Agisoft Metashape User Manual

Standard Edition, Version 1.7

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Overview

Agisoft Metashape is a stand-alone software product that performs photogrammetric processing of digital images (aerial and close-range photography) and generates 3D spatial data to be used in GIS applications, cultural heritage documentation, and visual effects production as well as for indirect measurements of objects of various scales.

The software allows to process images from RGB, thermal into the spatial information in the form of dense point clouds, textured polygonal models. Wisely implemented digital photogrammetry technique enforced with computer vision methods results in smart automated processing system that, on the one hand, can be managed by a new-comer in the field of photogrammetry, yet, on the other hand, has a lot to offer to a specialist who can benefit from advanced features like stereoscopic mode and have complete control over the results accuracy, with detailed report being generated at the end of processing.

How it works

Typical tasks for a photogrammetry processing project in Metashape is to build a textured 3D model. Imagery data processing procedure with Agisoft Metashape consists of two main steps.

1. The first step is called alignment. It includes aerial triangulation (AT) and bundle block adjustment (BBA). At this stage Metashape searches for feature points on the images and matches them across images into tie points. The program also finds the position of the camera for each image and refines camera calibration parameters (estimates internal (IO) and external (EO) camera orientation parameters).

   The results of these procedures are visualized in the form of a sparse point cloud and a set of camera positions. The sparse point cloud represents the results of image alignment and will not be directly used in further processing (except for the sparse point cloud based surface reconstruction method, which is suitable only for quick estimates, e.g., of completeness of a data set). But the sparse point cloud is necessary for the determination of depth maps (based on the sparse cloud selected stereo pairs). However it can be exported for further usage in external programs. For instance, a sparse point cloud model can be used in a 3D editor as a reference. On the contrary, the set of camera positions is required for further 3D surface reconstruction by Metashape.

2. The second step is generation of a surface in 3D (mesh) . Polygonal model (mesh) can be textured for photorealistic digital representation of the object/scene and exported in numerous formats compatible with post-processing software, both for CAD and 3D-modeling workflows.

   Dense point cloud can be built by Metashape based on the estimated camera positions and images themselves (dense stereo matching). Generated photogrammetric point cloud can be merged with LIDAR data.

About the manual

Basically, the sequence of actions described above covers most of the data processing needs. All these operations are carried out automatically according to the parameters set by user. Instructions on how to get through these operations and descriptions of the parameters controlling each step are given in the corresponding sections of the Chapter 3, *General workflow* chapter of the manual.

In some cases, however, additional actions may be required to get the desired results. Pictures taken using uncommon lenses such as fisheye one may require preliminary calibration of optical system parameters or usage of different calibration model specially implemented for ultra-wide angle lens. Metashape

enables to reestimate extrinsic and intrinsic camera parameters, optimizing them for a tie point pool preliminary filtered by user. Chapter 4, *Improving camera alignment results* covers that part of the software functionality. In some capturing scenarios masking of certain regions of the photos may be required to exclude them from the calculations. Application of masks in Metashape processing workflow as well as editing options available are described in Chapter 5, *Editing*. Chapter 6, *Automation* describes opportunities to save up on manual intervention to the processing workflow.

It can take up quite a long time to reconstruct a 3D model. Metashape allows to export obtained results and save intermediate data in a form of project files at any stage of the process. If you are not familiar with the concept of projects, its brief description is given at the end of the Chapter 3, *General workflow*.

In the manual you can also find instructions on the Metashape installation and activation procedures and basic rules for taking "good" photographs, i.e. pictures that provide most necessary information for 3D reconstruction. For the information refer to Chapter 1, *Installation and Activation* and Chapter 2, *Capturing scenarios*.

Chapter 1. Installation and Activation

System requirements

Minimal configuration

- Windows 7 SP 1 or later (64 bit), Windows Server 2008 R2 or later (64 bit), macOS High Sierra or later, Debian/Ubuntu with GLIBC 2.19+ (64 bit)
- Intel Core 2 Duo processor or equivalent
- 4 GB of RAM

Recommended configuration

- Windows 7 SP 1 or later (64 bit), Windows Server 2008 R2 or later (64 bit), macOS Mojave or later, Debian/Ubuntu with GLIBC 2.19+ (64 bit)
- Intel Core i7 or AMD Ryzen 7 processor
- Discrete NVIDIA or AMD GPU (4+ GB VRAM)
- 32 GB of RAM

The number of photos that can be processed by Metashape depends on the available RAM and reconstruction parameters used. Assuming that a single photo resolution is of the order of 10 MPix, 4 GB RAM is sufficient to make a model based on 30 to 50 photos. 16 GB RAM will allow to process up to 300-400 photographs.

GPU recommendations

Metashape supports accelerated image matching; depth maps reconstruction; depth maps based mesh model generation; texture blending; photoconsistent mesh refinement operation due to the graphics hardware (GPU) exploiting.

NVIDIA
: GeForce GTX 7xx series and later with CUDA support.

AMD
: Radeon R9 series and later with OpenCL 1.2 support.

Metashape is likely to be able to utilize processing power of any CUDA enabled device with compute capability 3.0 and higher or OpenCL 1.2 and higher enabled device with SPIR support for stages specified above, provided that CUDA/OpenCL drivers for the device are properly installed. However, because of the large number of various combinations of video chips, driver versions and operating systems, Agisoft is unable to test and guarantee Metashape's compatibility with every device and on every platform.

The processing performance of the GPU device is mainly related to the number of CUDA cores for NVIDIA video chips and the number of shader processor units for AMD and Intel video chips. Additionally depth maps based mesh model reconstruction as well as photoconsistent mesh refinement operations and texture blending would benefit from larger amount of VRAM available.

The table below lists currently supported devices (on Windows platform only). Agisoft will pay particular attention to possible problems with Metashape running on these devices.

Table 1.1. Supported Desktop GPUs on Windows platform

NVIDIA	AMD
GeForce RTX 3080	Radeon RX 6800
GeForce RTX 2080 Ti	Radeon VII
Tesla V100	Radeon RX 5700 XT
Tesla M60	Radeon RX Vega 64
Quadro P6000	Radeon RX Vega 56
Quadro M6000	Radeon Pro WX 7100
GeForce TITAN X	Radeon RX 580
GeForce GTX 1080 Ti	FirePro W9100
GeForce GTX TITAN X	Radeon R9 390x
GeForce GTX 980 Ti	Radeon R9 290x
GeForce GTX TITAN	
GeForce GTX 780 Ti	

Metashape supports texture blending on GPU using Vulkan technology on Linux and Windows OS. GPU accelerated texture blending is currently supported for frame and fisheye type cameras on NVIDIA cards since GeForce GTX 8XX / Quadro M4000 and driver versions from 435.xx and on AMD cards since Radeon R9 29x series / FirePro W9100 and 17.1.x drivers. Some older GPUs and older driver versions could also support texture blending using Vulkan, however, it is not guaranteed.

Although Metashape is supposed to be able to utilize other compatible GPU models and being run under a different operating system, Agisoft does not guarantee that it will work correctly. However, all GPU-based processing issues should be reported to Agisoft support team for more detailed investigation.

Note

- Use CPU enable flag to allow calculations both on CPU and GPU for GPU-supported tasks. However if at least one powerful discrete GPU is used it is recommended to disable CPU flag for stable and rapid processing.
- Using GPU acceleration with mobile or integrated graphics video chips is not recommended because of the low performance of such GPUs.
- CUDA supported devices for some older macOS versions may require to install CUDA drivers from official web-site first: http://www.nvidia.com/object/mac-driver-archive.html.

  Due to lack of CUDA support on certain macOS versions Metashape will automatically switch to OpenCL implementation for GPU-based processing on NVIDIA graphic devices.

Installation procedure

Installing Metashape on Microsoft Windows

To install Metashape on Microsoft Windows simply run the downloaded msi file and follow the instructions.

Installing Metashape on macOS

Open the downloaded dmg image and drag Metashape application bundle to the desired location on your hard drive (for example, to Applications folder. Do not run Metashape directly from the dmg image to avoid issues on license activation step.

Installing Metashape on Debian/Ubuntu

Unpack the downloaded archive with a program distribution kit to the desired location on your hard drive. Also, install the package: *sudo apt install libxcb-xinerama0*. Start Metashape by running metashape.sh script from the program folder.

30-day trial and demo mode

Once Metashape is downloaded and installed on your computer you can run it either in the Demo mode or in the full function mode. On every start until a license key sequence is entered it will show on activation dialog offering three options: (1) activate Metashape using a valid license code, (2) start a free 30-day trial, (3) continue using Metashape in Demo mode. Starting a 30-day trial period allows to evaluate the functionality of the program and explore the software in full-function mode, including save and export features. Trial license is intended to be used for evaluation purposes only and any commercial use of a trial license is prohibited.

If you are not ready yet to start the trial period, you can opt for the Demo mode. The employment of Metashape in the Demo mode is not time limited. Several functions, however, are not available in the Demo mode. These functions are the following:

- save the project;
- all export features, including exporting reconstruction results (you can only view a 3D model on the screen);

To use Metashape in the full function mode for various projects you have to purchase a license. On purchasing you will get a license code to be entered into the activation dialog of Metashape. Once the license code is entered you will get full access to all functions of the program and the activation dialog will no longer appear upon program start, unless the license is deactivated.

Activation procedure

Metashape license activation

Metashape software requires license key (a digital code) to be activated. First of all, make sure that you have a valid license key or a trial code at hand.

To activate Metashape

1. Launch Metashape software, previously installed on your machine, and go to *Help* menu for *Activate product...* command.
2. In *Activation* dialog insert license key according to the suggested 5 digit blocks structure. Please note that license codes does never include zero digit - only letter "O".
3. If the license code has been input correctly, then the *OK* button will become active. Click on it to complete the activation procedure. If the button is still grayed out, please make sure that the key you

are using is meant for the product you are trying to activate: a license key for the Professional Edition, for example, will not activate the Standard version of the software.

Note

- The node-locked license activation on Windows OS and macOS may require administrator privileges. During the activation process additional confirmation dialog will appear to apply the elevated privileges.

Chapter 2. Capturing scenarios

Photographs suitable for 3D model reconstruction in Metashape can be taken by any digital camera (both metric and non-metric), as long as you follow some specific capturing guidelines. This section explains general principles of taking and selecting pictures that provide the most appropriate data for 3D model generation.

IMPORTANT! Make sure you have studied the following rules and read the list of restrictions before you get out for shooting photographs.

Equipment

- Use a digital camera with reasonably high resolution (5 MPix or more).
- Avoid ultra-wide angle and fisheye lenses. The best choice is 50 mm focal length (35 mm film equivalent) lenses. It is recommended to use focal length from 20 to 80 mm interval in 35mm equivalent. If a data set was captured with fisheye lens, appropriate camera sensor type should be selected in Metashape Camera Calibration dialog prior to processing.
- Fixed lenses are preferred. If zoom lenses are used - focal length should be set either to maximal or to minimal value during the entire shooting session for more stable results, for intermediate focal lengths separate camera calibration groups should be used.

Camera settings

- Using RAW data losslessly converted to the TIFF files is preferred, since JPG compression may induce unwanted noise to the images.
- Take images at maximal possible resolution.
- ISO should be set to the lowest value, otherwise high ISO values will induce additional noise to images.
- Aperture value should be high enough to result in sufficient focal depth: it is important to capture sharp, not blurred photos.
- Shutter speed should not be too slow, otherwise blur can occur due to slight movements.

Object/scene requirements

- Avoid not textured, shiny, highly reflective or transparent objects.
- If still have to, shoot shiny objects under a cloudy sky.
- Avoid unwanted foregrounds.
- Avoid moving objects within the scene to be reconstructed.
- Avoid absolutely flat objects or scenes.

Image preprocessing

- Metashape operates with the original images. So do not crop or geometrically transform, i.e. resize or rotate, the images.

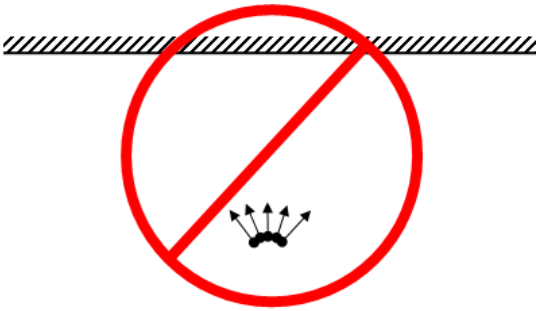
Capturing scenarios

Generally, spending some time planning your shot session might be very useful.

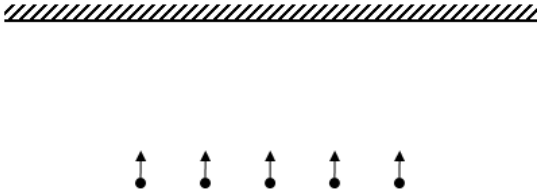
- Number of photos: more than required is better than not enough.
- Number of "blind-zones" should be minimized since Metashape is able to reconstruct only geometry visible from at least two cameras.
- Each photo should effectively use the frame size: object of interest should take up the maximum area. In some cases portrait camera orientation should be used.
- Do not try to place full object in the image frame, if some parts are missing it is not a problem providing that these parts appear on other images.
- Good lighting is required to achieve better quality of the results, yet blinks should be avoided. It is recommended to remove sources of light from camera fields of view. Avoid using flash.

The following figures represent advice on appropriate capturing scenarios:

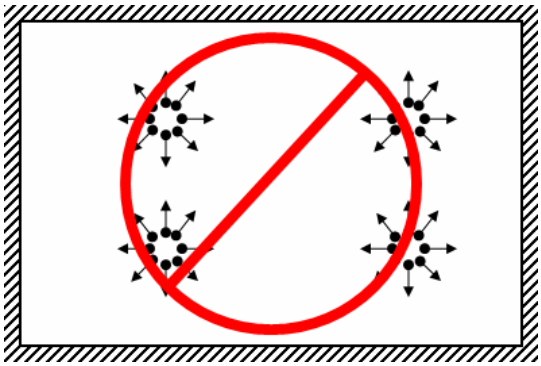
Facade (Incorrect)



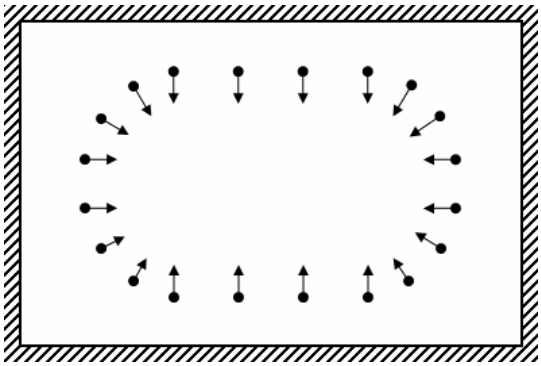
Facade (Correct)



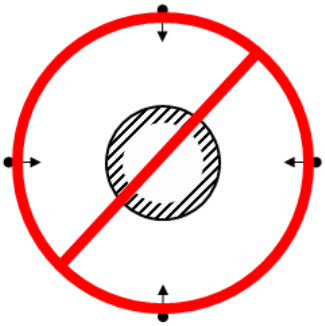
Interior (Incorrect)



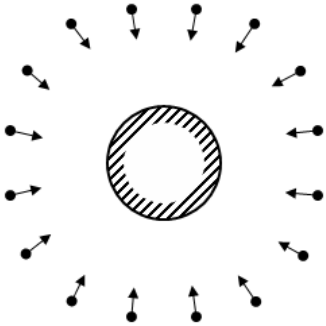
Interior (Correct)



Isolated Object (Incorrect)



Isolated Object (Correct)



Restrictions

In some cases it might be very difficult or even impossible to build a correct 3D model from a set of pictures. A short list of typical reasons for photographs unsuitability is given below.

Modifications of photographs

Metashape can process only unmodified photos as they were taken by a digital photo camera. Processing the photos which were manually cropped or geometrically warped is likely to fail or to produce highly inaccurate results. Photometric modifications do not affect reconstruction results.

Lack of EXIF data

Metashape calculates initial values of sensor pixel size and focal length parameters based on the EXIF data. The better initial approximation of the parameter values is, the more accurate autocalibration of the camera can be performed. Therefore, reliable EXIF data is important for accurate reconstruction results. However 3D scene can also be reconstructed in the absence of the EXIF data. In this case Metashape assumes that focal length in 35 mm equivalent equals to 50 mm and tries to align the photos in accordance with this assumption. If the correct focal length value differs significantly from 50 mm, the alignment can give incorrect results or even fail. In such cases it is required to specify initial camera calibration manually.

The details of necessary EXIF tags and instructions for manual setting of the calibration parameters are given in the Camera calibration section.

Lens distortion

The distortion of the lenses used to capture the photos should be well simulated with the camera model used in the software. Generally, Brown's distortion model implemented in Metashape works well for frame cameras. However, since fisheye/ultra-wide angle lenses are poorly simulated by the mentioned distortion model, it is crucial to choose proper camera type in Camera Calibration dialog prior to processing of such data - the software will switch to the appropriate distortion model.

Lens calibration

It is possible to use Metashape for automatic lens calibration. Metashape uses LCD screen as a calibration target (optionally it is possible to use a printed chessboard pattern, providing that it is flat and all its cells are

squares). Lens calibration procedure supports estimation of the full camera calibration matrix, including non-linear distortion coefficients. The details of camera models are given in the Appendix C, *Camera models* section.

Note

- Lens calibration procedure can usually be skipped in common workflow, as Metashape calculates the calibration parameters automatically during Align Photos process. However, if the alignment results are unstable, for example, due to the lack of the tie points between the images, the lens calibration may be useful.

The following camera calibration parameters can be estimated:

f
Focal length measured in pixels.

cx, cy
Principal point coordinates, i.e. coordinates of lens optical axis interception with sensor plane in pixels.

b1, b2
Affinity and Skew (non-orthogonality) transformation coefficients.

k1, k2, k3, k4
Radial distortion coefficients.

p1, p2
Tangential distortion coefficients.

Before using lens calibration tool a set of photos of calibration pattern should be loaded in Metashape.

To capture photos of the calibration pattern:

1. Select *Show Chessboard...* command from the *Lens* submenu in the *Tools* menu to display the calibration pattern.

2. Use mouse scroll wheel to zoom in/out the calibration pattern. Scale the calibration pattern so that the number of squares on each side of the screen would exceed 10.

3. Capture a series of photos of the displayed calibration pattern with your camera from slightly different angles, according to the guidelines, outlined below. Minimum number of photos for a given focal length is 3.

4. If you are calibrating zoom lens, change the focal length of your lens and repeat the previous step for other focal length settings.

5. Click anywhere on the calibration pattern or press *Escape* button to return to the program.

6. Upload the captured photos to the computer.

When capturing photos of the calibration pattern, try to fulfill the following guidelines:

- Make sure that the focal length keeps constant throughout the session (in case of zoom lens).

