



3D Instant Meshing

User Manual

User Manual for 3D Instant Meshing 2.0.0

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Table of Contents

Introduction	4
Getting Started	4
Licensing	5
System requirements	5
Multiple Versions of PhoXi Control	5
Windows	5
Linux	5
GUI overview	6
Device setup	6
Multiple device calibration	6
Overview	8
Resource inspector	8
Preview controls	9
Global settings	10
GUI Keyboard shortcuts	11
Meshing guide	11
Advanced parameters	13
API	15
Troubleshooting	17

Introduction

3D Instant Meshing is a C++ library for real-time tracking and integration of 3D scans into a triangular mesh. The library works only with Photoneo's scanning devices. The library is meant to be integrated into arbitrary applications by the user.

For requests on complete solutions, e.g. integration of the library with robotic manipulators, rotary tables, linear axis, or any other setups, please, contact Photoneo.

The 3D model is created by moving a Photoneo 3D sensor around an object or scene and capturing it from multiple perspectives. The device can be moved by hand or by a robot manipulator in arbitrary motion. For a scene with enough 3D features (not a planar scene), the process of creating a 3D model does not require any additional information about the position of the 3D camera. For planar objects, the position of the camera can be supplied to the library.

The library comes with a simple Graphical User Interface that demonstrates the use of the library. The data can be exported in *.ply, *.obj, and *.off file formats.

Getting Started

Before you start creating your own models, follow these steps:

1. Download and install [3D Instant Meshing](#) and [PhoXi Control](#) 1.10 or newer from our website.
 - a. Windows: Double-click the downloaded *.exe file to start the installation.
 - b. Linux: Use command `dpkg -i <downloaded-package-file>.deb`
2. A computer meeting the minimum or recommended system requirements (see the [System Requirements](#) section)
3. USB sentinel key or trial license provided by Photoneo according to the [Licensing section](#).
4. A computer meeting the minimum or recommended system requirements (see the [System Requirements](#))

Optionally:

1. Marker patterns printed without any scaling. Marker patterns are available in PhoXi Control in Menu → Tools → Marker Pattern or at photoneo.com
2. A rotary table provided by Photoneo or an arbitrary rotary table controller

Please contact us via [Help Center](#) for licensing details and available accessories.

Besides this manual, it is strongly recommended to read the [PhoXi Control User Manual](#)

Licensing

Sentinel licensing software is installed automatically during the installation of 3D Meshing (*Install Sentinel* checkbox must be selected). In order to run the 3D Instant Meshing or use the library, it is required to have

- a) A USB dongle connected to the device at all times (Sentinel software to recognize the USB dongle is installed automatically with 3D Meshing)
- b) A trial license provided by Photoneo. Request a free trial at <https://www.photoneo.com/p3dm-license>. **3D Meshing must be already installed on the computer** in order to request the license since the Sentinel licensing software (responsible for creating the c2v fingerprint file) is a part of the installation.

Refer to the [Licensing guide](#) if necessary.

System requirements

Minimum	Recommended
Intel i5 (gen 7) / AMD Ryzen 5 (gen 1)	Intel i7 (gen 7) / AMD Ryzen 7 (gen 1) or better
8GB RAM	16GB RAM or more
NVIDIA GTX 10xx series GPU with compute capability 6.1 and 3GB VRAM	NVIDIA GTX 2060 series GPU or better with at least 6GB VRAM
OS Win 10 64-bit or Ubuntu 18.04 64-bit	OS Win 10 64-bit or Ubuntu 18.04 64-bit
NVIDIA driver 531.68 (Windows)/515.65.01 (Ubuntu)	NVIDIA driver 531.68 (Windows)/525.105.17 (Ubuntu)
Photoneo PhoXi Control 1.10	Photoneo PhoXi Control 1.10 or newer

Multiple Versions of PhoXi Control

Multiple versions of 3D Instant Meshing can be installed on one computer. This is achieved by choosing different installation directories during the installation. The process is as follows:

Windows

On Windows, the installer asks for a path where the application should be installed. By default, this path is

```
C:\Program Files\Photoneo\PhoXiInstantMeshing\<version>
```

When another version of 3D Instant Meshing is installed, a different path should be specified, for example,

```
C:\Program Files\Photoneo\PhoXiInstantMeshing\<version>-custom\
```

User Directory (configuration, temporary, and log files)

```
C:/Users/AppData/Local/PhoXiInstantMeshing/<Version>/
```

Linux

Ubuntu installer automatically installs 3D Instant Meshing in the following folder:

```
/opt/Photoneo/PhoXiInstantMeshing
```

