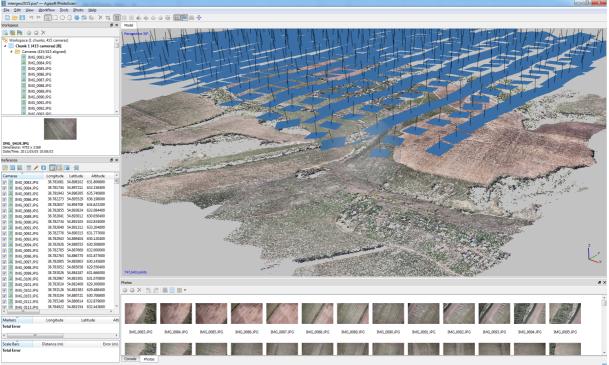
Accuracy: *High* (lower accuracy setting can be used to get rough camera positions in a shorter time)

<u>Pair preselection:</u> *Reference* (in case camera positions are unknown *Generic* preselection mode should be used)

<u>Constrain features by mask:</u> *Disabled (Enabled* in case any areas have been masked prior to processing)

Key point limit: 40000 Tie point limit: 10000

Click *OK* button to start photo alignment. In a short period of time (depends on the number of images in the project and their resolution) you will get sparse point cloud model shown in the Model view. Camera positions and orientations are indicated by blue rectangles in the view window:



Place Markers

Markers are used to optimize camera positions and orientation data, which allows for better model referencing results.

To generate accurately georeferenced orthomosaic at least 10 - 15 ground control points (GCPs) should be distributed evenly within the area of interest.

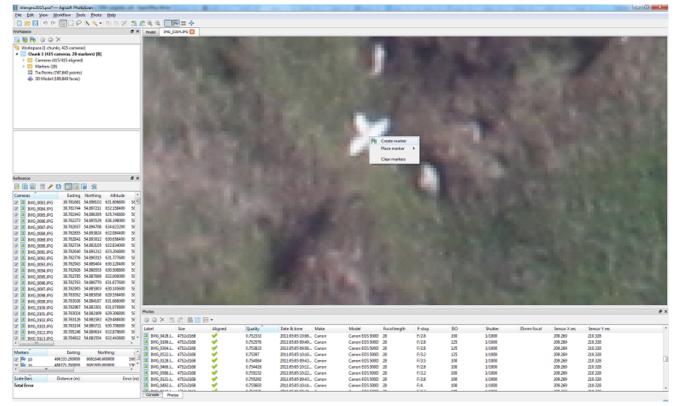
To be able to follow guided marker placement approach (which would be faster and easier), you need to reconstruct geometry first.

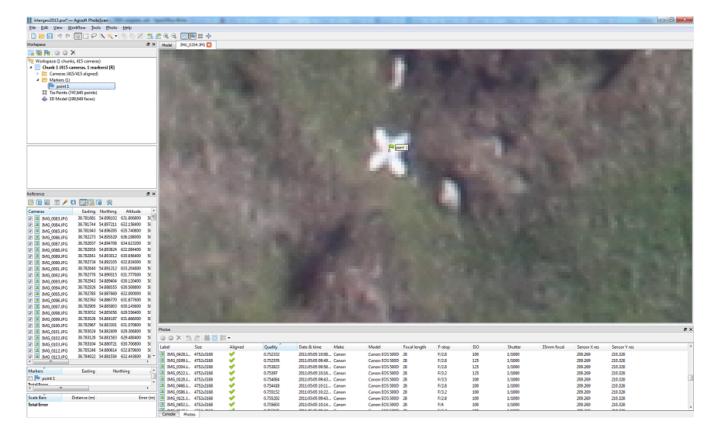
Select *Build Mesh* command from the *Workflow* menu and specify following parameters in the *Build Mesh* dialog:

Build Mesh	×
General	
Surface type:	Height field 🔹
Source data:	Sparse cloud 🔻
Face count:	200000 🔻
▼ Advanced	
Interpolation:	Extrapolated
Point classes: All	Select
ОК	Cancel

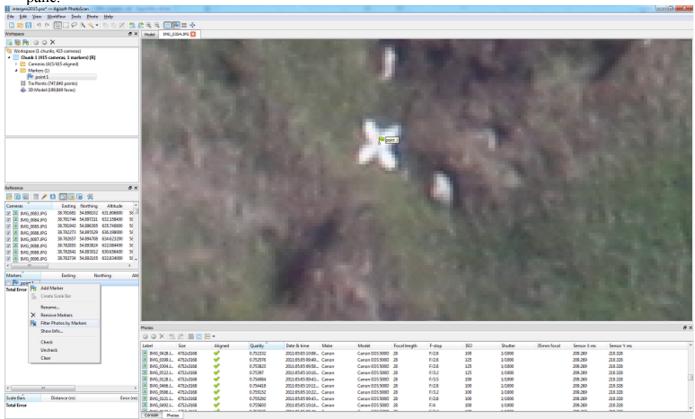
Click OK button.