- Avoid glare on the photos. Move the light sources away if required.

- Preferably, the whole area of the photos should be covered by calibration pattern. Move the camera closer to the LCD screen if required.

To load photos of the calibration pattern:

1. Create new chunk using *Add Chunk* toolbar button on the *Workspace* pane or selecting *Add Chunk* command from the Workspace context menu (available by right-clicking on the root element on the *Workspace* pane). See information on using chunks in Using chunks section.

2. Select *Add Photos...* command from the *Workflow* menu.

3. In the *Open* dialog box, browse to the folder, containing the photos, and select files to be processed. Then click *Open* button.

4. Loaded photos will appear in the *Photos* pane.

Note

- You can open any photo by double clicking on its thumbnail in the *Photos* pane. To obtain good calibration, the photos should be reasonably sharp, with crisp boundaries between cells.

- If you have loaded some unwanted photos, you can easily remove them at any time.

- Before calibrating fisheye lens you need to set the corresponding *Camera Type* in the *Camera Calibration...* dialog available from the *Tools* menu. See information on other camera calibration settings in Camera calibration section.

To calibrate camera lens

1. Select *Calibrate Lens...* command from the *Lens* submenu in the *Tools* menu.

2. In the *Calibrate Lens* dialog box, select the desired calibration parameters. Click *OK* button when done.

3. The progress dialog box will appear displaying the current processing status. To cancel processing click the *Cancel* button.

4. The calibration results will appear on the *Adjusted* tab of the *Camera Calibration...* dialog available from the *Tools* menu. The adjusted values can be saved to file by using *Save* button on the *Adjusted* tab. The saved lens calibration data can later be used in another chunk or project, providing that the same camera and lens is used.

Note

- After you have saved the calibration parameters for the lens, you may proceed with the workflow steps in a separate chunk for the actual image set captured by the same camera and lens. To protect the calibration data from being refined during Align Photos process one should check *Fix calibration* box on the *Initial* tab for the chunk with the data to be processed. In this case initial calibration values will not be changed during Align Photos process.

After calibration is finished, you will be presented with the following information:

Detected chessboard corners are displayed on each photo (the photo can be opened by double clicking on its name in the *Photos* pane). It is preferable when the majority of the corners were detected correctly. For

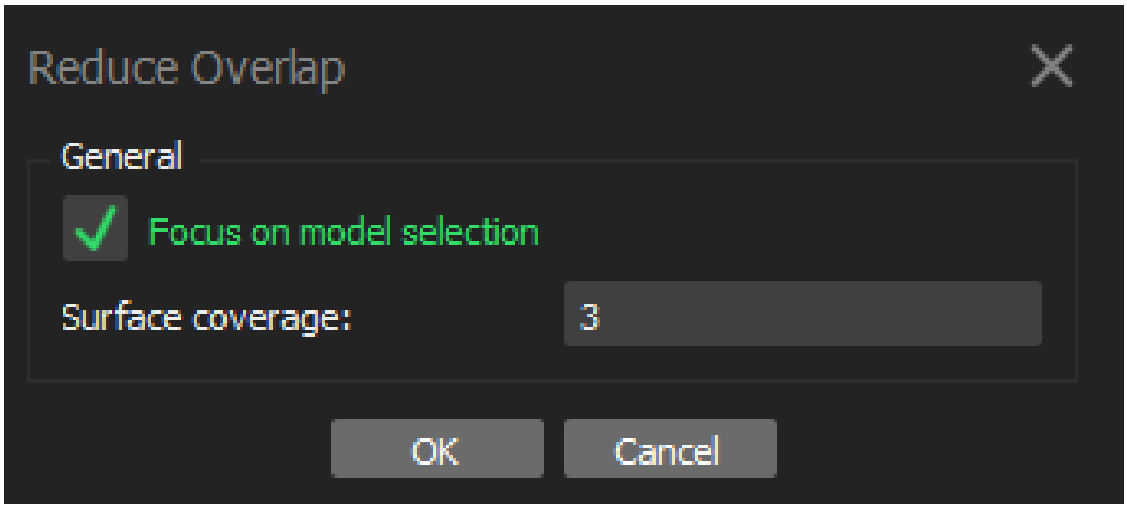
each detected corner the reprojection error between the detected corner position and estimated position according to the calculated calibration is also displayed. The errors are scaled x20 times for display.

Excessive image elimination

Reduce overlap feature is made for analyzing excessive image sets to understand which images are useful and which are redundant and may be disabled of removed.

1. Align photos using entire dataset and build rough mesh model from the sparse cloud.
2. Select *Reduce Overlap* dialog available from the *Tools* menu.
3. Choose parameters in *Reduce Overlap* dialog box.
4. Click *OK* button.
5. The progress dialog box will appear displaying the current processing status. To cancel processing click the *Cancel* button.
6. After the operation is finished all the cameras which are not included into optimal subset will get disabled.

Reduce overlap parameters



"Reduce overlap" dialog

Reduce overlap dialog parameters:

Focus on selection
To consider only selected triangles of the polygonal model as target for reconstruction. Cameras that do not have any of the selected polygons in the field of view would be automatically disabled.

Surface coverage
Number of cameras observing each point from different angles.

Chapter 3. General workflow

Processing of images with Metashape includes the following main steps:

- loading images into Metashape;
- inspecting loaded images, removing unnecessary images;
- aligning cameras;
- building dense point cloud;
- building mesh (3D polygonal model);
- generating texture;
- exporting results.

If you are using Metashape in the full function (not the Demo) mode, intermediate results of the image processing can be saved at any stage in the form of project files and can be used later. The concept of projects and project files is briefly explained in the Saving intermediate results section.

The list above represents all the necessary steps involved in the construction of a textured 3D model from your photos. Some additional tools, which you may find to be useful, are described in the successive chapters.

Preferences settings

Before starting a project with Metashape it is recommended to adjust the program settings for your needs. In *Preferences* dialog (*General* tab) available through the *Tools* menu you can indicate the path to the Metashape log file to be shared with the Agisoft support team in case you face any problem during the processing. Here you can also change GUI language to the one that is most convenient for you. The options are: English, Chinese, French, German, Italian, Japanese, Portuguese, Russian, Spanish.

Switch Theme in case you have preferences between Dark or Light program GUI or leave it as Classic for the simplest view. Shortcuts for the menu commands can be adjusted for your convenience on the General tab as well.

On the *GPU* tab you need to make sure that all discrete GPU devices detected by the program are checked. Metashape exploits GPU processing power that speeds up the process significantly. However, Agisoft does not recommend to use integrated graphic card adapters due to their possible unstable work under heavy load. If you have decided to switch on GPUs to boost the data processing with Metashape, it is recommended to uncheck *Use CPU when performing GPU accelerated processing* option, providing that at least one discrete GPU is enabled for processing.

Advanced tab allows to switch on such advanced features like rich Python console, for example. Furthermore, you can enable loading of extra camera data from XMP (camera calibration).

Keep depth maps option can be beneficial in terms of saving up the processing time, in case there might be a need to rebuild dense point cloud, once generated, for a smaller part of the scene, or if both mesh and dense cloud are based on the same quality depth maps.

Fine-level task subdivision option is useful in cases when large datasets are to be processed. Enabled option provides internal splitting of some tasks to the sub-jobs, thus allowing to reduce the memory consumption

during the processing. The tasks that are supported for fine-level distribution are the following: Match Photos, Align Cameras, Build Depth Maps, Build Dense Cloud.

Metashape allows for incremental image alignment, which may be useful in case of some data missing in the initially aligned project. If this may be the case, you should switch on the *Keep key points* option on the *Advanced* tab of the *Preferences* dialog before you start the processing of the data.

Loading images

Before starting any operation it is necessary to point out which images will be used as a source for photogrammetric processing. In fact, images themselves are not loaded into Metashape until they are needed. So, when *Add photos* command is used, only the links to the image files are added to the project contents to indicate the images that will be used for further processing.

Metashape uses the full color range for image matching operation and is not downsampling the color information to 8 bit. The point cloud points and texture would also have the original bit depth, providing that they are exported in the formats that support non 8-bit colors.

To load a set of photos

1. Select *Add Photos...* command from the *Workflow* menu or click *Add Photos* toolbar button on the *Workspace* pane.

2. In the *Add Photos* dialog box browse to the folder containing the images and select files to be processed. Then click *Open* button.

3. Selected images will appear on the *Workspace* pane.

Note

- Metashape accepts the following image formats: JPEG, JPEG 2000, TIFF, DNG, PNG, OpenEXR, BMP, TARGA, PPM, PGM, SEQ, ARA (thermal images) and JPEG Multi-Picture Format (MPO). Image files in any other format will not be displayed in the *Add Photos* dialog box. To work with such images is it necessary to convert them to one of the supported formats.

If some unwanted images have been added to the project, they can be easily removed at any moment.

To remove unwanted images

1. On the *Workspace* pane select the cameras to be removed.

2. Right-click on the selected cameras and choose *Remove Items* command from the opened context menu, or click *Remove Items* toolbar button on the *Workspace* pane. The related images will be removed from the working set.

Camera groups

If all the photos or a subset of photos were captured from one camera position - camera station, for Metashape to process them correctly it is obligatory to move those photos to a camera group and mark the group as Camera Station. It is important that for all the photos in a Camera Station group distances between camera centers were negligibly small compared to the camera-object minimal distance. Photogrammetric

processing will require at least two camera stations with overlapping photos to be present in a chunk. However, it is possible to export panoramic picture for the data captured from only one camera station. Refer to Exporting results section for guidance on panorama export.

Alternatively, camera group structure can be used to manipulate the image data in a chunk easily, e.g. to apply disable/enable functions to all the cameras in a group at once.

To move photos to a camera group

1. On the *Workspace* pane (or *Photos* pane) select the photos to be moved.

2. Right-click on the selected photos and choose *Move Cameras - New Camera Group* command from the opened context menu.

3. A new group will be added to the active chunk structure and selected photos will be moved to that group.

4. Alternatively selected photos can be moved to a camera group created earlier using *Move Cameras - Camera Group - Group_name* command from the context menu.

To mark group as camera station, right click on the camera group name and select *Set Group Type* command from the context menu.

Inspecting loaded images

Loaded images are displayed on the *Workspace* pane along with flags reflecting their status.

The following flags can appear next to the camera label:

NC (Not calibrated)
Notifies that the EXIF data available is not sufficient to estimate the camera focal length. In this case Metashape 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 have not been estimated for the current image yet.

Images loaded to Metashape will not be aligned until you perform the next step - photos alignment.

Notifies that Camera Station type was assigned to the group.

Video Data

Metashape allows for video data processing as well, which can be beneficial for quick inspection scenarios, for example. The video is to be divided into frames which will be further used as source images for 3D reconstruction.

To import a video file

1. Select *Import Video...* command from the *File* menu.

2. In the *Import Video* dialog you can inspect the video and set the output folder for the frames.

3. Set the filename pattern for the frames and indicate the frame extraction rate.

4. You can import part of the video, specify the parameters: *Start from* and *End at*.

5. Click *OK* button for the frames to be automatically extracted and saved to the designated folder. The images extracted from the video will be automatically added to the active chunk.

Note

- In Metashape you can choose the automatic frame step (Small, Medium, Large) which may be helpful to skip similar sequential frames or set manually via *Custom option*. Once the parameter value is set, the program calculates the shift for the images to be captured. For *Small* value, the shift of about 3% of the image width will be taken into account. For *Medium*, it corresponds to 7% and for *Large* - 14% of the image width.

After the frames have been extracted you can follow standard processing workflow for the images.

Aligning photos

The camera position at the time of image capture is defined by the interior and exterior orientation parameters.

Interior orientation parameters include camera focal length, coordinates of the image principal point and lens distortion coefficients. Before starting processing in Metashape the following configuration steps should be performed:

- Separate calibration groups should be created for each physical camera used in the project. It is also recommended to create a separate calibration group for each flight or survey. For details see Camera groups subsection of Loading images.

- For each calibration group initial approximation of interior orientation parameters should be specified. In most cases this is done automatically based on EXIF meta data. When EXIF meta data is not available, initial interior orientation parameters needs to be configured according to the camera certificate.

Exterior orientation parameters define the position and orientation of the camera. They are estimated during image alignment and consist of 3 translation components and 3 Euler rotation angles.

Exterior and interior image orientation parameters are calculated using aerotriangulation with bundle block adjustment based on collinearity equations.

The result of this processing step consists of estimated exterior (translation and rotation) and interior camera orientation parameters together with a sparse point cloud containing triangulated positions of matched image points.

To align a set of photos

1. Select *Align Photos...* command from the *Workflow* menu.

2. In the *Align Photos* dialog box select the desired alignment options. Click *OK* button when done.

3. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

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.

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. Select photos to be realigned and use *Align Selected Cameras* command from the photo context menu.

3. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

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

Image quality

Poor input, e. g. vague photos, can influence alignment results badly. To help you to exclude poorly focused images from processing Metashape 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 photogrammetric processing, providing that the rest of the photos cover the whole scene to be reconstructed. To disable a photo use *Disable* button from the *Photos* pane toolbar.

Metashape estimates image quality for each input image. The value of the parameter is calculated based on the sharpness level of the most focused part of the picture.

To estimate image quality

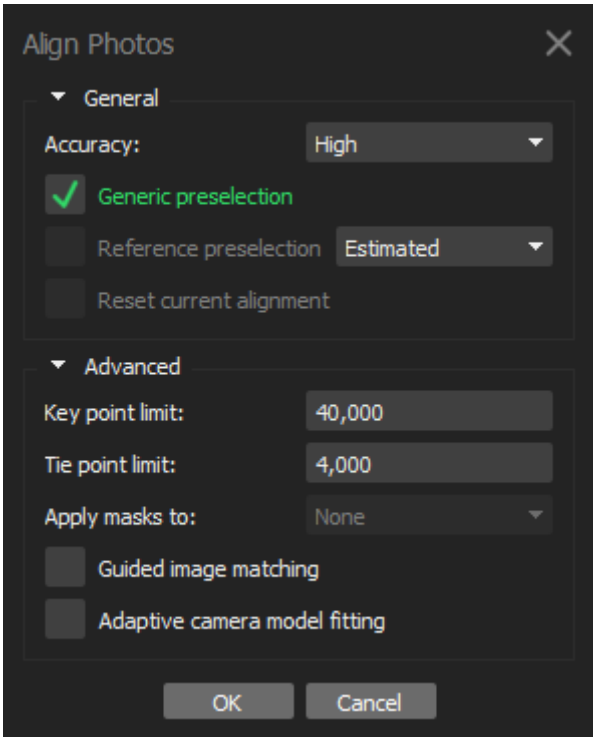
1. Switch to the detailed view in the *Photos* pane using *Details* command from the *Change* menu on the *Photos* pane toolbar.

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. Once the analysis procedure is over, a figure indicating estimated image quality value will be displayed in the *Quality* column on the *Photos* pane.

Alignment parameters



"Align Photos" dialog

The following parameters control the photo alignment procedure and can be modified in the *Align Photos* dialog box:

Accuracy

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

While at High accuracy setting the software works with the photos of the original size, Medium setting causes image downscaling by factor of 4 (2 times by each side), at Low accuracy source files are downscaled by factor of 16, and Lowest value means further downscaling by 4 times more. Highest accuracy setting upscales the image by factor of 4. Since tie point positions are estimated on the basis of feature spots found on the source images, it may be meaningful to upscale a source photo to accurately localize a tie point. However, Highest accuracy setting is recommended only for very sharp image data and mostly for research purposes due to the corresponding processing being quite time consuming.

Generic 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 **Generic preselection** mode the overlapping pairs of photos are selected by matching photos using lower accuracy setting first.

Reference preselection

The **Estimated** preselection mode takes into account the calculated exterior orientation parameters for the aligned cameras. That is, if the alignment operation has been already completed for the project, the estimated camera locations will be considered when the Align Photos procedure is run again with the Estimated preselection selected.

When using **Sequential** preselection mode the correspondence between the images is determined according to the sequence of photos (the sequence number of the image) it is worth noting that with this adjustment, the first with the last images in the sequence will also be compared.

Reset current alignment

If this option is checked, all the tie, and key, and matching points will be discarded and the alignment procedure will be started from the very beginning.

Additionally the following advanced parameters can be adjusted.

Key point limit

The number indicates upper limit of feature points on every image to be taken into account during current processing stage. Using zero value allows Metashape to find as many key points as possible, but it may result in a big number of less reliable points.

Tie point limit

The number indicates upper limit of matching points for every image. Using zero value doesn't apply any tie point filtering.

Apply mask to

If **apply mask to key points** option is selected, areas previously masked on the photos are excluded from feature detection procedure. **Apply mask to tie points** option means that certain tie points are excluded from alignment procedure. Effectively this implies that if some area is masked at least on a single photo, relevant key points on the rest of the photos picturing the same area will be also ignored during alignment procedure (a tie point is a set of key points which have been matched as projections of the same 3D point on different images). This can be useful to be able to suppress background in turntable shooting scenario with only one mask. For additional information on the usage of masks please refer to the Using masks section.

Exclude stationary tie points

Excludes tie points that remain stationary across multiple different images. This option enables alignment without masks for datasets with a static background, e.g. in a case of a turntable with a fixed camera scenario. Also enabling this option will help to eliminate false tie points related to the camera sensor or lens artefacts.

Guided image matching

This option allows to effectively boost the number of keypoints per image as if the value of Key point limit was straightforwardly increased, but without significant growth of processing time. Using this parameter can improve results for images with vegetation (wooded terrain, grass, cornfields and so on), spherical cameras and high resolution images (captured by professional grade cameras, satellites or acquired by high-resolution scanning of the archival aerial images). To enable Guided image matching, check corresponding option in Align Photos dialog and adjust **Key point limit per Mpx** if needed. The number of detected points per image is calculated as (Keypoint limit per Mpx) * (image size in Mpx). Small fraction will be extensively matched and used as guidance for matching of remaining points.

Adaptive camera model fitting

This option enables automatic selection of camera parameters to be included into adjustment based on their reliability estimates. For data sets with strong camera geometry, like images of a building taken from all the sides around, including different levels, it helps to adjust more parameters during initial camera alignment. For data sets with weak camera geometry , like a typical aerial data set, it helps to prevent divergence of some parameters. For example, estimation of radial distortion parameters for data sets with only small central parts covered by the object is very unreliable. When the option is unchecked, Metashape will refine only the fixed set of parameters: focal length, principal point position, three radial distortion coefficients (K1, K2, K3) and two tangential distortion coefficients (P1, P2).

Note

- Tie point limit parameter allows to optimize performance for the task and does not generally effect the quality of the further model. Recommended value is 4000. Too high or too low tie point limit value may cause some parts of the dense point cloud model to be missed. The reason is that Metashape generates depth maps only for pairs of photos for which number of matching points is above certain limit. This limit equals to 100 matching points, unless moved up by the figure "10% of the maximum number of matching points between the photo in question and other photos, only matching points corresponding to the area within the bounding box being considered."
- The number of tie points can be reduced after the alignment process with *Tie Points* - *Thin Point Cloud* command available from *Tools* menu. As a results sparse point cloud will be thinned, yet the alignment will be kept unchanged.