User Directory (configuration, temporary, and log files)

```
/home/.config/PhoXi3DMeshing/<Version>/
```

GUI overview

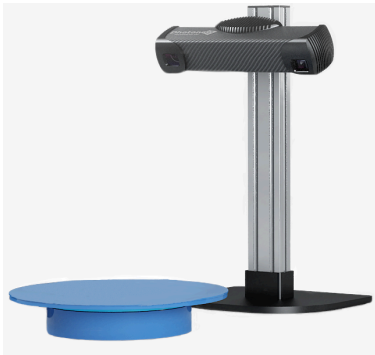
Graphical User Interface serves for evaluation of the library performance, creating and exporting of 3D models. It uses PhoXi Control API to connect to the Photoneo 3D sensors and provides scans directly to the library.

Device setup

After launching the 3D Instant Meshing, the Device Setup menu is displayed.

Choose the device from the list (PhoXi Control needs to be running) and hit the plus icon. The device will then be displayed in the Active Devices section. To remove the device from the Active devices, use the red trash bin icon.

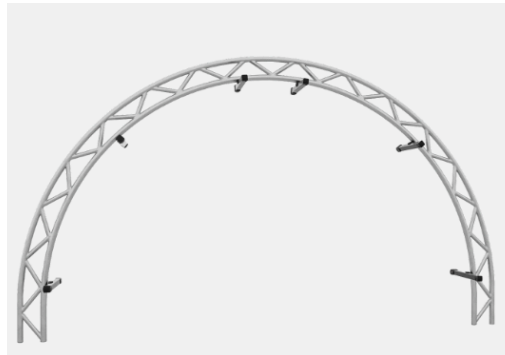
With automatic rotary table



On robotic arm/handheld



Gantry setup with multiple devices

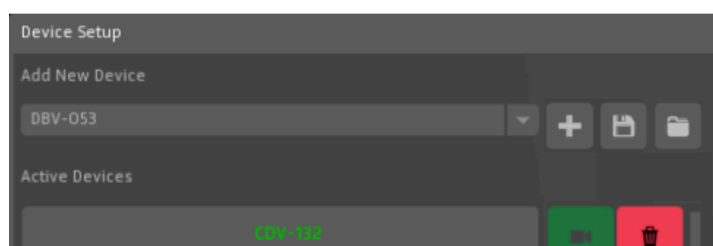





Multiple device calibration

It is possible to connect to multiple devices at once. In order to use multiple devices, a marker pattern needs to be used to calibrate the devices into one coordinate space. The calibration will be performed automatically, however, the marker needs to be visible by all sensors simultaneously. Using the floppy disk icon, you are able to save your existing calibration in a form of a *.json file. Use the folder icon to load existing *.json calibration (devices will be picked automatically based on the *.json configuration file).

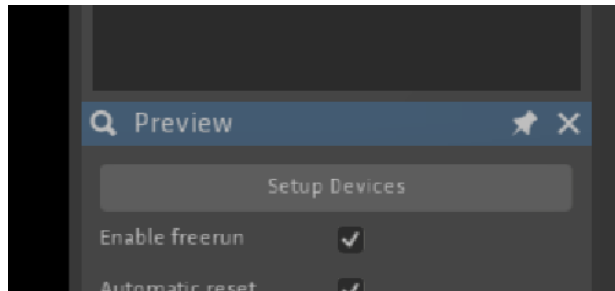
Note: Instant Meshing automatically uses LED texture for all the devices during the calibration process. If the ambient light is not sufficient, it might be necessary to **increase the LED power**. Additionally, it is recommended to update the device to **firmware version 1.10.0** which improved the marker board recognition significantly. Find out more at <https://www.photoneo.com/downloads/firmware/>.

	Add selected device
	Save calibration



	Load calibration
	Calibrate this device
	Remove this device
	Main device

Adding devices is also possible in the Control pane by clicking the *Setup Devices* button and it does not have to be done only at the launch of 3D Instant Meshing.