Then, when geometry is built (it usually takes a few seconds to reconstruct mesh based on the sparse point cloud), open a photo where a GCP is visible in Photo View by double-clicking on its icon on the *Photos* pane. Zoom in to locate the GCP on the photo and place a marker in the corresponding point of the image using *Create Marker* command from the photo context menu available on right-click on the opened photo in the corresponding position:





Select the marker on the *Reference* pane. Then filter images in *Photos* pane using **Filter** by *Markers* option in the context menu available by right-clicking on the markers label in the *Workspace* pane.



Now you need to check the marker location on every related photo and refine its position if necessary to provide maximum accuracy. Open each photo where the created marker is visible. Zoom in and drag the marker to the correct location while holding left mouse button. Repeat the described step for every GCP.

Input Marker Coordinates

Finally, import marker coordinates from a file. Click *Import* button on the *Reference* pane toolbar and select file containing GCP coordinates data in the *Open* dialog. The easiest way is to load simple character-separated file (*.txt) that contain markers name, x-, y- coordinates and height.

In *Import CSV* dialog indicate the delimiter according to the structure of the file and select the row to start loading from. Note that # character indicates a commented line that is not counted while numbering the rows. Indicate for the program what parameter is specified in each column through setting correct column numbers in the *Columns* section of the dialog.

Also it is recommended to specify valid coordinate system in the corresponding field for the values used for camera center data.

			•
	Columns		
	Label: 1	Accuracy: 5	*
	Easting: 2		Å
	_		
	Northing: 3	Pitch: 6	×
	Altitude: 4	Roll: 7	×
ecutive delimiters	Load accu	uracy 🔲 Load orientati	on
1			
Easting	Northing	Altitude	
-	-	-	
	.,	_,	
	6081668.600000	122.600000	
487254.900000			
487514.300000	6081588.700000	152.900000	
		152.900000 173.200000 162.400000	
	1 🔹 Easting	Label: 1 Easting: 2 Northing: 3 Altitude: 4 Code according Easting Northing GEOGCS["WGS DATUM["World X/East Y/North 486333.20000 6081648.600000 486771.70000 6081809.600000	Label: 1 Accuracy: 5 Easting: 2 Yaw: 5 Northing: 3 Pitch: 6 Altitude: 4 Roll: 7 Load accuracy Load orientati 1 C Easting Northing Altitude GEOGCS["WGS DATUM["World SPHEROID["WGS 84" X/East Y/North Z/Altitude 486333.20000 6081648.60000 168.500000 486771.70000 6081809.60000 156.500000

Check your settings in the sample data field in *Import CSV* dialog:

Click OK button. The data will be loaded into the Reference pane.

Optimize Camera Alignment

To achieve higher accuracy in calculating camera external and internal parameters and to correct possible distortion (e.g. "bowl effect" and etc.), optimization procedure should be run. This step is especially recommended if the ground control point coordinates are known almost precisely – within several centimeters accuracy (marker based optimization procedure).

Click the *Settings* button in the *Reference* pane and in the *Reference Settings* dialog select corresponding coordinate system from the list according to the GCP coordinates data.

Prior to optimization it is also possible to remove the points with the highest reprojection error values using corresponding criterion in Edit Menu \rightarrow Gradual Selection dialog.

Set the following values for the parameters in *Measurement accuracy* section and check that valid coordinate system is selected that corresponds to the system that was used to survey GCPs:

Reference Settings				×
Coordinate System				
WGS 84 / UTM zone 37N	(EPSG::32637)			
Measurement accuracy		Image coordinates accura	асу	
Camera accuracy (m):	10			
Camera accuracy (deg):	2			
Marker accuracy (m):	0.005	Marker accuracy (pix):	0.1	
Scale bar accuracy (m):	0.001	Tie point accuracy (pix):	4	
Miscellaneous				
Ground altitude (m):				
	ОК	Cancel		

Marker accuracy: 0.005 (specify value according to the measurement accuracy). Scale bar accuracy: 0.001 Projection accuracy: 0.1 Tie point accuracy: 4

Click OK button.