Components

Some image subsets may be not aligned as the result of the Align Photos operation, if the sufficient amount of tie points was not detected between such subsets. Such subsets which are not aligned with the main subset will be grouped into individually aligned parts - Components.

The components into which the camera alignment have been split after the Align Photos operation will be displayed in the chunk's contents of the *Workspace* pane inside the *Components* folder.

Incremental image alignment

In case some extra images should be subaligned to the set of already aligned images, you can benefit from incremental image alignment option. To make it possible, two rules must be followed: 1) the scene environment should not have changed significantly (lighting conditions, etc); 2) do not forget to switch on Keep key points option in the *Preferences* dialog, *Advanced* tab BEFORE the whole processing is started.

To subalign some extra images added to the chunk with already aligned set of images

1. Add extra photos to the active chunk using *Add photos* command from the *Workflow* menu.
2. Open *Align photos* dialog from the *Workflow* menu.
3. Set alignment parameters for the newly added photos. IMPORTANT! Uncheck Reset alignment option.
4. Click *OK*. Metashape will consider existing key points and try to match them with key points detected on the newly added images.

Point cloud generation based on imported camera data

Metashape supports import of external and internal camera orientation parameters. Thus, if precise camera data is available for the project, it is possible to load them into Metashape along with the photos, to be used as initial information for 3D reconstruction job.

To import external and internal camera parameters

1. Select *Import Cameras* command from the *File* menu.
2. Select the format of the file to be imported.

3. Browse to the file and click *Open* button.

4. The data will be loaded into the software. Camera calibration data can be inspected in the *Camera Calibration* dialog, *Adjusted* tab, available from *Tools* menu.

Camera data can be loaded in one of the following formats: Agisoft (*.xml), BINGO (*.dat), Inpho Project File (*.prj), Blocks Exchange (*.xml), Bundler (*.out), Autodesk FBX (*.fbx), VisionMap Detailed Report (*.txt), Realviz RZML (*.rzml), Alembic (*.abc).

Once the data is loaded, Metashape will offer to build point cloud. This step involves feature points detection and matching procedures. As a result, a sparse point cloud - 3D representation of the tie-points data, will be generated. *Build Point Cloud* command is available from *Tools - Tie Points* menu. Parameters controlling Build Point Cloud procedure are the same as the ones used at Align Photos step (see above).

Building dense point cloud

Metashape allows to create a dense point cloud based on the calculated exterior and interior image orientation parameters.

Dense point cloud generation is based on depth maps calculated using dense stereo matching. Depth maps are calculated for the overlapping image pairs considering their relative exterior and interior orientation parameters estimated with bundle adjustment. Multiple pairwise depth maps generated for each camera are merged together into combined depth map, using excessive information in the overlapping regions to filter wrong depth measurements.

Combined depth maps generated for each camera are transformed into the partial dense point clouds, which are then merged into a final dense point cloud with additional noise filtering step applied in the overlapping regions. The normals in the partial dense point clouds are calculated using plane fitting to the pixel neighborhood in the combined depth maps, and the colors are sampled from the images.

For every point in the final dense point cloud the number of contributing combined depth maps is recorded and stored as a confidence value. This confidence value can be used later to perform additional filtering of low confidence points using the *Filter by Confidence...* command from the *Tools* > *Dense Cloud* menu.

Metashape tends to produce extra dense point clouds, which are of almost the same density, if not denser, as LIDAR point clouds. A dense point cloud can be edited within Metashape environment and used as a basis for such processing stages as Build Mesh. Alternatively, the point cloud can be exported to an external tool for further analysis.

To build a dense point cloud

1. Check the reconstruction volume bounding box. To adjust the bounding box use the *Resize Region*, *Move Region* and *Rotate Region* toolbar buttons. To resize the bounding box, drag corners of the box to the desired positions; to move - hold the box with the left mouse button and drag it to the new location.

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

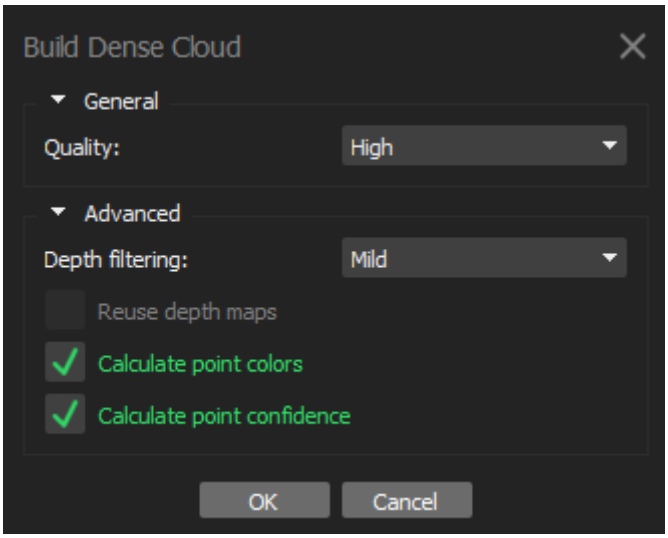
3. In the *Build Dense Cloud* dialog box select the desired reconstruction parameters. Click *OK* button when done.

4. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

Note

- More than one instance of Dense cloud can be stored in one chunk. In case you want to save current Dense cloud instance and build new one in current chunk, right-click on Dense cloud and uncheck *Set as default* option. In case you want to save current Dense cloud instance and edit its copy, right-click on *Dense cloud* and choose *Duplicate* option.

Build Dense Cloud parameters



"Build Dense Cloud" dialog

Quality

Specifies the desired quality of the depth maps genration. Higher quality settings can be used to obtain more detailed and accurate geometry, but they 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 preliminary image size downscaling by factor of 4 (2 times by each side).

Additionally the following advanced parameters can be adjusted.

Depth filtering modes

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

If there are important small details which are spatially distinguished in the scene to be reconstructed, then it is recommended to set **Mild** depth filtering mode, for important features not to be sorted out as outliers. This value of the parameter may also be useful for aerial projects in case the area contains poorly textured roofs, for example. **Mild** depth filtering mode is also required for the depth maps based mesh reconstruction.

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. This value of the parameter normally recommended for aerial data processing, however, mild filtering may be useful in some projects as well (see poorly textured roofs comment in the mild parameter value description above).

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.

Additionally depth filtering can be **Disabled**. But this option is not recommended as the resulting dense cloud could be extremely noisy.

The filtering modes control noise filtering in the raw depth maps. This is done using a connected component filter which operates on segmented depth maps based on the pixel depth values. The filtering preset control a maximum size of connected components that are discarded by the filter.

Note

- Stronger filter presets remove more noise, but also may remove useful information in case there are small and thin structures in the scene.

Reuse depth maps

Depth maps available in the chunk can be reused for the dense cloud generation operation. Select respective Quality and Depth filtering parameters values (see info next to Depth maps label on the *Workspace* pane) in *Build Dense Cloud* dialog and then check *Reuse depth maps* option.

Calculate point colors

This option can be unchecked in case the points color is not of interest. This will allow to save up processing time.

Calculate point confidence

If the option is enabled, the Metashape will count how many depth maps have been used to generate each dense cloud point. This parameter can used for dense cloud filtering (see Editing point cloud).

Import point cloud

Metashape allows to import a point cloud to be interpreted at further processing stages as a dense point cloud. If you want to upload a dense point cloud got from some external source (photogrammetry technology, laser scanning, etc), you can use *Import points* command from the *File* menu. In the *Import points* dialog browse to a file in one of the supported formats and click *Open* button.

Dense point cloud can be imported in one of the following formats: Wavefront OBJ, Stanford PLY, ASPRS LAS, LAZ, ASTM E57, ASCII PTS.

Building mesh

Mesh based on point cloud or depth maps data

Metashape can reconstruct polygonal mesh model based on the point cloud information (Dense Cloud, Sparse Cloud, Point Cloud imported from external source) or based on the depth maps data.

To build a mesh

1. Check the reconstruction volume bounding box. If the model has already been referenced, the bounding box will be properly positioned automatically. Otherwise, it is important to control its position manually.

   To adjust the bounding box manually, use the *Resize Region*, *Move Region* and *Rotate Region* toolbar buttons. Rotate the bounding box and then drag corners of the box to the desired

positions - only part of the scene inside the bounding box will be reconstructed. If the **Height field** reconstruction method is to be applied, it is important to control the position of the red side of the bounding box: it defines reconstruction plane. In this case make sure that the bounding box is correctly oriented.

2. Select the *Build Mesh...* command from the *Workflow* menu.

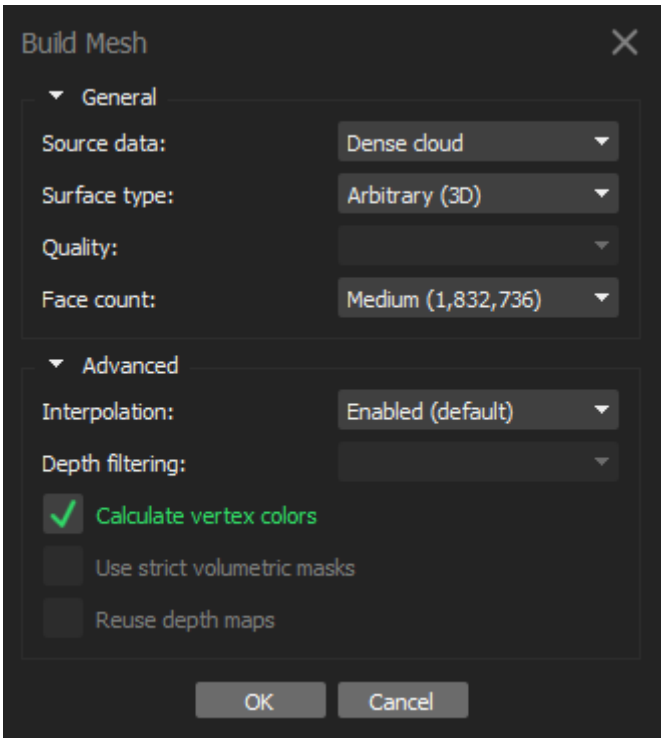
3. In the *Build Mesh* dialog box select the desired reconstruction parameters. Click *OK* button when done.

4. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

Note

- More than one instance of Mesh can be stored in one chunk. In case you want to save current Mesh instance and build new one in current chunk, right-click on Mesh and uncheck *Set as default* option. In case you want to save current Mesh instance and edit its copy, right-click on Mesh and choose *Duplicate* option.

Build Mesh parameters



"Build Mesh" dialog

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

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.
- **Depth maps** setting allows to use all the information from the input images more effectively and is less resource demanding compared to the dense cloud based reconstruction. The option is recommended to be used for Arbitrary surface type reconstruction, unless the workflow used assumes dense cloud editing prior to the mesh reconstruction.

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 being 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 basereliefs. It should be selected for aerial photography processing as it requires lower amount of memory and allows for larger data sets processing.

Quality

Specifies the desired reconstruction quality of the depth maps, providing that they are selected as a source option. Higher quality settings can be used to obtain more detailed and accurate geometry, but they require longer time for the 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 preliminary image size downscaling by factor of 4 (2 times by each side). For depth maps based mesh generation *Mild filtering* option is used by default, unless *Reuse depth maps* option is enabled. *Aggressive filtering* can be used if the excessive geometry (such as isolated mesh components around the reconstructed object) is observed, however, some fine level thin elements may be lost due to this depth filtering mode selection.

Face count

Specifies the maximum number of polygons in the final mesh. Suggested values (High, Medium, Low) present optimal number of polygons for a mesh of a corresponding level of detail. For the dense cloud based reconstruction they are calculated based on the number of points in the source dense point cloud: the ratio is 1/5, 1/15, and 1/45 respectively. It is still possible for a user to indicate the target number of polygons in the final mesh through the Custom value of the Face 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 visualization problems in external software.

Additionally the following advanced parameters can be adjusted.

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 Metashape 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. In **Extrapolated** mode the program 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.

Calculate vertex colors

If source data has color information (point cloud colors or images are present for the depth maps based calculation) enabling this option would allow to calculate the colors for the mesh vertices and display the interpolated colors for the mesh polygons in Shaded view mode.

Use strict volumetric masking

When this option is enabled, space volume covered with mask from at least one photo will be suppressed. Each mask is strict - so you should use them as little as possible to prevent accidental suppressing some surface parts. Each mask also makes mesh reconstruction slower. For example strict volumetric masks are useful to suppress noise between fingers by masking space between them from single camera. Also this is useful to suppress textureless background stuck to object contours - by masking out background from single camera. For additional information on the usage of masks please refer to the Using masks section. The option is only applicable for the Depth Maps source option selected.

Reuse depth maps

If available depth maps should be reused for mesh generation, select respective Quality (see info next to Depth maps label on the *Workspace* pane in the chunk's contents) and then check *Reuse depth maps* option. The option is applicable to the depth maps based reconstruction method only.

Note

- Metashape tends to produce 3D models with excessive geometry resolution, so it may be reasonable to perform mesh decimation after geometry computation. More information on mesh decimation and other 3D model geometry editing tools is given in the Editing model geometry section.

Building model texture

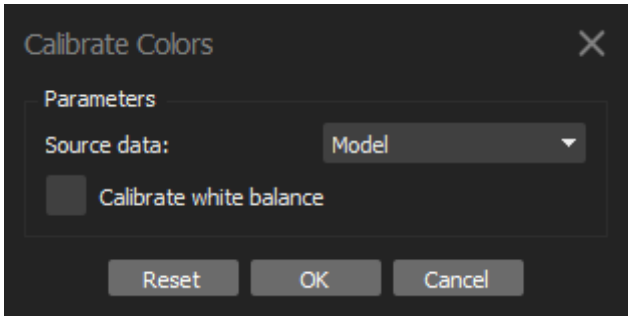
Color calibration

If the lighting conditions have been changing significantly during capturing scenario, it is recommended to use *Calibrate colors* option from the *Tools* menu before *Build texture* procedure. The option can help to even brightness and white balance of the images over the data set. Please note that for large data sets *Calibrate colors* procedure can turn out to be quite time consuming.

To calibrate colors

1. Select *Calibrate colors...* command from the *Tools* menu.
2. Select the desired colors calibration parameters in the *Calibrate colors* dialog box. Click *OK* button when done.
3. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

Color calibration parameters



"Calibrate Colors" dialog

Source data

Defines what data should be taken as the basis for overlapping areas estimation.
Sparse cloud - the quickest yet the roughest estimation available.

Model - gives more precise results, but only on condition that the surface is detailed enough. This parameter value is the recommended one if the aim is to calibrate colors to improve the quality of the model texture.

Calibrate white balance

Additional option to be switched on if white balance should be evened as well.

In Metashape it is possible to manually set color level adjustments for one or more images using the Adjust color levels tool. The *Adjust Color Levels* tool is available from the selected images context menu in the *Photos* pane. If the image is very dark or overexposed, you can manually set adjust the levels for each channel of the image in the Color levels dialog of the tool or set the Average value for all channels.

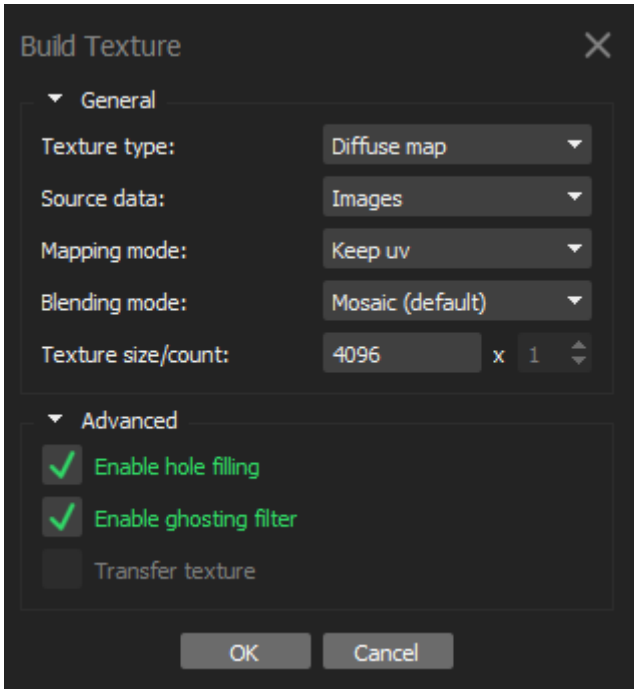
Build Texture

The texture feature allows to build different types of textures for a model.

To generate 3D model texture

1. Select *Build Texture...* command from the *Workflow* menu.
2. Select the desired texture generation parameters in the *Build Texture* dialog box. Click *OK* button when done.
3. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

Texture generation parameters



"Build Texture" dialog

The following parameters control various aspects of texture atlas generation:

Texture type

Diffuse map - the basic texture that stores the colors of the model surface.

Normal map - texture map that allows to calculate the illumination of the model parts from different light sources in the post-processing workflow.

Occlusion map - a texture that contains pre-calculated shading information from background lighting.

Source data

Images - allow to build a color texture map (diffuse map) based on the aligned images of the model or transferred from another model with already generated color texture map.

3D model - the normal and occlusion texture maps can be built based on another model and the relief of the model specified in the *Source data* field will be transferred to the current model. Usually it is recommended to use the more detailed model as a source data for the Normal and Occlusion map generation for the 3D model with the lower polygon count. *Normal map* option will not be available in the *Source data* field, if less than two 3D model instances are present in the active chunk.

Mapping mode

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.

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.

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.

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 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.

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

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 (not used in Single camera mapping mode)

Selects the way how color values of pixels from different cameras will be combined in the final texture.

Mosaic - implies two-step approach: it does blending of low frequency component for overlapping images to avoid seamline problem (weighted average, weight being dependent on a number of parameters including proximity of the pixel in question to the center of the image), while high frequency component, that is in charge of picture details, is taken from a single image - the one that presents good resolution for the area of interest while the camera view is almost along the normal to the reconstructed surface in that point.

Average - uses the weighted average value of all pixels from individual photos, the weight being dependent on the same parameters that are considered for high frequency component in mosaic mode.

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

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

Disabled - the image to take the color value for the pixel from is chosen like the one for the high frequency component in mosaic mode.

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.

Multi-page texture atlas generation is supported for **Generic** mapping mode only and **Keep UV** option, if the imported model contains proper texture layout.

Additionally the following advanced parameters can be adjusted.

Enable hole filling

This option is enabled on default since it helps to avoid salt-and-pepper effect in case of complicated surface with numerous tiny parts shading other parts of the model. Only in case of very specific tasks might it be recommended to switch the function off.