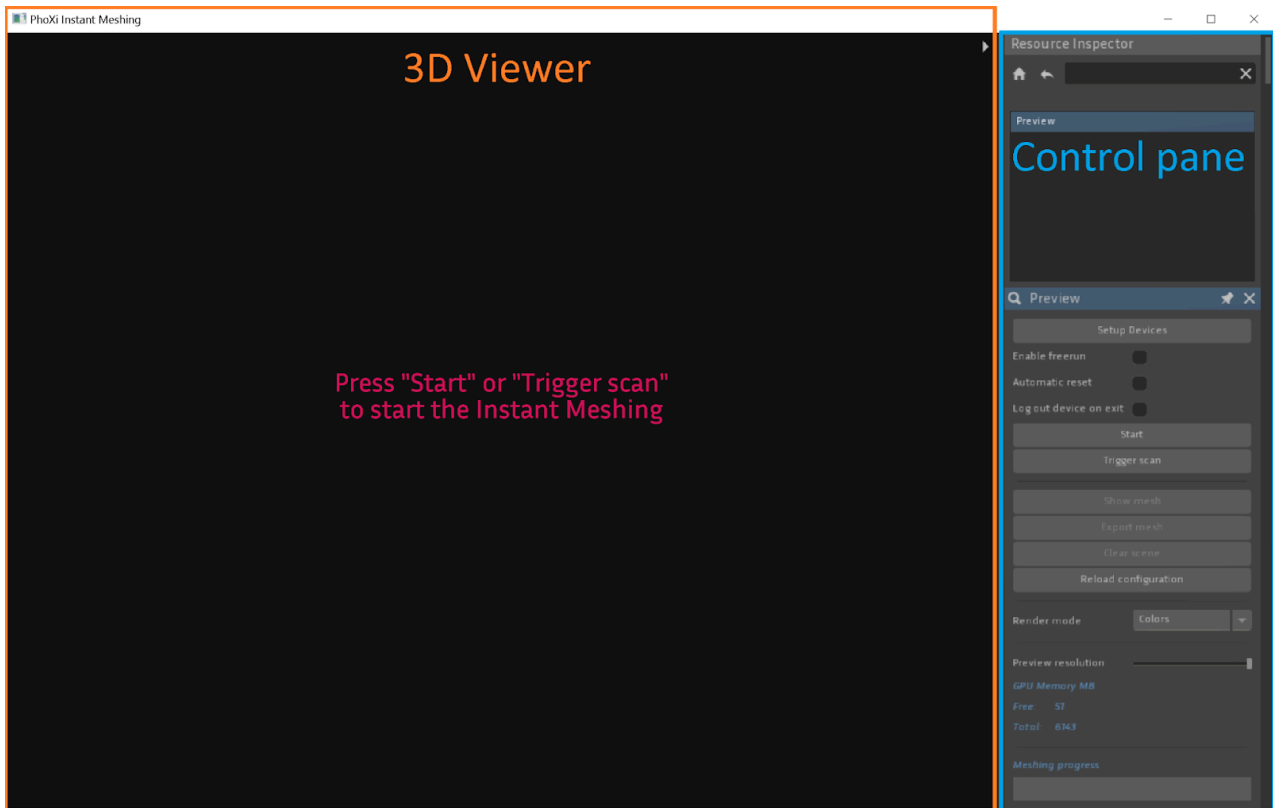


Note: Marker patterns can be found at *C:\Program Files\Photoneo\PhoXiControl<version>\MarkerPatterns* or at photoneo.com



In order for multiple devices to be running at the same time, it is recommended that the devices are triggered sequentially, so their projections do not overlap (possible point cloud distortions). The user has 2 options:

- a) Uncheck the *Enable Freerun* checkbox which means, that the devices are triggered by a software trigger and not running in freerun. This option lowers the framerate.
- b) Use the **hardware trigger** to acquire data from multiple devices. if the Photoneo 3D Sensors are configured in a Hardware trigger mode, the *Enable freerun* checkbox needs to be selected. For more detailed information about the software side and topologies refer to the [PhoXi Control User Manual](#). To find out more about the wiring and hardware requirements, refer to the [Photoneo 3D Sensor User Manual](#).

Overview

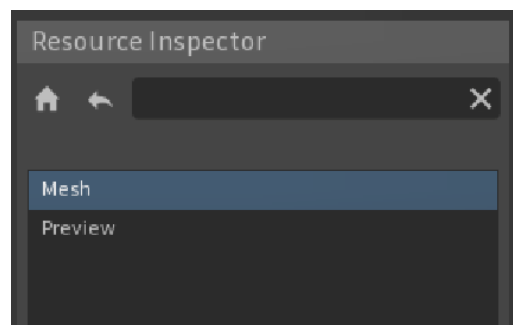


The application UI consists of the following parts:

- 3D Viewer
 - 3D Viewer can be maximized using the gray arrow in the top right corner of the 3D Viewer
 - It can be used to display the actual preview of the meshing process or to display a mesh
- Control pane
 - Resource inspector (displayed at the start)
 - Global settings 
 - Camera Animator 