On the *Reference* pane **uncheck all photos** and <u>check on the markers</u> to be used in optimization procedure. The rest of the markers that are not taken into account can serve as validation points to evaluate the optimization results. It is recommended since camera coordinates are usually measured with considerably lower accuracy than GCPs, also it allows to exclude any possible outliers for camera positions caused by the onboard GPS device failures.

Click *POptimize* button on the *Reference* pane toolbar.

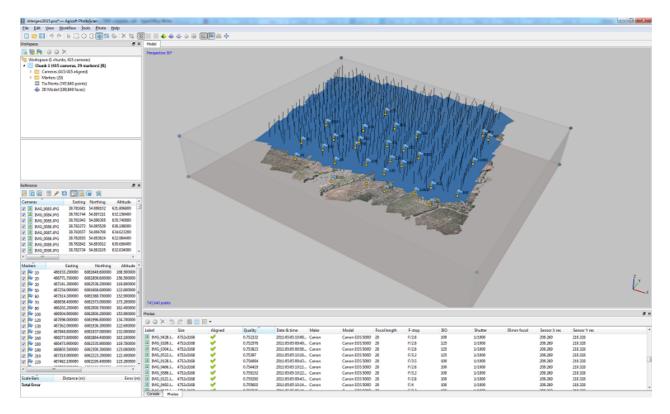
Doptimize Camera Alignment		
General		
📝 Fit f	V Fit k1, k2, k3	
Fit aspect	Fit k4	
📝 Fit cx, cy	V Fit p1, p2	
Fit skew	Fit p3	
	Fit p4	
ОК	Cancel	

Select camera parameters you would like to optimize. Click OK button to start optimization process.

Set Bounding Box

Bounding Box is used to define the reconstruction area.

Bounding box is resizable and rotatable with the help of 🚳 Resize Region and 🚧 Rotate Region tools from the Toolbar.



Important: The red-colored side of the bounding box indicates the plane that would be treated as ground plane and has to be set **under** the model and **parallel** to the XY plane. This is important if mesh is to be built in Height Field mode, which is reasonable for aerial data processing workflow.

Build Dense Point Cloud

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

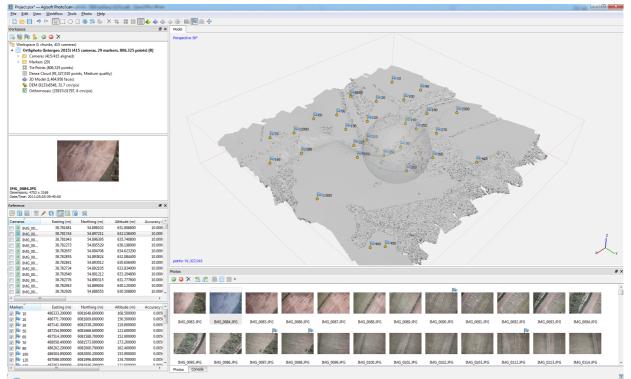
Select *Build Dense Cloud* command from the *Workflow* menu.

Build Dense Cloud	×
▼ General	
Quality:	Medium
Advanced	
Depth filtering:	Aggressive
Reuse depth maps	
ОК	Cancel

Set the following recommended values for the parameters in the Build Dense Cloud dialog:

Quality: *Medium* (higher quality takes quite a long time and demands more computational resources, lower quality can be used for fast processing)

Depth filtering: *Aggressive* (if the geometry of the scene to be reconstructed is complex with numerous small details or untextured surfaces, like roofs, it is recommended to set *Mild* depth filtering mode, for important features not to be sorted out)



Points from the dense cloud can be removed with the help of selection tools and *Delete/Crop* instruments located on the Toolbar.

Build Mesh (optional: can be skipped if polygonal model is not required as a final result)

After dense point cloud has been reconstructed it is possible to generate polygonal mesh model based on the dense cloud data.

Select Build Mesh command from the Workflow menu.

Build Mesh	x
General	
Surface type:	Height field 🔹
Source data:	Dense cloud 🔻
Face count:	Medium (4,506,786) 🔹
▼ Advanced	
Interpolation:	Enabled (default)
Point classes: All	Select
ОК	Cancel

Set the following recommended values for the parameters in the Build Mesh dialog:

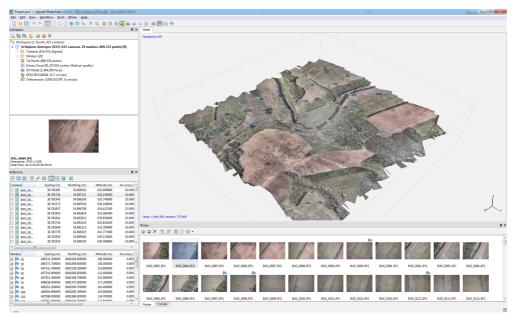
Surface type: Height Field

Source data: Dense cloud

Polygon count: *Medium* (maximum number of faces in the resulting model. The values indicated next to *High/Medium/Low* preset labels are based on the number of points in the dense cloud. Custom values could be used for more detailed surface reconstruction).