Enable ghosting filter

In case the scene includes some thin structures or moving objects which failed to be reconstructed as part of polygonal model, it can be useful to switch on this option to avoid ghosting effect on the resulting texture.

Note

- HDR texture generation requires HDR photos on input.

Improving texture quality

To improve resulting texture quality it may be reasonable to exclude poorly focused images from processing at this step. Metashape 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. To disable an image use *Disable* button from the *Photos* pane toolbar.

Metashape estimates image quality as a relative sharpness of the image 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.

To estimate image quality

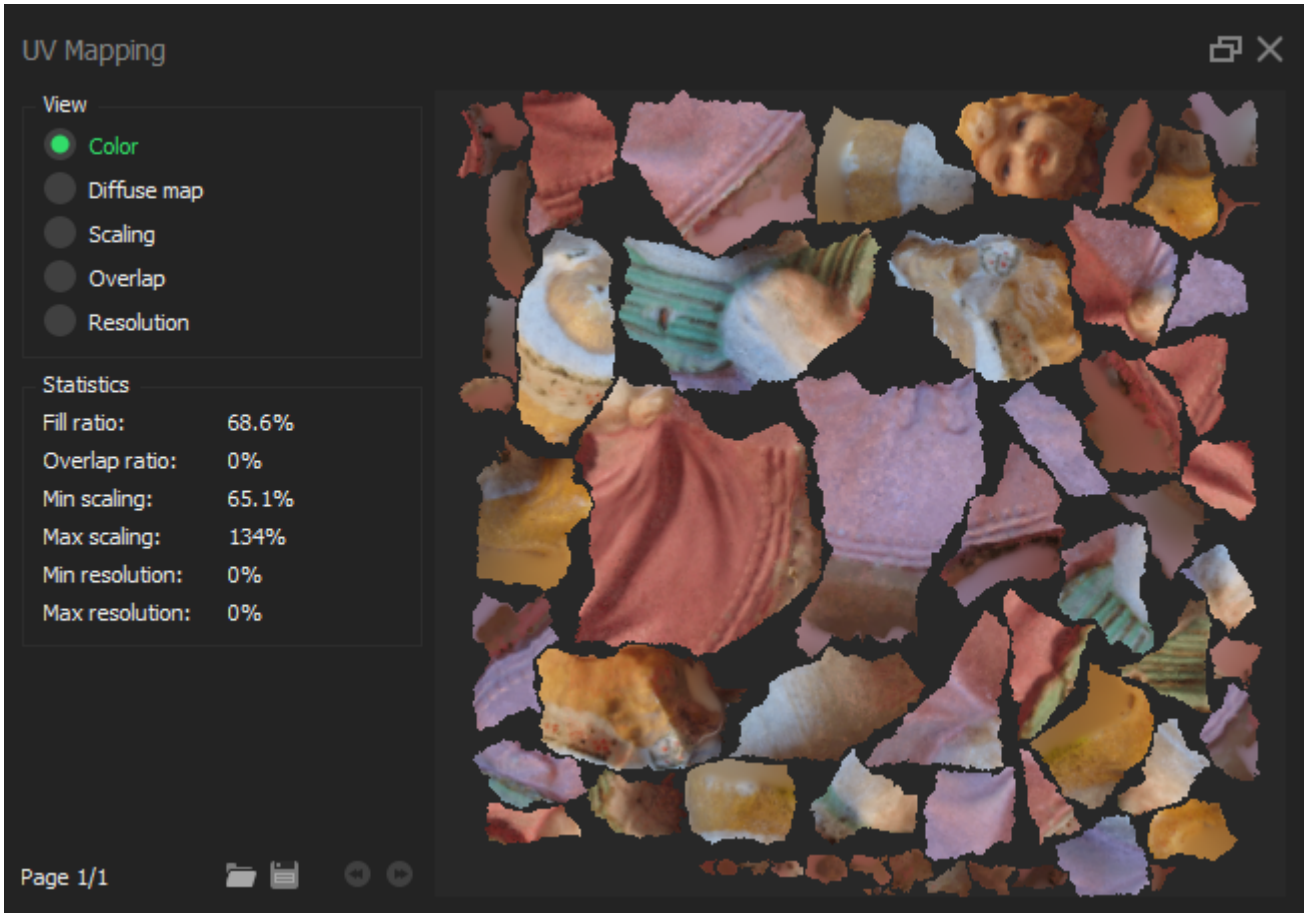
1. Switch to the detailed view in the *Photos* pane using *Details* command from the *Change* menu on the *Photos* pane toolbar.
2. Select all images to be analyzed on the *Photos* pane.
3. Right button click on the selected image(s) and choose *Estimate Image Quality* command from the context menu.
4. Once the analysis procedure is over, a figure indicating estimated image quality value will be displayed in the *Quality* column on the *Photos* pane.

View Mesh UVs

In Metashape it is possible to analyze Mesh UV statistic. You can evaluate the quality of the resulting texture using data in this dialog window.

To open UV Mapping dialog window

1. Select *View Mesh UVs...* command on *Mesh* submenu from the *Tools* menu.
2. Check parameters for the texture was built in *UV Mapping* dialog box. You can save data from this page using *Save* button.



"UV Mapping" dialog

The following parameters can be specified in *UV Mapping* dialog:

View

Color - displays the colors of the mesh vertices.

Diffuse map - display the basic texture that stores the colors of the model surface.

Scaling - displays the ratio of the area of the texture triangle to its area on the mesh surface.

Overlap - displays how many pixels in the atlas correspond to more than one triangle in the mesh.

Resolution - displays the detail as a percentage. It is calculated as the ratio of the number of pixels for the triangle from the most detailed photo to the area of the triangle in the atlas.

Statistics

Fill ratio: - displays the percentage of occupied pixels (in percent).

Overlap ratio: - value of the overlap in percent (in percent).

Min scaling: - minimum scaling value (in percent).

Max scaling: - maximum scaling value (in percent).

Min Resolution: - minimum resolution value (in percent).

Max Resolution: - maximum resolution value (in percent).

Saving intermediate results

Certain stages of 3D model reconstruction can take a long time. The full chain of operations could eventually last for 4-6 hours when building a model from hundreds of photos. It is not always possible to complete all the operations in one run. Metashape allows to save intermediate results in a project file.

Metashape project archive (.PSZ)

Metashape Archive files (*.psz) 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.
- Depth maps for cameras.
- Dense point cloud model.
- Reconstructed 3D polygonal model with any changes made by user. This includes mesh and texture if it was built.
- Structure of the project, i.e. number of chunks in the project and their content.

Note that since Metashape tends to generate extra dense point clouds and highly detailed polygonal models, project saving procedure can take up quite a long time.

Metashape project file (.PSX)

You can save the project at the end of any processing stage and return to it later. To restart work simply load the corresponding file into Metashape. 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, Metashape 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 *Advanced* tab of the *Preferences* dialog available from *Tools* menu.

Exporting results

Metashape supports export of processing results in various representations: sparse and dense point clouds, camera calibration and camera orientation data, mesh, etc.

Point cloud and camera calibration data can be exported right after photo alignment is completed. All other export options are available after the corresponding processing step.

If you are going to export the results (point cloud / mesh) for the chunk that is not referenced, please note that the resulting file will be oriented according to a default coordinate system (see axes in the bottom right corner of the *Model* view), i. e. the model can be shown differently from what you see in Metashape window.

To align the model orientation with the default coordinate system use Rotate object button from the *Toolbar*. Move object and Scale object instruments can be used to adjust the size and location of the unreferenced model.

In some cases editing model geometry in the external software may be required. Metashape supports model export for editing in external software and then allows to import it back as it is described in the Editing model geometry section of the manual.

Main export commands are available from the *File* menu.

Point cloud export

To export sparse or dense point cloud

1. Select *Export Points...* command from the *File* menu.
2. Browse the destination folder, choose the file type, and print in the file name. Click *Save* button.
3. In the *Export Points* dialog box select desired type of point cloud: *Sparse point cloud* or *Dense point cloud*.
4. Indicate export parameters applicable to the selected file type.
5. Click *OK* button to start export.
6. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

In some cases it may be reasonable to edit point cloud before exporting it. To read about point cloud editing refer to the Editing point cloud section of the manual.

Metashape supports point cloud export in the following formats:

- Wavefront OBJ (*.obj)
- Stanford PLY (*.ply)
- XYZ Point Cloud (*.txt)
- ASPRS LAS (*.las)
- LAZ (*.laz)
- ASTM E57 (*.e57)
- Topcon CL3 (*.cl3)
- ASCII PTS (*.pts)
- Autodesk DXF (*.dxf)
- U3D (*.u3d)
- Adobe PDF (*.pdf)
- Point Cloud Data (*.pcd)
- potree (*.zip)
- Cesium 3D Tiles (*.zip)
- Agisoft OC3 (*.oc3)

Note

- Saving color information of the point cloud is not supported by the OBJ and DXF formats.
- Saving point normals information is not supported by the LAS, LAZ, PTS, CL3 and DXF formats.

Metashape supports direct uploading of the point clouds to the following resources: 4DMapper, PointBox, PointScene and Sketchfab. To publish your point cloud online use *Upload Data...* command from the *File* menu.

Tie points and camera calibration, orientation data export

To export camera calibration and camera orientation data select *Export Cameras...* command from the *File* menu.

Metashape supports camera data export in the following formats:

- Agisoft XML structure (*.xml)

- Bundler OUT file format (*.out)
- CHAN file format (*.chan)
- Boujou TXT file format (*.txt)
- Realviz RZML format (*.rzml)
- Omega Phi Kappa text file format (*.txt)
- PATB project (*.pro)
- BINGO project file (*.dat)
- ORIMA file (*.txt)
- AeroSys Exterior orientation (*.orn)
- Inpho project file (*.prj)
- Summit Evolution project (*.smtxml)
- Blocks Exchange (*.xml)
- Alembic (*.abc)
- Autodesk FBX (*.fbx)

Note

- Camera data export in Bundler and Boujou file formats will save sparse point cloud data in the same file.
- Camera data export in Bundler file format would not save distortion coefficients k3, k4.

To export tie points data one should choose one of the following export formats in the *Export Cameras* dialog: BINGO, ORIMA, PATB, Summit Evolution or Blocks exchange. Tie points can be exported only along with interior and exterion orientation parameters of the cameras.

As a result of export in PATB format, the following files will be written:

example.pro
Project file PATB. It contains information on the units of measurement (microns/millimeters). This eliminates the ambiguity in interpreting the data on import.

example.im
File with coordinates of tie points projections on the images.

example.ori
File with the calculated parameters of the exterior orientation for the cameras.

example.at
File with the calculated coordinates of tie points (adjusted terrain coordinates).

Note

- *.im and *.con formats are input files for PATB and *.ori. and *.at are output formats.

As a result of export in BINGO format, the following files will be written to the destination folder: itera.dat (ITERA file); image.dat (IMAGE COORDINATE file); geoin.dat (GEO INPUT file); gps-imu.dat (GPS/IMU data).

As a result of export in Summit Evolution format two files will be created (*.cam, *.smtxml). File in *.cam format includes information about camera calibration parameters. File in *.smtxml format is Summit Evolution project file.

To export / import camera calibration data only select *Camera Calibration...* command from the *Tools* menu. Using / buttons it is possible to load / save camera calibration data in the following formats:

- Agisoft Camera Calibration (*.xml)
- Australis Camera Parameters (*.txt)
- Australis v7 Camera Parameters (*.txt)
- PhotoModeler Camera Calibration (*.ini)
- 3DM CalibCam Camera Parameters (*.txt)
- CalCam Camera Calibration (*.cal)
- Inpho Camera Calibration (*.txt)
- USGS Camera Calibration (*.txt)
- Pix4D Camera Calibration (*.cam)
- OpenCV Camera Calibration (*.xml)
- Z/I Distortion Grid (*.dat)

Panorama export

Metashape is capable of panorama stitching for images taken from the same camera position - camera station. To indicate for the software that loaded images have been taken from one camera station, one should move those photos to a camera group and assign Camera Station type to it. For information on camera groups refer to Loading images section.

To export panorama

1. Select *Export Panorama...* command from the *File* menu.
2. Select camera group which panorama should be previewed for.
3. Choose panorama orientation in the file with the help of navigation buttons to the right of the preview window in the *Export Panorama* dialog.
4. Set exporting parameters: select camera groups which panorama should be exported for and indicate export file name mask.
5. Click *OK* button
6. Browse the destination folder and click *Save* button.

Additionally, you can set boundaries for the region of panorama to be exported using *Setup boundaries* section of the *Export Panorama* dialog. Text boxes in the first line (X) allow to indicate the angle in the horizontal plane and the second line (Y) serves for angle in the vertical plane limits. *Image size (pix)* option enables to control the dimensions of the exported image file.

Metashape supports panorama export in the following formats:

- JPEG (*.jpg, *.jpeg)
- JPEG 2000 (*.jp2)
- TIFF (*.tif, *.tiff)
- PNG (*.png)
- BMP (*.bmp)
- OpenEXR (*.exr)
- TARGA (*.tga)

3D model export

To export 3D model

1. Select *Export Model...* command from the *File* menu.
2. Browse the destination folder, choose the file type, and print in the file name. Click *Save* button.
3. In the *Export Model* dialog indicate export parameters applicable to the selected file type.
4. Click *OK* button to start export.
5. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

Metashape supports model export in the following formats:

- Wavefront OBJ (*.obj)
- 3DS file format (*.3ds)
- VRML models (*.wrl)
- COLLADA (*.dae)
- Stanford PLY (*.ply)
- X3D models (*.x3d)
- STL models (*.stl)
- Alembic (*.abc)
- Autodesk FBX (*.fbx)
- Autodesk DXF Polyline (*.dxf)

- Autodesk DXF 3DFace (*.dxf)
- Open Scene Graph (*.osgb)
- Binary glTF (*.glb)
- U3D models (*.u3d)
- Adobe PDF (*.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.

Metashape supports direct uploading of the models to Sketchfab resource. To publish your model online use *Upload Data...* command from the *File* menu.

Extra products to export

In addition to main targeted products Metashape allows to export some other processing results, like:

- *Convert Images...* command is available from *Export* submenu of the *File* menu and allows to export free of lens distortions and geometrically corrected images. It also allows to convert large images to a pyramid-optimized TIFF format for prompt navigation in the *Photo* view mode.

In the *Parameters* section of the *Convert Images* dialog window the user can check the following options: *Correct distortions*, *Center principal point*, *Square pixels*, *Apply color correction*. *Filename template* for converted images should also be specified in the dialog window.

In the *Compression* section of the *Convert Images* dialog window the user can set one of the suggested TIFF compression parameters: LSW, JPEG, Packbits, Deflate; set *JPEG quality* and specify if Tiled TIFF, BigTIFF file or TIFF overviews should also be saved. The corrections can be applied to all cameras, entire workspace, selected cameras or even to a current photo.

- Depth map for any image (*Export Depth...* command available from photo context menu). You can export diffuse map, depth map and normal map.

- High resolution image of the model as it is shown in the *Model* view mode. *Capture View* command available from the context menu shown on right button click in the *Model* view.

Note

- You need to have mesh model generated in the chunk in order to export diffuse map, depth map and normal map.

Processing report generation

Metashape supports automatic processing report generation in PDF format, which contains the basic parameters of the project, processing results and accuracy evaluations.

To generate processing report

1. Select *Generate Report...* command from the *File* menu.
2. Browse the destination folder, choose the file type, and print in the file name. Click *Save* button.

3. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

Metashape processing report presents the following data:

- Model overview in the desired projection.
- Survey data including coverage area, flying altitude, GSD, general camera(s) info, as well as overlap statistics.
- Camera calibration results: figures and an illustration for every sensor involved in the project.
- Processing parameters used at every stage of the project.

Note

- Processing report can be exported after alignment step.

Survey Data

Fig. **Camera locations and image overlap** - shows the model and position the cameras is shown and the number of overlaps is displayed in color.

Number of images - total number of images uploaded into the project.

Camera stations - number of aligned images.

Flying altitude - average height above ground level.

Tie points - total number of valid tie points (equals to the number of points in the sparse cloud).

Ground resolution - effective ground resolution averaged over all aligned images.

Projections - total number of projections of valid tie points.

Coverage area - size of the area that has been surveyed.

Reprojection error - root mean square reprojection error averaged over all tie points on all images.

Table. Cameras - table with the parameters: camera model, resolution, focal length, pixel size, precalibrated.

Reprojection error is the distance between the point on the image where a reconstructed 3D point can be projected and the original projection of that 3D point detected on the photo and used as a basis for the 3D point reconstruction procedure.

Camera Calibration

For precalibrated cameras internal parameters input by the user are shown on the report page. If a camera was not precalibrated, internal camera parameters estimated by Metashape are presented.

Fig. Image residuals for camera - displays the reprojection errors for the tie points detected on the source images, averaged across all the images of the calibration group and inside the certain "cells" on the images.

Camera name (focal length) - camera model name and number of images.

Type - camera type.

Resolution - image dimensions in pixels.

Focal Length - focal length in mm.

Pixel Size - pixel size in µm.

Table. Calibration coefficients and correlation matrix - table with the calibration coefficients and parameters of the covariance matrix (F, Cx, Cy, B1, B2, K1, K2, K3, K4, P1, P2).

Digital Elevation Model

Fig. **Reconstructed digital elevation model** - presenting digital elevation model.

Resolution - effective resolution of the exported DEM. The value depends on the *Quality* parameter value used at Build point cloud step, providing that DEM has been generated from dense point cloud.

Point Density - average number of dense cloud points per square meter.

Processing Parameters

Processing report contains processing parameters information, which is also available form Chunk context menu. Along with the values of the parameters used at various processing stages, this page of the report presents information on processing time.

Metashape matches images on different scales to improve robustness with blurred or difficult to match images. The accuracy of tie point projections depends on the scale at which they were located. Metashape uses information about scale to weight tie point reprojection errors. Key point size is the Sigma of the Gaussian blur at the pyramid level of scales at which the key point was found.

On the processing parameters page of the report (as well as in chunk information dialog) two reprojection errors are provided: the reprojection error in the units of key point scale (this is the quantity that is minimized during bundle adjustment), and the reprojection error in pixels (for convenience). The Mean key point size value is averaged Key point size value over all key points. Average tie point multiplicity value is the ratio of the total number of projections to the number of tie points.

Camera track creation and fly through video rendering

In Metashape you can create an overview video of the model along a certain trajectory. Camera track can be created automatically (using simple preset options), imported from external file and edited manually.

To manually create a track and add a viewpoint, click *Append* button on the *Animation* pane. Append option will add the current viewpoint to the active camera track.

To create Horizontal track

1. Select *Animation* command from the *View* menu.
2. Click *Create* button on the *Animation* pane toolbar.
3. Choose *Horizontal* preset parameter in *Create Track* dialog window and set the *Keyframe count*.
4. Click *OK* button.