Resource inspector

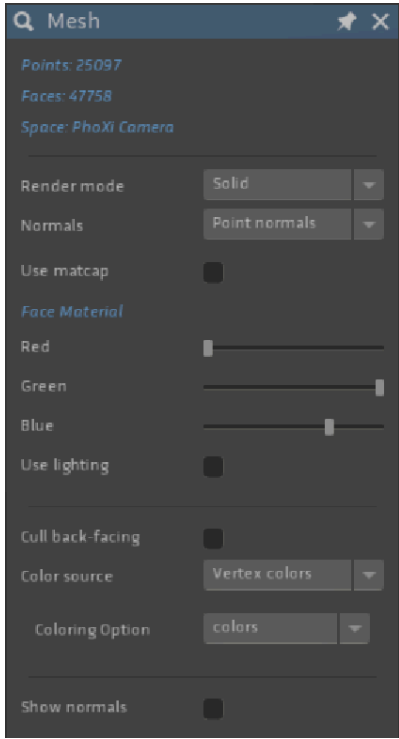
After launching the 3D Instant Meshing, Resource Inspector will contain only a Preview. Additionally, after creating a mesh, *Mesh* will appear in the list.



Preview controls

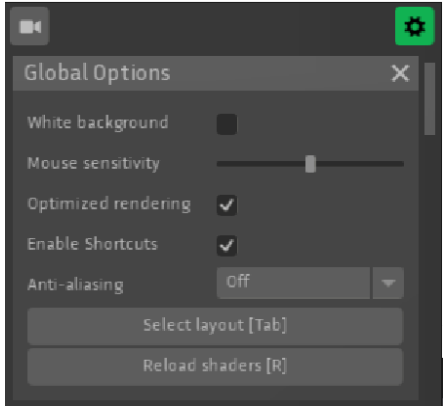
Setup Devices	Opens up a Device setup menu to add or remove active devices	
Enable Freerun	Uses freerun acquisition	
Automatic reset	Automatically resets the meshing sequence at <i>Tracking lost</i>	
Log out device on exit	After closing 3D Instant meshing, the device will be disconnected in PhoXi Control	
Start	Start the acquisition	
Trigger scan	Triggers only an individual scan	
Show mesh	Shows a rendered mesh in the <i>Mesh</i> window	
Export mesh	Exports the mesh in a *.ply, *.obj, or *.off file	
Clear scene	Deletes the previous scans in the Preview window	
Render mode	Colors - uses the Color texture source Normals - uses the Normals Grey - uses the Laser Color texture source	
Preview resolution	Adjusts the resolution in the preview window	
GPU memory	Displays the Total and Free GPU memory	

Points/Faces/Space	Provides detailed information about the mesh	
Render mode	Offers a variety of rendering options. Each option opens <i>Material</i> settings to adjust the color and lighting	
Normals	Point normals - per-vertex normals (each vertex has its own normal and lighting is computed from interpolation of 3 normals for a given triangle) Flat normals - computed for each triangle only once so triangles can be seen as flat surfaces	
Back-face culling	The process makes rendering objects quicker and more efficient by reducing the number of polygons for the program to draw.	
Color source	Material - default material Normals - uses the normals Vector colors - uses the texture used during the mesh creation	
Show normals	Displays normals. Additionally, the length and color of	

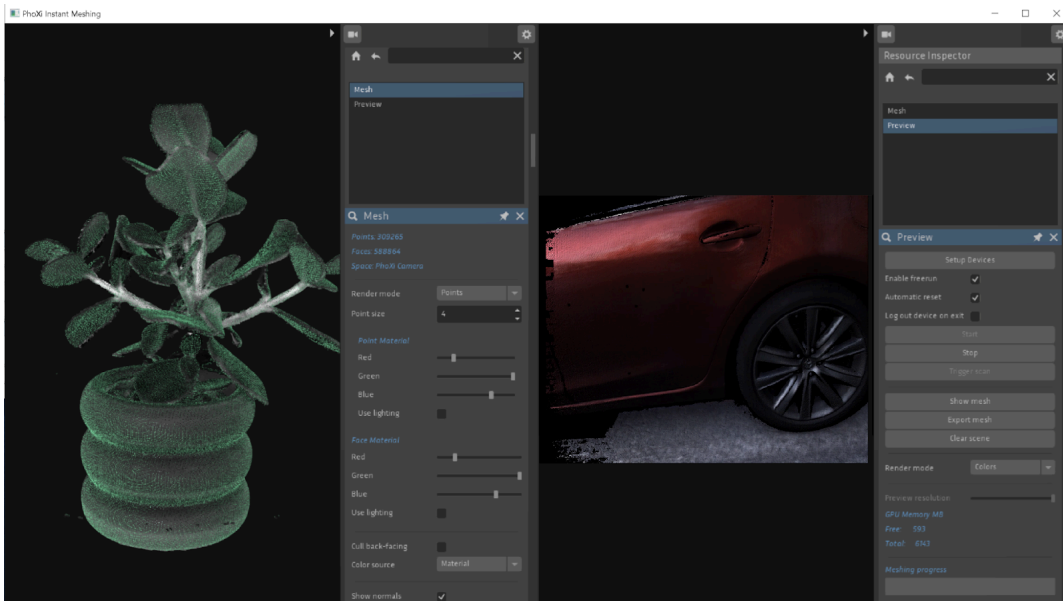
	<p>the normals can be further adjusted.</p>	
--	---------------------------------------------	-------------------------------------------------------------------------------------