Interpolation: Enabled

Click OK button to start mesh reconstruction.



Edit Geometry

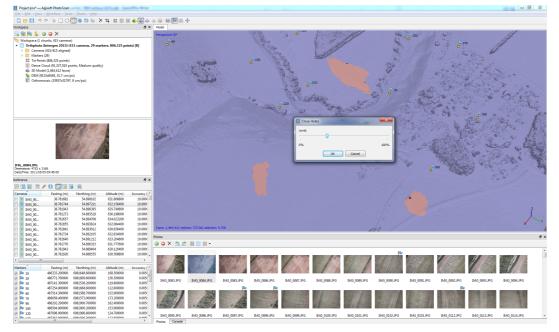
Sometimes it is necessary to edit geometry before building texture atlas and exporting the model.

Unwanted faces could be removed from the model. Firstly, you need to indicate the faces to be deleted using selection tools from the toolbar. Selected areas are highlighted with red color in the Model View. Then, to remove the selection use Delete Selection button on the Toolbar (or Del key) or use Crop Selection button on the Toolbar to remove all but selected faces.

If the overlap of the original images was not sufficient, it may be required to use *Close Holes* command from the *Tools* menu at geometry editing stage to produced holeless model. In *Close Holes* dialog select the size of the largest hole to be closed (in percentage of the total model size).



PhotoScan tends to produce 3D models with excessive geometry resolution. That's why it is recommended to decimate mesh before exporting it to a different editing tool to avoid performance



decrease of the external program.

To decimate 3D model select *Decimate Mesh...* command from the Tools menu. In the *Decimate Mesh* dialog specify the target number of faces that should remain in the final model. For PDF export task or web-viewer upload it is recommended to downsize the number of faces to 100000-200000.

Decimate Mesh	×
Parameters	
Source face count:	4457654
Target face count:	2000000
	OK Cancel

Click OK button to start mesh decimation procedure.

Build Texture (optional; applicable only to polygonal models)

This step is not really needed in the orthomosaic export workflow, but it might be necessary to inspect a textured model before exporting it or it might be helpful for precise marker placement.

Select Build Texture command from the Workflow menu.

Build Texture	×
General	
Mapping mode:	Orthophoto 🔻
Blending mode:	Mosaic (default)
Texture size/count:	8192 x 1 🛓
▼ Advanced	
Enable color correction	
ОК	Cancel

Set the following recommended values for the parameters in the Build Texture dialog:

Mapping mode: Orthophoto

Blending mode: Mosaic

Texture size/count: 8192 (width & height of the texture atlas in pixels)

Enable color correction: *disabled* (the feature is useful for processing of data sets with extreme brightness variation, but for general case it could be left unchecked to save the processing time)

Click OK button to start texture generation.

Build DEM

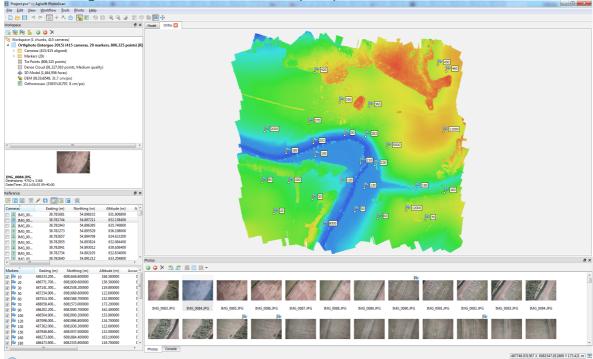
Digital elevation model can be generated based on the dense cloud or mesh model. Usually first option is preferred, as it provides more accurate results (low-poly model, being used as a source data, may result in inaccurate DEM) and allows for faster processing, since mesh generation step can be skipped.