5. Adjust the position of the viewpoint in the camera track in *Model* view by dragging the left mouse button to display it visually.

To create Vertical track

1. Select *Animation* command from the *View* menu.
2. Click *Create* button on the *Animation* pane toolbar.
3. Choose *Vertical* preset parameter in *Create Track* dialog window and set the *Keyframe count*.
4. Click *OK* button.
5. Adjust the position of the viewpoint in the camera track in *Model* view by dragging the left mouse button to display it visually.

Note

- To display the camera track path, select *Show animation* command from the *Show/Hide items* submenu on the *Model* menu.

Camera track parameters can be adjusted in the *Animation Settings* dialog window. The following parameters can be changed: Camera Track Label, Duration (in seconds), Field of view (deg), Smooth camera track option, Loop camera track option, Rotation angles convention. Click *Settings* button on the *Animation* pane to open *Animation Settings* dialog.

To record the video

1. To record the video according to the created camera track to the external file click on *Capture* on the *Animation* pane toolbar.
2. Select the desired export parameters in the *Capture Video* dialog, such as export video resolution, compression type and frame rate.
3. To save the track path to external file click *Save* button on the *Animation* pane.

Metashape supports camera track export in the following formats:

- Camera Path
- KML

Note

- That KML format is only supported for projects georeferenced in geographic/projected systems convertible to WGS84 system.

Chapter 4. Improving camera alignment results

Camera calibration

Calibration groups

While carrying out photo alignment Metashape estimates both internal and external camera orientation parameters, including nonlinear radial distortions. For the estimation to be successful it is crucial to apply the estimation procedure separately to photos taken with different cameras. Once photos have been loaded in the program, Metashape automatically divides them into calibration groups according to the image resolution and/or EXIF meta data like camera type and focal length. All the actions described below could and should be applied (or not applied) to each calibration group individually.

Calibration groups can be rearranged manually.

To create a new calibration group

1. Select *Camera Calibration...* command from the *Tools* menu.
2. In the *Camera Calibration* dialog box, select photos to be arranged in a new group.
3. In the right-click context menu choose *Create Group* command.
4. A new group will be created and depicted on the left-hand part of the *Camera Calibration* dialog box.

To move photos from one group to another

1. Select *Camera Calibration...* command from the *Tools* menu.
2. In the *Camera Calibration* dialog box choose the source group on the left-hand part of the dialog.
3. Select photos to be moved and drag them to the target group on the left-hand part of the *Camera Calibration* dialog box.

To place each photo into a separate group you can use *Split Groups* command available at the right button click on a calibration group name in the left-hand part of the *Camera Calibration* dialog

Camera types

Metashape supports two major types of camera: frame camera and fisheye camera. Camera type can be set in *Camera Calibration* dialog box available from *Tools* menu.

Frame camera. If the source data within a calibration group was shot with a frame camera, for successful estimation of camera orientation parameters the information on approximate focal length (pix) is required. Obviously, to calculate focal length value in pixel it is enough to know focal length in mm along with the sensor pixel size in mm. Normally this data is extracted automatically from the EXIF meta data.

Frame camera with **Fisheye** lens. If extra wide lenses were used to get the source data, standard Metashape camera model will not allow to estimate camera parameters successfully. Fisheye camera type setting will initialize implementation of a different camera model to fit ultra-wide lens distortions.

Optionally rolling shutter compensation can be enabled by checking the **Enable rolling shutter compensation** box in the *Camera Calibration* dialog available from *Tools* menu.

In case source images lack EXIF data or the EXIF data is insufficient to calculate focal length in pixels, Metashape will assume that focal length equals to 50 mm (35 mm film equivalent). However, if the initial guess values differ significantly from the actual focal length, it is likely to lead to failure of the alignment process. So, if photos do not contain EXIF meta data, it is preferable to specify focal length (mm) and sensor pixel size (mm) manually. It can be done in *Camera Calibration* dialog box available from *Tools* menu. Generally, this data is indicated in camera specification or can be received from some online source. To indicate to the program that camera orientation parameters should be estimated based on the focal length and pixel size information, it is necessary to set the *Type* parameter on the *Initial* tab to *Auto* value.

Camera calibration parameters

Photogrammetric calibration of cameras is performed to determine the values of the interior orientation of the cameras, including the parameters of distortion of the camera lens. The camera calibration parameters can be input manually, if they have been acquired as a part of precalibration procedure.

To specify camera calibration parameters

1. Select *Camera Calibration...* command from the *Tools* menu.
2. Select calibration group, which requires re-estimation of camera orientation parameters on the left side of the *Camera Calibration* dialog box.
3. In the *Camera Calibration* dialog box, select **Initial** tab.
4. Modify the calibration parameters displayed in the corresponding edit boxes.
5. Set the *Type* to the *Precalibrated* value.
6. Repeat to every calibration group where applicable.
7. Click *OK* button to set the calibration.

The following calibration parameters are available:

f
: Focal length measured in pixels.

cx, cy
: Principal point coordinates, i.e. coordinates of lens optical axis interception with sensor plane in pixels.

b1, b2
: Affinity and Skew (non-orthogonality) transformation coefficients.

k1, k2, k3, k4
: Radial distortion coefficients.

p1, p2
: Tangential distortion coefficients.

Note

- Alternatively, initial calibration data can be imported from file using *Load* button on the *Initial* tab of the *Camera Calibration* dialog box. In addition to Agisoft calibration file format it is possible to import data from Australis, PhotoModeler, 3DM CalibCam, CalCam, Inpho camera calibration, USGS camera calibration, OpenCV and Z/I Distortion Grid formats.

Initial calibration data will be adjusted during the Align Photos processing step. Once Align Photos processing step is finished adjusted calibration data will be displayed on the *Adjusted* tab of the *Camera*

Calibration dialog box. The details about distortion models used in Metashape are given in the Appendix C, *Camera models* section.

If very precise calibration data is available, click *Select...* button next to *Fixed parameters:* item. In *Fixed parameters* dialog choose calibration parameters that are to be fixed and click *OK* button. The initial values for the chosen parameters will not be changed during Align Photos or Optimize Cameras operations.

In some cases it may be required to estimate some sub-set of parameters individually for each camera in the calibration group. In this case such parameters should be selected in the section *Image-variant parameters*. Click *Select* button and choose these parameters in *Image-variant parameters* dialog box.

Adjusted camera calibration data can be saved to file using *Save* button on the *Adjusted* tab of the *Camera Calibration* dialog box.

Analyzing calibration results

Metashape provides a number of tools to analyze camera calibration results available from context menu of a camera group in the *Camera Calibration* dialog.

Distortion

Distortion tab presents estimated camera distortion plot. Total, Radial, Decentering, Corrections and Residual options are available in the tab. Distortion graph represent the distortion values and direction according to the adjusted calibration coefficient values. It shows the plot in the discrete vectors mode for a central point in the corresponding image cell. Residuals presents residuals graph which allows to evaluate how adequately the camera is described with the applied mathematical model. Note that residuals are averaged per cell of an image and then across all the images in a camera group. Scale reference under the plot indicates the scale of the distortions/residuals.

Profile

Profile tab presents increase of the corresponding radial and decentering distortions with distance from the center of the photo. Profiles can be saved as image.

Correlation

Correlation tab presents:

- Adjusted values of the internal camera orientation parameters;
- Errors - standard deviation;
- Correlation values for internal camera orientation parameters - reflect the degree of correlation between the corresponding parameters.

Vignetting

Vignetting tab presents radiometric distortion of the lens. Metashape uses radiometric distortion parameters of the lens from photos metadata, in case there is no information about radiometric distortion of the lens in photo metadata *Vignetting* tab is inactive. You can calculate radiometric distortion manually using *Calibrate Colors* command available from the *Tools* menu, read more in Building model texture section.

Optimization

Optimization of camera alignment

During photo alignment step Metashape automatically finds tie points and estimates intrinsic and extrinsic camera parameters. However, the accuracy of the estimates depends on many factors, like overlap between

the neighboring photos, as well as on the shape of the object surface. Thus, it is recommended to inspect alignment results in order to delete tie points with too large reprojection error if any. Please refer to Editing point cloud section for information on point cloud editing. Once the set of tie points has been edited, it is necessary to run optimization procedure to reestimate intrinsic and extrinsic camera parameters.

Optimization procedure calculates intrinsic and extrinsic camera parameters based on the tie points left after editing procedure. Providing that outliers have been removed, the estimates will be more accurate. In addition, this step involves estimation of a number of intrinsic camera parameters which are fixed at the alignment step: b1 (aspect), b2 (skew) and higher order radial distortion coefficient k4. Optionally you may turn on **Adaptive camera model fitting** read more in Aligning photos section.

To optimize camera alignment

1. Choose *Optimize Cameras...* command from the *Tools* menu.
2. In *Optimize Camera Alignment* dialog box check camera parameters to be optimized. Click *OK* button to start optimization.
3. After optimization is complete, estimated intrinsic camera parameters can be inspected on the *Adjusted* tab of the *Camera Calibration* dialog available from the *Tools* menu.

Note

- The model data (if any) is cleared by the optimization procedure. You will have to rebuild the model geometry after optimization.

Chapter 5. Editing

Using masks

Overview

Masks are used in Metashape to specify the areas on the photos which can otherwise be confusing to the program or lead to incorrect reconstruction results. Masks can be applied at the following stages of processing:

- Matching of the images
- Building Depth Maps
- Building Mesh from the depth maps source with the strict volumetric masks option applied
- Building Texture

Alignment of the photos

Masked areas can be excluded during feature point detection. Thus, the objects on the masked parts of the photos are not taken into account while estimating camera positions. This is important in the setups, where the object of interest is not static with respect to the scene, like when using a turn table to capture the photos.

Masking may be also useful when the object of interest occupies only a small part of the photo. In this case a small number of useful matches can be filtered out mistakenly as a noise among a much greater number of matches between background objects.

Building dense point cloud

While building dense point cloud, masked areas are not used in the depth maps computation process. Masking can be used to reduce the resulting dense cloud complexity, by eliminating the areas on the photos that are not of interest.

Masked areas are always excluded from processing during dense point cloud and texture generation stages, including Tiled Model generation process.

Let's take for instance a set of photos of some object. Along with an object itself on each photo some background areas are present. These areas may be useful for more precise camera positioning, so it is better to use them while aligning the photos. However, impact of these areas at the building dense point cloud is exactly opposite: the resulting model will contain object of interest and its background. Background geometry will "consume" some part of mesh polygons that could be otherwise used for modeling the main object.

Setting the masks for such background areas allows to avoid this problem and increases the precision and quality of geometry reconstruction.

Building texture atlas

During texture atlas generation (for single mesh model and tiled model), masked areas on the photos are not used for texturing. Masking areas on the photos that are occluded by outliers or obstacles helps to prevent the "ghosting" effect on the resulting texture atlas.

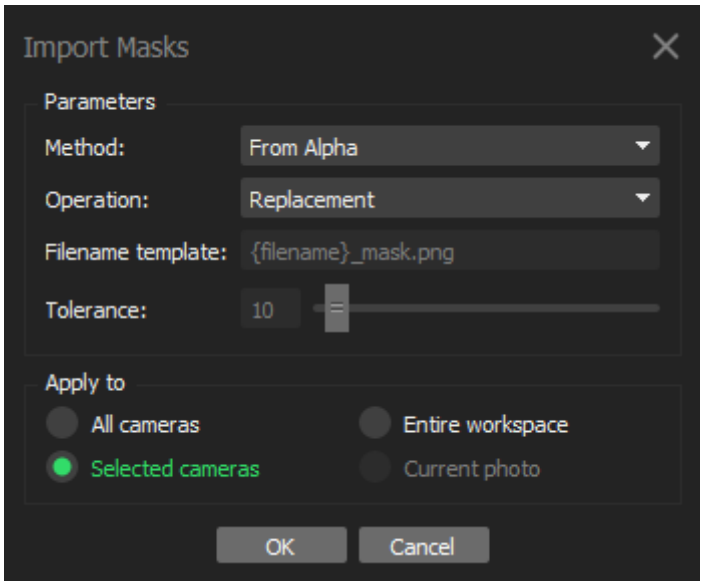
Loading masks

Masks can be loaded from external sources, as well as generated automatically from background images if such data is available. Metashape supports loading masks from the following sources:

- From alpha channel of the source photos.
- From separate images.
- Generated from background photos based on background differencing technique.
- Based on reconstructed 3D model.

To import masks

1. Select *Import Masks...* command from the *File* menu.
2. In the *Import Mask* dialog select suitable parameters. Click *OK* button when done.
3. When generating masks from separate or background images, the folder selection dialog will appear. Browse to the folder containing corresponding images and select it.
4. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.



"Import Masks" dialog

The following parameters can be specified during mask import:

Method

Specifies the source of the mask data.

From Alpha - load masks from alpha channel of the source photos.

From File - load masks from separate images.

From Background - generate masks from background photos.

From Model - generate masks based on reconstructed model.

Operation

Specifies the action to be done in case a second mask is imported for the photo.

Replacement - new mask will be loaded and stored instead of the original one.

Union - two masks will be united and stored.

Intersection - the intersection of the two masks will be stored as a new mask for the photo.

Difference - only the difference between two masks will be stored as a new mask for the photo.

Filename template (not used in From alpha mode)

Specifies the file name template used to generate mask file names. This template can contain special tokens, that will be substituted by corresponding data for each photo being processed. The following tokens are supported:

{filename} - file name of the source photo without extension.

{fileext} - extension of the source photo.

{camera} - camera label.

{filenum} - sequential number of the mask being imported.

For example, {filename}_mask.png template can be used if masks are available in PNG format and have a **_mask** suffix.

Tolerance (From Background method only)
Specifies the tolerance threshold used for background differencing. Tolerance value should be set according to the color separation between foreground and background pixels. For larger separation higher tolerance values can be used.

Apply to
Specifies whether masks should be imported for the currently opened photo, active chunk or entire *Workspace*.

All cameras - load masks for active chunk.

Entire workspace - load masks for all chunks in the project.

Selected cameras - load mask for the currently checked cameras (if any).

Current photo - load mask for the currently opened photo (if any).

Editing masks

Modification of the current mask is performed by adding or subtracting selections. A selection is created with one of the supported selection tools and is not incorporated in the current mask until it is merged with a mask using *Add Selection* or *Subtract Selection* operations.

To edit the mask

1. Open the photo to be masked by double clicking on its name on the *Workspace* / *Photos* pane. The photo will be opened in the main window. The existing mask will be displayed as a shaded region on the photo.
2. Select the desired selection tool and generate a selection.
3. Click on Add Selection toolbar button to add current selection to the mask, or Subtract Selection to subtract the selection from the mask. Invert Selection button allows to invert current selection prior to adding or subtracting it from the mask.

The following tools can be used for creating selections:

Rectangle selection tool
Rectangle selection tool is used to select large areas or to clean up the mask after other selection tools were applied.

Intelligent scissors tool
Intelligent scissors is used to generate a selection by specifying its boundary. The boundary is formed by selecting a sequence of vertices with a mouse, which are automatically connected with segments. The segments can be formed either by straight lines, or by curved contours snapped to the object boundaries. To enable snapping, hold **Ctrl** key while selecting the next vertex. To complete the selection, the boundary should be closed by clicking on the first boundary vertex.

Intelligent paint tool
Intelligent paint tool is used to "paint" a selection by the mouse, continuously adding small image regions, bounded by object boundaries.

Magic wand tool

Magic Wand tool is used to select uniform areas of the image. To make a selection with a Magic Wand tool, click inside the region to be selected.

The range of pixel colors selected by Magic Wand is controlled by the tolerance value. At lower tolerance values the tool selects fewer colors similar to the pixel you click with the Magic Wand tool. Higher value broadens the range of colors selected.

Note

- To add new area to the current selection hold the **Ctrl** key during selection of additional area.
- To subtract a part from the current selection hold the **Shift** key during selection of the area to be subtracted.
- To reset mask selection on the current photo press **Esc** key.

A mask can be inverted using *Invert Mask* command from the *Edit* menu. The command is active in *Photo* view only. Alternatively, you can invert masks either for selected cameras or for all cameras in a chunk using *Invert Masks...* command from a photo context menu on the *Photos* pane.

The masks are generated individually for each image. If some object should be masked out, it should be masked out on all photos, where that object appears.

Saving masks

Created masks can be also saved for external editing or storage.

To export masks

1. Select *Export Masks...* command from the *File* menu.
2. In the *Export Mask* dialog select suitable parameters. Click *OK* button when done.
3. Browse to the folder where the masks should be saved and select it.
4. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

"Export Masks" dialog

The following parameters can be specified during mask export:

Export masks for

Specifies whether masks should be exported for the currently opened photo, active chunk or entire *Workspace*.

Current photo - save mask for the currently opened photo (if any).

Active chunk - save masks for active chunk.

Entire workspace - save masks for all chunks in the project.

File type

Specifies the type of generated files.

Single channel mask image - generates single channel black and white mask images.

Image with alpha channel - generates color images from source photos combined with mask data in alpha channel.

Mask file names

Specifies the file name template used to generate mask file names. This template can contain special tokens, that will be substituted by corresponding data for each photo being processed. The following tokens are supported:

{filename} - file name of the source photo without extension.

{fileext} - extension of the source photo.

{camera} - camera label.

{filenum} - sequential number of the mask being exported.

For example, {filename}_mask.png template can be used to export masks in PNG format with **_mask** suffix.

Note

- When importing/exporting mask for the current photo only, Metashape will prompt for the actual image instead of image folder. *Mask file names* parameter will not be used in this case.

Editing point cloud

The following point cloud editing tools are available in Metashape:

- Automatic filtering based on specified criterion (sparse cloud only)
- Automatic filtering based on applied masks (dense cloud only)
- Automatic filtering based on points colors (dense cloud only)
- Automatic filtering by selection (dense cloud only)
- Automatic filtering by confidence (dense cloud only)
- Reducing number of points in point cloud by setting tie point per photo limit (sparse cloud only)
- Reducing number of dense cloud points by setting up point spacing value
- Colorize dense point cloud
- Sample points operation to create dense point cloud from the mesh or tiled model
- Manual points removal

Note

- Point cloud editing operation can be undone/redone using *Undo/Redo* command from the *Edit* menu.

Filtering 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.

Metashape supports the following criteria for point cloud filtering:

Reprojection error

Maximum reprojection error in normalized units across all images where tie-point was measured.

$max_i |x'_i - x_i| / s_i$

where

x'_i - point projection according to adjusted orientation parameters on the i-th image in pixels,

x_i - measured point projection coordinates on the i-th image in pixels,

s_i - image scale at which corresponding projection was measured on the i-th image

High reprojection error usually indicates poor localization accuracy of the corresponding point projections at the point matching step. It is also typical for false matches. Removing such points can improve accuracy of the subsequent optimization step.

Reconstruction uncertainty

Ratio of the largest semi-axis to the smallest semi-axis of the error ellipse of the triangulated 3D point coordinates. The error ellipse corresponds to the uncertainty of the point triangulation alone without taking into account propagation of uncertainties from interior and exterior orientation parameters.

$sqrt(k_1 / k_3)$

where

k_1 - largest eigenvalue of the tie-point covariance matrix,

k_3 - smallest eigenvalue of the tie-point covariance matrix

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

Number of images where the tie point was measured.

Metashape reconstruct all the points that are visible at least on two photos. However, points that are visible only on two photos are likely to be located with poor accuracy. Image count filtering enables to remove such unreliable points from the cloud.

Projection Accuracy

Average image scale at which image coordinates of the tie-point were measured.

$sum_i s_i / n$

where

s_i - image scale at which corresponding projection was measured on the i-th image,

n - number of images where tie-point was measured

This criterion allows to filter out points which projections were relatively poorer localized due to their bigger size.

To remove points based on specified criterion

1. Switch to *Point Cloud* view mode using Point Cloud toolbar button.
2. Select *Gradual Selection...* command from the *Model* menu.
3. In the *Gradual Selection* dialog box specify the criterion to be used for filtering. Adjust the threshold level using the slider. You can observe how the selection changes while dragging the slider. Click *OK* button to finalize the selection.
4. To remove selected points use *Delete Selection* command from the *Edit* menu or click Delete Selection toolbar button (or simply press **Del** button on the keyboard).

Filtering points based on applied masks

To remove points based on applied masks

1. Switch to *Dense Cloud* view mode using Dense Cloud toolbar button.
2. Choose *Select Masked Points...* command from the *Dense Cloud* submenu of the *Tools* menu.
3. In the *Select Masked Points* dialog box indicate the photos whose masks to be taken into account. Adjust the edge softness level using the slider. Click *OK* button to run the selection procedure.
4. To remove selected points use *Delete Selection* command from the *Edit* menu or click Delete Selection toolbar button (or simply press **Del** button on the keyboard).

Filtering points based on points colors

To remove points based on points colors

1. Switch to *Dense Cloud* view mode using *Dense Cloud* toolbar button.
2. Choose *Select Points by Color...* command from the *Dense Cloud* submenu of the *Tools* menu.
3. In the *Select Points by Color* dialog box the color to be used as the criterion. Adjust the tolerance level using the slider. Click *OK* button to run the selection procedure.
4. To remove selected points use *Delete Selection* command from the *Edit* menu or click *Delete Selection* toolbar button (or simply press **Del** button on the keyboard).

Filtering points by selection

Filter by selection

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

2. Select points to be filter *Rectangle Selection*, *Circle Selection* or *Free-Form Selection* tools.
3. Choose *Filter By Selection...* command from the *Dense Cloud* submenu of the *Tools* menu.
4. The result of the filtering will be shown in the *Model* view.
5. Select *Reset filter* command from the *Dense Cloud* submenu of the *Tools* menu to cancel filtering by classes

Filtering points by confidence

Metashape supports dense point cloud filtering by confidence value. To perform such filtering *Calculate point confidence* option should be enabled in the *Build Dense Cloud* dialog before the dense point cloud of interest is generated.

Filter by confidence

1. Switch to *Dense Cloud* view mode using *Dense Cloud Confidence* toolbar button.
2. Choose *Filter by Confidence...* command from the *Dense Cloud* submenu of the *Tools* menu.
3. In the *Select Confidence Range* dialog box choose min and max value to be used as the filter. The values define the number of depth maps involved in the point generation.
4. Click *OK* button to run the selection procedure.
5. The result of the filtering will be shown in the *Model* view.
6. Select *Reset filter* command from the *Dense Cloud* submenu of the *Tools* menu to cancel filtering by confidence.

Tie point per photo limit

Tie point limit parameter could be adjusted before Align photos procedure. The number indicates the upper limit for matching points for every image. Using zero value doesn't apply any tie-point filtering.

The number of tie points can also be reduced after the alignment process with *Tie Points - Thin Point Cloud* command available from *Tools* menu. As a results sparse point cloud will be thinned, yet the alignment will be kept unchanged.

Filter dense cloud

In Metashape it is possible to reduce the number of the dense cloud points by setting the point spacing parameter manually which defines the regular grid step.

To filter dense point cloud

1. Select *Filter dense cloud* command from the *Dense Cloud* submenu of the *Tools* menu.
2. In the *Filter Dense Cloud* dialog box specify *Point spacing* in meters to be used.
3. Click *OK* button to run the selection procedure.
4. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

Note

- In the confirmation dialog box click *Yes* button if a new dense cloud instance with result calculation should be created in the active chunk. If *No* button is pressed the dense cloud filtering result will overwrite the active dense point cloud instance.

Colorize Dense Cloud

Metashape supports the option to colorize dense point clouds with the colors from the images.

To colorize dense cloud

1. Select an active Dense Cloud in the *Workspace* pane.
2. Choose *Colorize Dense Cloud...* command from the *Dense Cloud* submenu of the *Tools* menu.
3. In the *Colorize Dense Cloud* dialog box select *Source* data from *Images* option.
4. Click on the *OK* button to start the procedure. The progress dialog box will appear displaying the current processing status.

Sample points

Sample points tool creates a dense point cloud based on a Mesh or Tiled model.

To create the dense point cloud from the polygonal surface

1. Select *Sample Points* command from the *Dense Cloud* submenu of the *Tools* menu.
2. In the *Sample Points* dialog select the source polygonal surface type (mesh or tiled model) and desired point spacing value. Target point count based on the input parameters will be displayed in *Estimated points* field.
3. Click on the *OK* button to start the procedure. The progress dialog box will appear displaying the current processing status. To cancel processing click *Cancel* button.

The following parameters can be specified in *Sample points* dialog:

Source data
Specifies the source polygonal surface for the dense point cloud generation (Mesh or Tiled model).

Points spacing
Specifies the desired distance between points of the dense cloud to be generated.

Estimated points
Defines the expected number of points to be generated.

Manual points removal

Incorrect points can be also removed manually.

To remove points from a point cloud manually

1. Switch to *Sparse Cloud* view mode using *Point Cloud* toolbar button or to *Dense Cloud* view mode using *Dense Cloud* toolbar button.

2. Select points to be removed using *Rectangle Selection*, *Circle Selection* or *Free-Form Selection* tools. To add new points to the current selection hold the **Ctrl** key during selection of additional points. To remove some points from the current selection hold the **Shift** key during selection of points to be removed.

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

Editing model geometry

The following mesh editing tools are available in Metashape:

- Decimation tool
- Photoconsistent mesh refinement tool
- Close holes tool
- Smooth tool
- Colorize vertices
- Automatic filtering based on specified criterion
- Manual polygon removal
- Fixing mesh topology

More complex editing can be done in the external 3D editing tools. Metashape allows to export mesh and then import it back for this purpose.

Note

- For polygon removal operations such as manual removal and connected component filtering it is possible to undo the last mesh editing operation. There are *Undo/Redo* commands in the *Edit* menu.
- Please note that *Undo/Redo* commands are not supported for mesh decimation and this operation cannot be undone.

Decimation tool

Decimation is a tool used to decrease the geometric resolution of the model by replacing high resolution mesh with a lower resolution one, which is still capable of representing the object geometry with high accuracy. Metashape tends to produce 3D models with excessive geometry resolution, so mesh decimation is usually a desirable step after geometry computation.

Highly detailed models may contain hundreds of thousands of 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. High complexity also results in longer time required to build texture and to export model in PDF file format.

In some cases it is desirable to keep as much geometry details as possible like it is needed for scientific and archive purposes. 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.

To decimate 3D model

1. Select *Decimate Mesh...* command from the *Tools* menu.
2. In the *Decimate Mesh* dialog box specify the target number of polygons, which should remain in the final model. Click on the *OK* button to start decimation.
3. The progress dialog box will appear displaying the current processing status. To cancel processing click on the *Cancel* button.

Note

- Texture atlas is discarded during decimation process. You will have to rebuild texture atlas after decimation is complete.

Photoconsistent mesh refinement tool

Metashape allows to refine already reconstructed mesh with respect to camera photos. This is iterative process that can further recover details on surface. For example it can recover basrelief or ditch.

To refine mesh

1. Check the model - it will be refined with respect to camera photos. You can duplicate it with right click on the model and selecting *Duplicate...* to refine the copy of model.
2. Select *Refine Mesh...* command from the *Tools* menu.
3. In the *Refine Mesh...* dialog box specify the target quality of refinement, number of iterations and smoothness. Click on the *OK* button to start refinement.
4. The progress dialog box will appear displaying the current processing status. To cancel processing click on the *Cancel* button.

Refinement parameters

Quality
Specifies the desired refinement quality. Higher quality settings can be used to obtain more detailed and accurate geometry, but they require longer time for processing. Interpretation of the quality parameters here is similar to that of accuracy settings given in Building dense point cloud section.

Iterations
Number of refinement iterations. In some cases additional iterations are able to recover more details, but it will lead to proportional slow down.

Smoothness
Smaller smoothness parameter leads to better features recovering but also it can increase noise. Bigger smoothness parameter leads to better noise suppression, but can smooth out features too. Changing smoothness value can help to balance between noise suppression and features recovering.

Colorize model vertices

In Metashape the mesh model vertices can be colorized using images, sparse / dense cloud points colors.

To colorize model vertices

1. Select *Colorize Vertices* command in *Mesh* submenu from the *Tools* menu.
2. In the *Colorize Model* dialog box select source data for the operation.
3. Click on the *OK* button to start the procedure.
4. The progress dialog box will appear displaying the current processing status. To cancel processing click on the *Cancel* button.

Close holes tool

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.

Close holes tool enables to close void areas on the model substituting photogrammetric reconstruction with extrapolation data. It is possible to control an acceptable level of accuracy indicating the maximum size of a hole to be covered with extrapolated data.

To close holes in a 3D model

1. Select *Close Holes...* command in *Mesh* submenu from the *Tools* menu.
2. In the *Close Holes* dialog box indicate the maximum size of a hole to be covered with the slider.
3. Click on the *OK* button to start the procedure.
4. The progress dialog box will appear displaying the current processing status. To cancel processing click on the *Cancel* button.

Note

- The slider allows to set the size of a hole in relation to the size of the whole model surface.

Smooth tool

The Smooth tool allows you to make the model smoother and remove irregularities on the surface. Some tasks require a sleek surface disregarding of details or real object more smooth than mesh in Metashape. You can apply the tool to the entire mesh or only to the selected area.

Note

- To apply smoothing to a specific area, you must first select it and then apply the tool.

To smooth mesh

1. Select *Smooth mesh...* command in *Mesh* submenu of *Tools* menu.
2. In the *Smooth mesh* dialog box set the *Strength* parameter using slider. You can also enable check box *Apply to selected faces*.
3. Click *OK* when done. To cancel processing click *Cancel* button.

Note

- *Fix borders* option can be applied to the models with the open edges, it allows to preserve the position of the mesh vertices along the open edges when using smoothing.

Polygon filtering on specified criterion

In some cases reconstructed geometry may contain the cloud of small isolated mesh fragments surrounding the "main" model or big unwanted polygons. Mesh filtering based on different criteria helps to select polygons, which usually are supposed to be removed.

Metashape 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 with the extrapolation and there is a need to remove extra polygons automatically added by Metashape to fill the gaps; these polygons are often of a larger size than the rest.

To remove small isolated mesh fragments

1. Select *Gradual Selection...* command from the *Model* menu.
2. In the *Gradual Selection* dialog box select *Connected component size* criterion.
3. Select the size of isolated components to be removed using the slider. Size of the largest component is taken for 100%. You can observe how the selection changes while dragging the slider. Click *OK* button to finalize the selection.
4. To remove the selected components use *Delete Selection* command from the *Edit* menu or click *Delete Selection* toolbar button (or simply press **Del** button on the keyboard).

To remove large polygons

1. Select *Gradual Selection...* command from the *Model* menu.
2. In the *Gradual Selection* dialog box select *Polygon size* criterion.
3. Select the size of polygons to be removed using the slider. Size of the largest polygon is taken for 100%. You can observe how the selection changes while dragging the slider. Click *OK* button to finalize the selection.
4. To remove the selected components use *Delete Selection* command from the *Edit* menu or click *Delete Selection* toolbar button (or simply press **Del** button on the keyboard).

Note that Metashape always selects the fragments starting from the smallest ones. If the model contains only one component the selection will be empty.

Manual face removal

Unnecessary and excessive sections of model geometry can be also removed manually.

To remove part of the mesh polygons manually

1. Select rectangle, circle or free-form selection tool using *Rectangle Selection*, *Circle Selection* or *Free-Form Selection* toolbar buttons.

2. Make the selection using the mouse. To add new polygons to the current selection hold the **Ctrl** key during selection of additional polygons. To remove some polygons from the current selection hold the **Shift** key during selection of polygons to be excluded.

3. To delete selected polygons click the *Delete Selection* toolbar button or use *Delete Selection* command from the *Edit* menu. To crop selection to the selected polygons click the Crop Selection toolbar button or use *Crop Selection* command from the *Edit* menu.

To grow or shrink current selection

1. To grow current selection press **PageUp** key in the selection mode. To grow selection by even a larger amount, press **PageUp** while holding **Shift** key pressed.

2. To shrink current selection press **PageDown** key in the selection mode. To shrink selection by even a larger amount, press **PageDown** while holding **Shift** key pressed.

Fixing mesh topology

Metashape is capable of basic mesh topology fixing.

To fix mesh topology

1. Select *View Mesh Statistics...* command from the *Tools* menu.

2. In the *Mesh Statistics* dialog box you can inspect mesh parameters. If there are any topological problems, *Fix Topology* button will be active and can be clicked to solve the problems.

3. The progress dialog box will appear displaying the current processing status. To cancel processing click on the *Cancel* button.

Editing mesh in the external program

To export mesh for editing in the external program

1. Select *Export Model...* command from the *File* menu.

2. In the *Save As* dialog box, specify the desired mesh format in the *Save as type* combo box. Select the file name to be used for the model and click *Save* button.

3. In the opened dialog box specify additional parameters specific to the selected file format. Click *OK* button when done.

To import edited mesh

1. Select *Import Mesh...* command from the *File* menu.
2. In the *Open* dialog box, browse to the file with the edited model and click *Open*.

Note

- Metashape supports loading models in Wavefront OBJ, 3DS, STL, COLLADA, Stanford PLY, Autodesk FBX, Autodesk DXF, OpenCTM and U3D file formats only. Please make sure to select one of these file formats when exporting model from the external 3D editor.

Chapter 6. Automation

Using chunks

When working with typical data sets, automation of general processing workflow allows to perform routine operations efficiently. Metashape allows to assign several processing steps to be run one by one without user intervention thanks to Batch Processing feature. Manual user intervention can be minimized even further due to 'multiple chunk project' concept, each chunk to include one typical data set. For a project with several chunks of the same nature, common operations available in *Batch Processing* dialog are applied to each selected chunk individually, thus allowing to set several data sets for automatic processing following predefined workflow pattern.

In addition, multiple chunk project could be useful when it turns out to be hard or even impossible to generate a 3D model of the whole scene in one go. This could happen, for instance, if the total amount of photographs is too large to be processed at a time. To overcome this difficulty Metashape offers a possibility to split the set of photos into several separate chunks within the same project. Alignment of photos, building dense point cloud, building mesh, and forming texture atlas operations can be performed for each chunk separately and then resulting 3D models can be combined together.

Working with chunks is not more difficult than using Metashape following the general workflow. In fact, in Metashape always exists at least one active chunk and all the 3D model processing workflow operations are applied to this chunk.

To work with several chunks you need to know how to create chunks and how to combine resulting 3D models from separate chunks into one model.

Creating a chunk

To create new chunk click on the *Add Chunk* toolbar button on the *Workspace* pane or select *Add Chunk* command from the *Workspace* context menu (available by right-clicking on the root element on the *Workspace* pane).

After the chunk is created you may load photos in it, align them, generate dense point cloud, generate mesh surface model, build texture atlas, export the models at any stage and so on. The models in the chunks are not linked with each other.

The list of all the chunks created in the current project is displayed in the *Workspace* pane along with flags reflecting their status.

The following flags can appear next to the chunk name:

R (Referenced)
Will appear when two or more chunks are aligned with each other.

To move photos from one chunk to another simply select them in the list of photos on the *Workspace* pane, and then drag and drop to the target chunk.

Note

- Chunk can contain several instances of the same object (point clouds, 3D model, etc).

Working with chunks

All operations within the chunk are carried out following the common workflow: loading photographs, aligning them, generating dense point cloud, building mesh, building texture atlas, exporting 3D model and so on.

Note that all these operations are applied to the active chunk. When a new chunk is created it is activated automatically. Save project operation saves the content of all chunks. To save selected chunks as a separate project use *Save Chunks* command from the chunk context menu.

To set another chunk as active

1. Right-click on the chunk title on the *Workspace* pane.
2. Select *Set Active* command from the context menu.

To remove chunk

1. Right-click on the chunk title on the *Workspace* pane.
2. Select *Remove Chunks* command from the context menu.

To rearrange the order of chunks in the *Workspace* pane simply drag and drop the chunks in the pane.

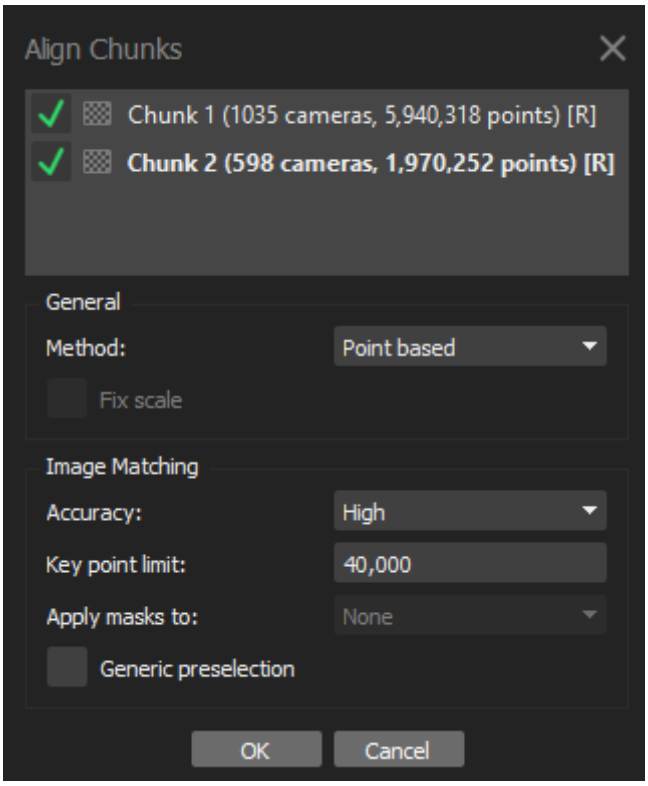
Aligning chunks

After the "partial" 3D models are built in several chunks they can be merged together. Before merging chunks they need to be aligned.