Select *Build DEM* command from the Workflow menu:

Build DEM			x
Coordinate System WGS 84 / UTM zone 37	7N (EPSG::32637)		•
Parameters			
Source data:	Dense	cloud	•
Interpolation:	Enable	d (default)	•
Point classes: All		Select	
Region			
Setup boundaries:	485105.715	- 489290.917) x
Reset	6080525.564	- 6084251.238] Y
Resolution (m/pix):	0.316635		
Total size (pix):	13223	× 11771	
	OK Car	ncel	

Coordinate system should be specified in accordance with the system used for the model referencing. At the export stage it will be possible to project the results to a different geographical coordinate system.

After DEM generation process is finished, it is possible to open the reconstructed model in Ortho view by double-clicking on the DEM label in the Workspace pane:



Build Orthomosaic

Build Orthomosaic					x
Projection					
Type:	Plan	ar		Geographic	
WGS 84 / UTM zone 37	N (EPSG	::32637)			-
Parameters					
Parameters Surface:		DEM			•
Blending mode:		Mosaic (det	fault)	•
Enable color correct	ion			<i>y</i>	
• Pixel size (m):		0.0791272			x
Metres		0.0791272			Y
Max. dimension (pix	:):	4096			
Region					
Setup boundaries:	485845	5.329] -	488560.343	x
Estimate	608118	36.296] -	6083730.078	Y
Total size (pix):	34312		x	32148	
	ОК	Car	ncel		

Select Build Orthomosaic command from the Workflow menu:

Select desired surface for orthomosaic generation process: mesh or DEM, and blending mode.

Pixel size will be suggested according to the average ground sampling resolution of the original images. According to the surface size and the input pixel size the total size of the orthomosaic (in pixels) will be calculated and shown in the bottom of the dialog box.

Generated orthomosaic can be reviewed in Ortho mode similar to the digital elevation model. It can be opened in this view mode by double-clicking on the orthomosaic label in the Workspace pane.

Export Orthomosaic

	SG::32637)	•		
Raster				
Pixel size (m):	0.08			
Metres	0.08			
Max. dimension (pix):	4096			
Split in blocks (pix):	10000 × 10000			
Raster transform:	None	-		
Region				
Setup boundaries:	485845.329 - 488560.2	89 X		
Reset	6081186.296 - 6083730.	056 Y		
Total size (pix):	33937 × 31797			
Write KML file	Write World file			
Compression				
TIFF compression:	LZW	•		
JPEG quality:	90			

Select *Export Orthomosaic* \rightarrow *Export JPEG/TIFF/PNG* command from *File* menu.

Set the following recommended values for the parameters in the *Export Orthomosaic* dialog: **Projection:** *Desired coordinate system*

- **<u>Pixel size:</u>** desired export resolution (please note that for WGS84 coordinate system units should be specified in degrees. Use *Metres* button to specify the resolution in metres).
- **Split in blocks:** 10000 x 10000 (if the exported area is large it is recommended to enable *Split in Blocks* feature, since the memory consumption is rather high at exporting stage)
- **Region:** set the boundaries of the model's part that should be projected and presented as orthomosaic. Also polygonal shapes drawn in the Ortho view and marked as boundaries will be taken into account for the orthomosaic export.

TIFF compression and JPEG quality should be specified according to the job requirements.

BigTIFF format allows to overcome the TIFF file size limit for the large orthomosaics, but it is not supported by some applications.

Click *Export*... button and then specify target file name and select type of the exported file (e.g. GeoTIFF). Click *Save* button to start orthomosaic generation.

Export DEM

WGS 84 / UTM zone 37N (EF Raster			
Pixel size (m):	0.316509		
Metres	0.316509		Y
Max. dimension (pix):	4096		
Split in blocks (pix):	3000 x	3000]
No-data value:	-32767		
Region			
Setup boundaries:	485730.437 -	488621.113	x
Reset	6081094.508 -	6083800.027	Y
Total size (pix):	9132 x	8547]
Write KML file	Write World file		
Compression			

Select *Export DEM* \rightarrow Export GeoTIFF/BIL/XYZ command from *File* menu.

Set the following recommended values for the parameters in the *Export DEM* dialog: **Projection:** *Desired coordinate system*

No-data value: value for not visible points; should be specified according to the requirements of the post processing application.

- **<u>Pixel size:</u>** desired export resolution
- **Split in blocks:** 10000 x 10000 (if the exported area is large, it is recommended to enable *Split in blocks* feature, since the memory consumption is rather high at exporting stage)
- **<u>Region</u>**: set the boundaries of the model's part that should be projected and presented as DEM. Also polygonal shapes drawn in the Ortho view and marked as boundaries will be taken into account for the DEM export.

Click *Export*... button and then specify target file name and select type of the exported file (e.g. GeoTIFF). Click *Save* button to start DEM generation.