To align separate chunks

1. Select *Align Chunks* command from the *Workflow* menu.
2. In the *Align Chunks* dialog box select chunks to be aligned, indicate reference chunk with a double-click. Set desired alignment options. Click *OK* button when done.
3. The progress dialog box will appear displaying the current processing status. To cancel processing click the *Cancel* button.

Aligning chunks parameters



"Align Chunks" dialog

The following parameters control the chunks alignment procedure and can be modified in the *Align Chunks* dialog box:

Method

Defines the chunks alignment method. **Point based** method aligns chunks by matching photos across all the chunks. **Camera based** method is used to align chunks based on estimated camera locations. Corresponding cameras should have the same label.

Accuracy (Point based alignment only)

Higher accuracy setting helps to obtain more accurate chunk alignment results. Lower accuracy setting can be used to get the rough chunk alignment in the shorter time.

Point limit (Point based alignment only)

The number indicates upper limit of feature points on every image to be taken into account during **Point based** chunks alignment.

Fix scale

Option is to be enabled in case the scales of the models in different chunks were set precisely and should be left unchanged during chunks alignment process.

Preselect image pairs (Point based alignment only)

The alignment process of many chunks may take a long time. A significant portion of this time is spent for matching of detected features across the photos. Image pair preselection option can speed up this process by selection of a subset of image pairs to be matched.

Apply mask to (Point based alignment only)

If **apply mask to key points** option is selected, areas previously masked on the photos are excluded from feature detection procedure. **Apply mask to tie points** option means that certain tie points are excluded from alignment procedure. Effectively this implies that if some area is masked at least on a

single photo, relevant key points on the rest of the photos picturing the same area will be also ignored during alignment procedure (a tie point is a set of key points which have been matched as projections of the same 3D point on different images). This can be useful to be able to suppress background in turntable shooting scenario with only one mask. For additional information on the usage of masks please refer to the Using masks section.

Note

- Chunk alignment can be performed only for chunks containing aligned photos.

Merging chunks

After alignment is complete the separate chunks can be merged into a single chunk.

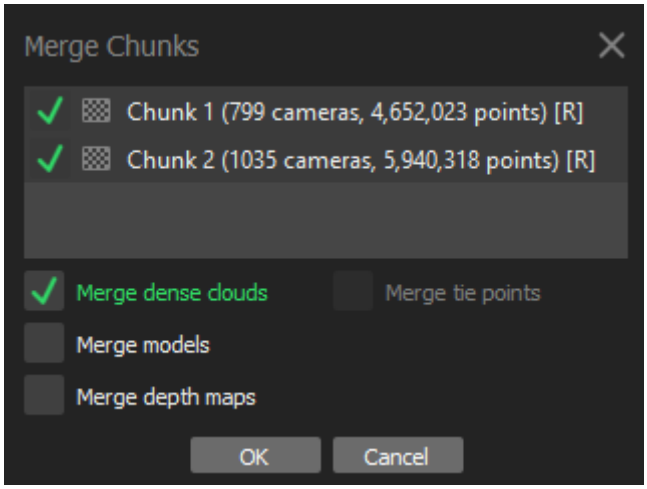
Note

- We recommend processing all the images in a single chunk to provide better accuracy and quality of the final results than the chunking method (separate processing of the sub-sets of the complete photos set and merging them).

To merge chunks

1. Select *Merge Chunks* command from the *Workflow* menu.
2. In the *Merge Chunks* dialog box select chunks to be merged and the desired merging options. Click *OK* button when done.
3. Metashape will merge the separate chunks into one. The merged chunk will be displayed in the project content list on *Workspace* pane.

Merge chunks parameters



"Merge Chunks" dialog

The following parameters control the chunks merging procedure and can be modified in the *Merge Chunks* dialog box:

Merge dense clouds
Defines if dense clouds from the selected chunks are combined.

Merge models
Defines if models from the selected chunks are combined.

Merge tie points
Defines if the projections of the tie points for corresponding features should be merged. Since tie points merging operation assumes re-matching of the features from different chunks, the operation may be time consuming. Thus it is recommended to disable tie points merging, unless it is required by the task specifics.

Chunks merging result (i.e. photos, point clouds and geometry) will be stored in the new chunk and it may be treated as an ordinary chunk (e.g. the model can be textured and/or exported).

Note

- Dense cloud and model merging operations will be applied only to the active items. Disabled (inactive) items will not be transferred to the merged chunk.

Batch processing

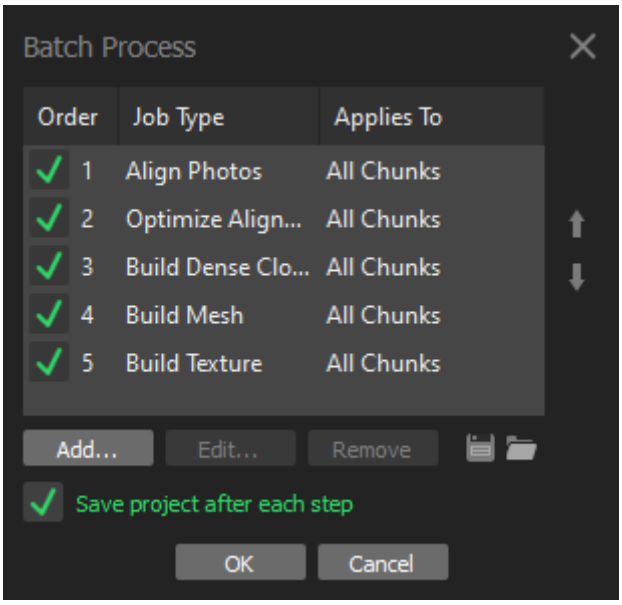
Metashape allows to perform general workflow operations with multiple chunks automatically. It is useful when dealing with a large number of chunks to be processed.

Batch processing can be applied to all chunks in the *Workspace*, to unprocessed chunks only, or to the chunks selected by the user. Each operation chosen in the *Batch processing* dialog will be applied to every selected chunk before processing will move on to the next step.

Align Photos	Align/Merge Chunks	Save/Load Project
Optimize Alignment	Decimate Mesh	Export/Import Cameras
Build Dense Cloud	Smooth Model	Export Points
Build Mesh	Close Holes	Export Model
Build Texture	Calibrate Colors	Export Texture
Refine Mesh	Import Masks	Reset Region
Sample Points	Generate Masks	Convert Images
Generate Report	Colorize Dense Cloud / Model	

To start batch processing

1. Select *Batch Process...* command from the *Workflow* menu.
2. Click *Add* to add the desired processing stages.
3. In the *Add Job* dialog select the kind of operation to be performed, the list of chunks it should be applied to, and desired processing parameters. Click *OK* button when done.
4. Repeat the previous steps to add other processing steps as required.
5. Arrange jobs by clicking Up and Down arrows at the right of the *Batch Process...* dialog box.
6. Click *OK* button to start processing.
7. The progress dialog box will appear displaying the list and status of batch jobs and current operation progress. To cancel processing click the *Cancel* button.



"Batch Process" dialog

When the batch process includes import/export features that are applied to multiple chunks it is reasonable to use the following templates in the Path field of the import/export jobs:

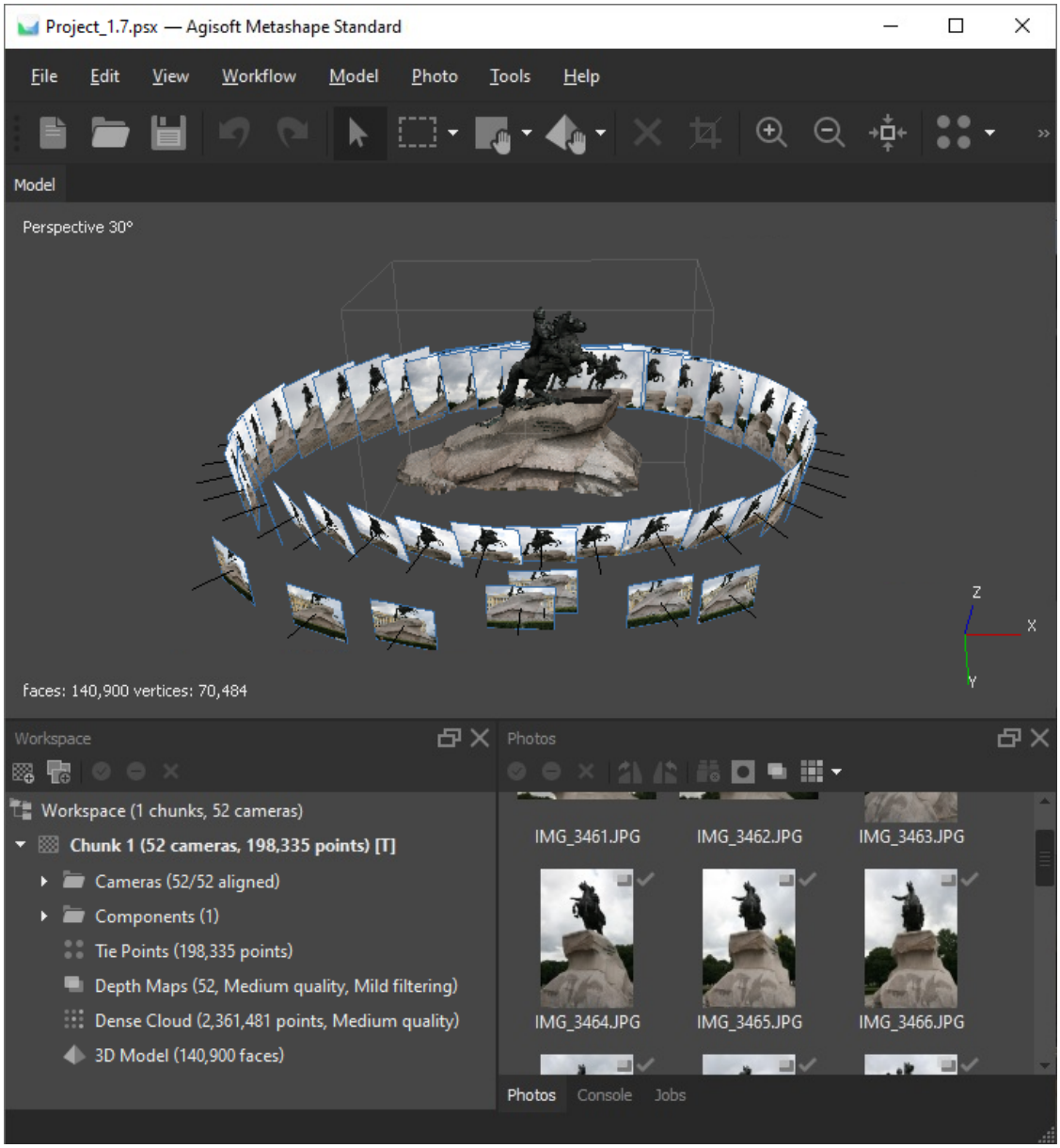
- **{filename}** - filename (without extension),
- **{fileext}** - file extension,
- **{camera}** - camera label,
- **{frame}** - frame index,
- **{chunklabel}** - chunk label,
- **{imagefolder}** - folder containing images of an active chunk,
- **{projectfolder}** - path to the folder containing current project,
- **{projectname}** - current project filename,
- **{projectpath}** - absolute path to the current project.

The list of tasks for batch processing can be exported to XML structured file using *Save* button in the *Batch processing* dialog and imported in a different project using *Open* button.

Appendix A. Graphical user interface

Application window

General view



General view of application window

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 Metashape toolbar.

Model can be shown as a dense cloud 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 visualized data.

Metashape supports the following tools for navigation in the 3D view:

Tool	Keyboard modifier
Rotation Tool	Default
Pan Tool	**Ctrl** key pressed
Zooming Tool	**Shift** key pressed

All navigation tools are accessible in the navigation mode only. To enter the navigation mode click the *Navigation* toolbar button.

Note

- Zooming into the model can be also controlled by the mouse wheel.

Photo view

Photo view tab is used for displaying individual images as well as corresponding depth maps in semi-transparent representation and masks on them.

In the Photo view tab it is allowed to draw masks on the images. Additionally in Photo view tab it is possible to display the residuals for the tie points providing that the corresponding camera is aligned.

Photo view is visible only if any image is opened. To open an image in Photo view mode double-click on the label of the corresponding camera on the *Workspace* or *Photos* pane.

Switching to Photo view mode changes the contents of the Toolbar, presenting related instruments and hiding irrelevant buttons.

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 and camera groups in each chunk
- Tie points in each chunk
- Components in each chunk
- Depth maps in each chunk
- Dense point clouds in each chunk
- 3D models in each chunk
- Camera tracks in each chunk

Buttons located on the Workspace pane toolbar allow to:

- Add chunk

- Add photos
- Enable or disable certain cameras or chunks for processing at further stages.
- Remove items

Each element in the list is linked with the context menu providing quick access to some common operations.

Photos pane

Photos pane displays the list of photos / masks / depth maps in the active chunk in the form of thumbnails.

Buttons located on the *Photos* pane toolbar allow to:

- Enable / disable certain cameras
- Remove cameras
- Rotate selected photos clockwise / counterclockwise (for display purposes only)
- Reset current photo filtering option
- Switch between images / masks / depth maps thumbnails
- Increase / decrease icons' size or display detailed information on photos including EXIF data

Console pane

Console pane is used for:

- Displaying auxiliary information
- Displaying error messages

Buttons located on the *Console* pane toolbar allow:

- Save log (in HTML, XHTML or Plain Text format)
- Clear log

Jobs pane

Jobs pane is designed for:

- Monitoring the processing status for active and background projects
- Organizing the background processing queue
- Switching between the projects

Buttons located on the pane toolbar allow:

- Start / pause / cancel the selected tasks
- Change the order of the tasks in the processing queue
- Clear the processing tasks history

Note

- You can switch between projects by right-clicking on the project name.

Animation pane

Animation pane is designed for:

- Creating a new camera track from pre-sets (Horizontal, Vertical) with the given number of the keyframes
- Loading camera track from external file in supported formats (Autodesk FBX, Camera Path)
- Exporting camera track
- Playing the viewpoint camera movement according to the track
- Rendering the frame sequence to the form of the separate images for the keyframes
- Rendering the frame sequence to the form of the video file
- Appeneding current viewpoint to the camera track
- Removing keyframes from the camera track
- Changing the selected keyframes positions in current camera track sequence
- Settinging the camera track parameters (label, duration, field of view, loop camera track)

Buttons located on the pane toolbar allow:

- Create new track
- Load camera track
- Save camera track
- Start / stop the animation according to the camera track
- Capture video file
- Append current viewpoint to the active camera track
- Remove selected keyframes from the active camera track
- Move selected keyframes up
- Move selected keyframes down
- Update selected keyframe to the current viewpoint
- Change camera track settings

Note

- To open any pane select a corresponding command from the *View* menu.
- To display the track path, select *Show animation* in *Show/Hide items* submenu from the *Model* menu.

- You can adjust the position of the viewpoint in *Model* view by dragging the left mouse button to display it visually.

Menu commands

File Menu

New	Creates an empty Metashape project.
Open...	Opens Metashape project file.
Append...	Appends existing Metashape project file to the current one.
Save	Saves Metashape project file.
Save As...	Saves Metashape project file with a new name.
Export Points...	Saves sparse / dense point cloud.
Export Model...	Saves 3D model.
Export Cameras...	Exports camera positions, orientation data and tie points measurements.
Export Masks...	Exports masks.
Export Texture...	Exports model texture.
Export Panorama...	Exports spherical panorama for camera stations.
Convert Images...	Exports the images corresponding to the original camera with distortion or color correction applied.
Render Photos...	Generates lenticular images for the current scene.
Import Cameras...	Imports camera positions and orientation data.
Import Reference	Imports reference data.
Import Masks...	Imports masks or creates mask from model or background.
Import Points...	Imports points in a form of the dense point cloud.
Import Model...	Imports polygonal mesh model.
Import Texture...	Imports texture and applies it to the current model.
Import Laser Scans	Imports laser scans data.
Import Video...	Imports video in a form of frame sequence and saves the extracted frames as images.
Upload Data...	Uploads generated products (points, textured mesh models) to one of the supported web-sites.
Exit	Closes the application window.

Edit Menu

Undo	Undo the last editing operation.
Redo	Redo the previously undone editing operation.
Snap type	Enable or disable snap type (Axis, Vertex, Edge, 2D snap).
Add selection	Adds current selection to the mask.
Subtract selection	Subtracts current selection from the mask.
Invert Selection	Inverts current selection for the photo.
Invert Selection	Inverts current selection of faces / points / cameras.
Grow Selection	Grows current selection of mesh faces.
Shrink Selection	Shrinks current selection of mesh faces.
Delete Selection	Removes selected faces from the mesh or selected points from the point cloud.
Crop Selection	Crops selected faces / points.
Invert Mask	Inverts mask for the current photo.
Reset mask	Resets mask for the current photo.
Rotate right	Rotates the photo clockwise.
Rotate left	Rotates the photo counterclockwise.

View Menu

Zoom In	Increases magnification in the active view mode.
Zoom Out	Decreases magnification in the active view mode.
Reset View	Resets the viewport to display the complete model or photo.
Capture view	Saves screenshot of current view of the project (Model/Photo)
Workspace	Shows or hides Workspace pane.
Animation	Shows or hides Animation pane.
Properties	Shows or hides shape Properties pane.
Photos	Shows or hides Photos pane.
Console	Shows or hides Console pane.
Jobs	Shows or hides Jobs pane.
Toolbar	Shows or hides Toolbar.

View Menu

Full Screen	Switches to or from Full Screen mode.

Workflow Menu

Add Photos...	Loads additional photos to be processed by Metashape.
Add Folder...	Loads additional photos from folders to be processed by Metashape.
Align Photos...	Estimates camera positions and sparse point cloud.
Build Dense Cloud...	Generates dense point cloud.
Build Mesh...	Generates polygonal mesh model.
Build Texture...	Generates texture map for the mesh model.
Align Chunks...	Aligns multiple chunks.
Merge Chunks...	Merges multiple chunks into the single chunk.
Batch Process...	Opens Batch Process dialog box.

Model Menu

Navigation	Switches to navigation mode.
Rectangle Selection	Rectangle selection tool for the elements of the Model view.
Circle Selection	Circle selection tool for the elements of the Model view.
Free-form Selection	Free-form selection tool for the elements of the Model view.
Gradual selection...	Selects faces / points based on the specified criterion.
Move Object	Switches to object movement tool.
Rotate Object	Switches to object rotation tool.
Scale Object	Switches to object scaling tool.
Reset Transform	Resets the transformations applied to the object.
Move Region	Switches to volume movement tool.
Rotate Region	Switches to volume rotation tool.
Resize Region	Switches to volume resize tool.
Reset Region	Resets the transformations applied to the volume to default.
Show Basemap	Displays or hides Basemap.

Model Menu

Show Cameras	Displays or hides camera positions estimated during image alignment.
Show Thumbnails	Displays or hides image thumbnails in the camera placeholders.
Show Labels	Displays or hides item labels.
Show Region	Displays or hides region selector.
Show Animation	Displays or hides animation track.
Show Trackball	Displays or hides the trackball.
Show Info	Displays or hides the auxiliary on-screen information.
Show Grid	Displays or hides the grid.
Show Aligned Chunks	Displays all enabled aligned chunks in project workspace.
Show All	Displays all elements at the same time.
Hide All	Hides all elements.
Point Cloud	Displays sparse point cloud reconstructed during photo alignment.
Point Cloud Variance	Displays sparse point cloud colored by variance.
Dense Cloud	Displays dense point cloud.
Dense Cloud Confidence	Displays dense point cloud colored according to the confidence values.
Model Shaded	Displays 3D model in the shaded mode with vertices colored with interpolated colors.
Model Solid	Displays 3D model in the solid mode.
Model Wireframe	Displays 3D model in the wireframe mode.
Model Textured	Displays 3D model in the textured mode.
Model Confidence	Displays 3D model with vertices colored according to the confidence values.
Perspective/Orthographic	Switches visualization view between Perspective and Orthographic.
Stereo Mode	Enables or disables stereo view mode according to the parameters specified in Preferences dialog.
Predefined views	Switches viewport to one of the predefined views.

Photo Menu

Navigation	Switches to navigation mode.

Photo Menu

Rectangle Selection	Rectangle selection tool.
Intelligent Scissors	Intelligent Scissors selection tool.
Intelligent Paint	Intelligent Paint selection tool.
Magic Wand	Magic Wand selection tool.
Open Next Photo	Opens next photo from the list in the Photos pane.
Open Previous Photo	Opens previous photo from the list in the Photos pane.
Show Masks	Turns mask shading on or off.
Show Depth Maps	Displays or hides the depth maps overlay.
Show Labels	Displays or hides item labels.
Show Points	Displays or hides tie point projections used for the camera alignment.
Show Point Residuals	Displays or hides the residuals of each point.
Show All	Displays all elements at the same time.
Hide All	Hides all elements.

Tools Menu

Build Point Cloud...	Builds sparse point cloud based on the estimated camera parameters available.
Thin Point Cloud...	Thins sparse point cloud by reducing the number of projections on the individual photos to the given limit.
View Matches...	Displays View Matches dialog for visual representation of the common tie points between the image pairs.
Invert Point Normals...	Inverts normals for the selected points of the dense cloud.
Select Points by Masks...	Selects dense cloud points according to the masks of the selected images.
Select Points by Color...	Selects dense cloud points according to the color and tolerance.
Filter By Confidence	Filters the points in the dense cloud according to the calculated confidence value.
Filter By Selection	Filters the points in the dense cloud according to the selected points.
Reset Filter	Resets all applied dense cloud filters.
Compact Dense Cloud...	Permanently removes all deleted points from the dense cloud.

Tools Menu

Restore Dense Cloud...	Restores all deleted points of the dense cloud that were once marked as removed.
Update Dense Cloud...	Updates statistics of the dense cloud, including point numbers and assigned classes.
Refine Mesh...	Starts photoconsistent mesh refinement operation.
Decimate Mesh...	Decimates mesh to the target face count.
Smooth Mesh...	Smooths mesh.
Close Holes...	Closes holes on the model surface.
Colorize Vertices...	Applies colors to the mesh vertices basing on source images or point cloud.
Resize texture...	Starts resize texture operation for mesh.
View Mesh Statistics...	Collects and displays mesh statistics.
View Mesh UVs...	Displays mesh UV mapping.
Filter By Selection	Filters the faces of the polygonal model according to the selected points.
Reset Filter	Resets all applied mesh filters.
Calibrate Lens...	Displays lens calibration dialog.
Show Chessboard...	Displays the calibration board on screen.
Camera Calibration...	Displays camera calibration dialog box.
Optimize Cameras...	Starts the optimization of exterior and interior parameters of the aligned cameras.
Calibrate Colors...	Displays the color correction dialog for the brightness and white balance compensation of the images.
Set Primary Channel...	Displays the primary channel selection dialog.
Set Brightness...	Adjusts image brightness and contrast for more convenient display.
Preferences...	Displays preferences dialog box.

Help Menu

Contents	Displays help contents.
Check for Updates...	Checks if Metashape update is available for download.
Activate Product...	Displays the activation dialog for activation / deactivation of the product using the activation key.

Help Menu

About Metashape...	Displays program information, version number and copyright.

Toolbar buttons

General commands

New	Creates a new Metashape project file.
Open	Opens a Metashape project file.
Save	Saves a Metashape project file.

3D view commands

Undo	Undo the last editing operation.
Redo	Redo the previously undone editing operation.
Navigation	Navigation tool.
Rectangle Selection	Rectangle selection tool.
Circle Selection	Circle selection tool.
Free-Form Selection	Free-form selection tool.
Reset Selection	Resets current selection.
Move region	Volume translation tool.
Resize region	Volume resize tool.
Rotate Region	Volume rotation tool.
Reset Region	Resets region according to the actual point cloud.
Move Object	Model translation tool.
Rotate Object	Model rotation tool.
Scale Object	Model resize tool.
Reset Transform	Resets all transformations applied to the model.
Delete Selection	Removes selected faces / points.
Crop Selection	Crops selected faces / points.

3D view settings

Zoom In	Increases magnification.
Zoom Out	Decreases magnification.

3D view settings

Reset View	Resets model view.
Point Cloud	Displays sparse point cloud reconstructed during image alignment.
Point Cloud Variance	Displays sparse point cloud colored by variance.
Dense Cloud	Displays dense point cloud model.
Dense Cloud Confidence	Displays dense point cloud colored according to the confidence values.
Model Shaded	Displays 3D model in the shaded mode with vertices colored with interpolated colors.
Model Solid	Displays 3D model in the solid mode.
Model Wireframe	Displays 3D model in the wireframe mode.
Model Confidence	Displays 3D model with vertices colored according to the confidence values.
Model Textured	Displays 3D model in the textured mode.
Diffuse Map	Displays diffuse map for the textured mode.
Normal Map	Displays normal map for the textured mode.
Occlusion Map	Displays occlusion map the textured mode.
Show Basemap	Displays or hides basemap.
Show Cameras	Displays or hides camera positions, reconstructed during image alignment.
Show Thumbnails	Displays or hides image thumbnails in the camera placeholders.
Show Aligned Chunks	Displays or hides enabled aligned chunks.

Photo view commands

Undo	Undo the last mask editing operation.
Redo	Redo the previously undone mask editing operation.
Navigation	Switches to the navigation mode.
Rectangle Selection	Rectangle selection tool.
Intelligent Scissors	Intelligent scissors tool.
Intelligent Paint	Intelligent paint tool.
Magic Wand	Magic wand tool.
Magic Wand Options	Changing the parameters of the magic wand.

Photo view commands

Reset Selection	Resets current selection.
Add Selection	Adds current selection to the mask.
Subtract Selection	Subtracts current selection from the mask.
Invert Selection	Inverts current selection.
Set Brightness	Adjusts image brightness and contrast for more convenient display.
Rotate Right	Rotates the image clockwise.
Rotate Left	Rotates the image counterclockwise.
Zoom In	Increases magnification.
Zoom Out	Decreases magnification.
Reset View	Resets the viewport to display the whole image.
Show Masks	Enables or disables the mask shading overlay.
Show Depth Maps	Enables or disables the depth map overlay of the selected level.
Show Points	Displays or hides tie point projections.
Show Point Residuals	Displays or hides residuals related to tie point projections.

Hot keys

For convenient operation in the Metashape it is possible to use Hot keys. Below is a list of default hot keys that can be customized in the *Preferences* dialog. Select the *Customize* button at the *Shortcuts* menu item.

General

Create new project	Ctrl + N
Save project	Ctrl + S
Open project	Ctrl + O
Run Script	Ctrl + R
Full Screen	F11

Model View

Undo (only for Delete, Masking and Close Holes operations)	Ctrl + Z
Redo (only for Delete, Masking and Close Holes operations)	Ctrl + Y
Switch between navigation and any other previously selected mode	Space

Zoom In	Ctrl + +
Zoom Out	Ctrl + -
Reset view	0
Switch to stereoview mode	9
Switch between orthographic and perspective view modes	5
Change the angle for perspective view	Ctrl + mouse wheel
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

Photo View

Next photo (according to Photos pane order)	Page Up
Previous photo (according to Photos pane order)	Page Down
Navigation mode	V
Selection Tools	
Rectangle selection	M
Intelligent scissors	L
Intelligent paint	P
Magic wand	W
Add selection	Ctrl + Shift + A
Subtract selection	Ctrl + Shift + S
Invert selection	Ctrl + Shift + I

Appendix B. Supported formats

Images

Input formats	Undistort formats
JPG	JPG
TIFF	TIFF
PNG	PNG
BMP	BMP
OpenEXR	OpenEXR
JPEG 2000	JPEG 2000
TARGA	
Digital Negative (DNG)	
Portable Bit Map (PGM, PPM)	
Multi-Picture Object (MPO)	
Norpix Sequence (SEQ)	
AscTec Thermal Images (ARA)	

Camera calibration

Import formats	Export formats
Agisoft Camera Calibration (*.xml)	Agisoft Camera Calibration (*.xml)
Australis Camera Parameters (*.txt)	Australis Camera Parameters (*.txt)
Australis v.7 Camera Parameters (*.txt)	Australis v.7 Camera Parameters (*.txt)
PhotoModeler Camera Calibration (*.ini)	PhotoModeler Camera Calibration (*.ini)
3DM CalibCam Camera Parameters (*.txt)	3DM CalibCam Camera Parameters (*.txt)
CalCam Camera Calibration (*.cal)	CalCam Camera Calibration (*.cal)
Inpho Camera Calibration (*.txt)	Inpho Camera Calibration (*.txt)
USGS Camera Calibration (*.txt)	USGS Camera Calibration (*.txt)
Pix4D Camera Calibration (*.cam)	Pix4D Camera Calibration (*.cam)
OpenCV Camera Calibration (*.xml)	OpenCV Camera Calibration (*.xml)
Photomod Camera Calibration (*.x-cam)	Photomod Camera Calibration (*.x-cam)
Z/I Distortion Grid (*.dat)	Z/I Distortion Grid (*.dat)

Interior and exterior camera orientation parameters

Import camera positions	Export camera positions
Agisoft XML (*.xml)	Agisoft XML (*.xml)
Autodesk FBX (*.fbx)	Autodesk FBX (*.fbx)

Import camera positions

Alembic (*.abc)
Realviz RZML (*.rzml)
Bundler (*.out)
Inpho Project File (*.prj)
BINGO (*.dat)
Blocks Exchange (*.xml)
N-View Match (*.nvm)
PATB Camera Orientation (*.ori)
VisionMap Detailed Report (*.txt)

Export camera positions

Alembic (*.abc)
Realviz RZML (*.rzml)
Bundler (*.out)
Inpho Project File (*.prj)
BINGO Project (*.dat)
Blocks Exchange (*.xml)
N-View Match (*.nvm)
PATB Project (*.pro)
Boujou (*.txt)
CHAN files (*.chan)
ORIMA (*.txt)
AeroSys Exterior Orientation (*.orn)
Summit Evolution Project (*.smtxml)
Omega Phi Kappa (*.txt)

Tie points

Import tie points

Bundler (*.out)

Export tie points

Bundler (*.out)
BINGO (*.dat)
ORIMA (*.txt)
PATB (*.ptb)
Summit Evolution Project (*.smtxml)
Blocks Exchange (*.xml)

Sparse/dense point cloud

Import formats

Wavefront OBJ (*.obj)
Stanford PLY (*.ply)
ASCII PTS (*.pts)
ASPRS LAS (*.las)
LAZ (*.laz)
ASTM E57 (*.e57)
Point Cloud Data (*.pcd)
PTX format (*.ptx)

Export formats

Wavefront OBJ (*.obj)
Stanford PLY (*.ply)
ASCII PTS (*.pts)
ASPRS LAS (*.las)
LAZ (*.laz)
ASTM E57 (*.e57)
Point Cloud Data (*.pcd)
XYZ Point Cloud (*.txt)

Universal 3D (*.u3d)
Autodesk DXF (*.dxf)

Import formats	Export formats
	potree (*.zip)
	Agisoft OC3 (*.oc3)
	Adobe 3D PDF (*.pdf)

Mesh model

Import mesh	Export mesh
Wavefront OBJ (*.obj)	Wavefront OBJ (*.obj)
3DS models (*.3ds)	3DS models (*.3ds)
COLLADA (*.dae)	COLLADA (*.dae)
Stanford PLY (*.ply)	Stanford PLY (*.ply)
Alembic (*.abc)	Alembic (*.abc)
STL models (*.stl)	STL models (*.stl)
OpenCTM models (*.ctm)	VRML models (*.wrl)
Universal 3D models (*.u3d)	Universal 3D models (*.u3d)
Autodesk FBX (*.fbx)	Autodesk FBX (*.fbx)
Autodesk DXF (*.dxf)	Autodesk DXF Polyline (*.dxf)
	Autodesk DXF 3DFace (*.dxf)
	Binary glTF (*.glb)
	X3D models (*.x3d)
	OpenSceneGraph (*.osgb)
	Adobe PDF (*.pdf)

Texture maps

Import texture	Export texture
JPG	JPG
TIFF	TIFF
PNG	PNG
BMP	BMP
TARGA	TARGA
JPEG 2000	JPEG 2000
OpenEXR	OpenEXR
Portable Bit Map	
Digital negative	
Multi-Picture Object	
Norpix Sequence File	
AscTec Thermal Images	

Appendix C. Camera models

A camera model specifies the transformation from point coordinates in the local camera coordinate system to the pixel coordinates in the image frame.

The local camera coordinate system has origin at the camera projection center. The Z axis points towards the viewing direction, X axis points to the right, Y axis points down.

The image coordinate system has origin in the middle of the top-left pixel (with coordinates (0.5, 0.5)). The X axis in the image coordinate system points to the right, Y axis points down. Image coordinates are measured in pixels.

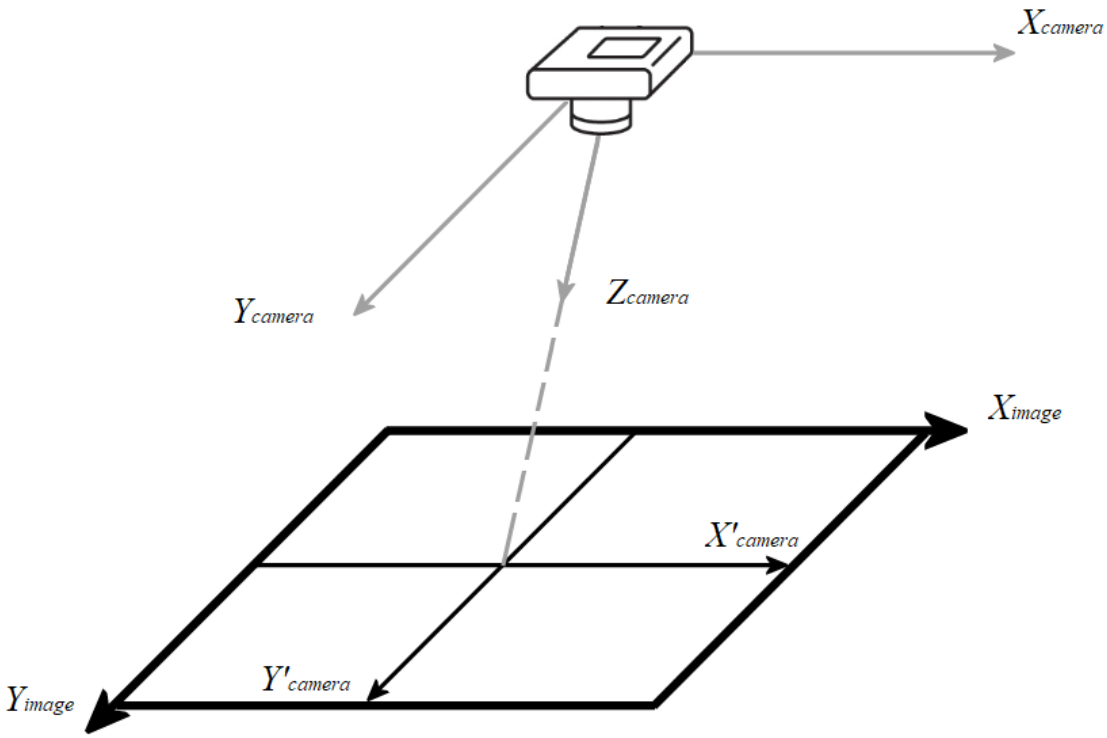


Image and camera coordinate systems

Equations used to project a points in the local camera coordinate system to the image plane are provided below for each supported camera model.

The following definitions are used in the equations:

(X, Y, Z) - point coordinates in the local camera coordinate system,

(u, v) - projected point coordinates in the image coordinate system (in pixels),

f - focal length (in pixels),

c_x, c_y - principal point offset (in pixels),

K_1, K_2, K_3, K_4 - radial distortion coefficients (dimensionless),

P_1, P_2 - tangential distortion coefficients (dimensionless),

B_1, B_2 - affinity and non-orthogonality (skew) coefficients (in pixels),

w, h - image width and height (in pixels).

Frame cameras

$x = X / Z$

$y = Y / Z$

$r = sqrt(x^2 + y^2)$

$x' = x(1 + K_1r^2 + K_2r^4 + K_3r^6 + K_4r^8) + (P_1(r^2+2x^2) + 2P_2xy)$

$y' = y(1 + K_1r^2 + K_2r^4 + K_3r^6 + K_4r^8) + (P_2(r^2+2y^2) + 2P_1xy)$

$u = w * 0.5 + c_x + x'f + x'B_1 + y'B_2$

$v = h * 0.5 + c_y + y'f$

Fisheye cameras

$x_0 = X / Z$

$y_0 = Y / Z$

$r_0 = sqrt(x_0^2 + y_0^2)$

$x = x_0 * tan^{-1}r_0 / r_0$

$y = y_0 * tan^{-1}r_0 / r_0$

$r = sqrt(x^2 + y^2)$

$x' = x(1 + K_1r^2 + K_2r^4 + K_3r^6 + K_4r^8) + (P_1(r^2+2x^2) + 2P_2xy)$

$y' = y(1 + K_1r^2 + K_2r^4 + K_3r^6 + K_4r^8) + (P_2(r^2+2y^2) + 2P_1xy)$

$u = w * 0.5 + c_x + x'f + x'B_1 + y'B_2$

$v = h * 0.5 + c_y + y'f$