Global settings

This gadget can be displayed by clicking the  icon, which will change to  when activated.

<p>White Background</p>	<p>Changes the color of the background in 3D Viewer to white</p>	
<p>Mouse sensitivity</p>	<p>Adjusts the sensitivity of the mouse using a slider</p>	
<p>Optimized rendering</p>	<p>It is recommended to keep this option true. It allows for smoother rendering</p>	
<p>Enable Shortcuts</p>	<p>Enables using the keyboard shortcuts</p>	
<p>Antialiasing</p>	<p>It is a processing option for smoothing lines and removing visual distortions. It can have an impact on performance</p>	

Select layout option allows the user to split the UI up into 4 areas. Each area can display different information. The following figure shows a split-screen mode where the left side shows the finalized mesh and the right side displays the actual meshing process.



GUI Keyboard shortcuts

- F11 - Fullscreen toggle
- TAB - Change UI layout
- Right mouse click on viewport - Scene options
- Home - Reset view (the magnifying glass button)
- E - Export mesh
- R - Reload config
- SPACE - Start/stop stream
- T - Trigger the next frame
- X - Clear scene
- 1 - Vertex colors
- 2 - Normals
- 3 - Gray

Meshing guide

Operation Principle

3D Instant Meshing is designed as a library for real-time tracking and integration of 3D scans into a triangular mesh and it is independent of the data source (Photoneo 3D Sensor). As an input, it expects a sequence of scans of the scene that differ only slightly (small perspective change), so the library can track the movement of the camera relative to the scene, and add new scans to an existing model. The basic coordinate system of the model is defined by the first scan or can be arbitrarily changed.

Tracking Performance

Tracking is the ability of the library to recognize the movement between the 3D camera and the scene so that the newly acquired scan from the new perspective can be added to the existing 3D model.

The tracking performance relies on

- Geometrical features of the scene
- 2D features (if texture tracking is enabled).

The more distinguishable features the object has, the easier it is to match the individual scans, and therefore it is less probable that the tracking is lost. The sensitivity of tracking can be adjusted. Highly sensitive setting requires very small movements, less sensitive allows for larger movements, but can also introduce incorrect alignment of the scans.

In the case of a mostly planar scene or a scene that does not consist of enough features, the algorithm can partially rely on 2D tracking, however, it is possible to override the tracking ((partially/completely) by providing a transformation matrix for each scan. This could be useful, for example, if a robotic arm with very precise position reporting is used. Two or multiple cameras which are calibrated in the same space can contribute to the same model.

Retrieving the Data

The library creates a data representation of the 3D model which can be retrieved in the form of a 3D surface model at any time. The finalized mesh can be exported in *.ply, *.obj, or *.off formats. The size of the 3D model, as well as the processing time, depends on several factors, such as the scanning volume of the device, ROI, the voxel size or the size of the scanned area. Additionally, the user can export a virtual 3D scan of the 3D model from an arbitrary view.

Quality of the 3D Model and Performance

The spatial resolution and accuracy of the 3D model depend on the resolution of the 3D sensor and can't be higher. Because the 3D model is created from a high number of scans, the temporal noise of the 3D sensor (noise of individual scans) is effectively minimized.

Library internal data representation of the 3D model is defined by the voxel size. Voxel size defines the smallest space unit of the 3D model. The maximum number of voxels that can be used for the representation of a 3D model is defined by the GPU memory size. The user can control the number of voxels being used as well as the voxel size. Small voxel size provides

higher model detail but reduces the physical dimension of the scene that can be scanned into a 3D model. High voxel size allows scanning much larger scenes at the cost of a reduced level of detail as well as reduced tracking performance.

Advanced parameters

The GUI of PhoXi Instant Meshing offers access to a limited number of scanning and meshing parameters. To adjust advanced parameters, a config.txt file is used. It can be found at:

Windows:

```
C:\Users\<User>\AppData\Local\PhoXiInstantMeshingGui\<Version>\config\config.txt
```

Ubuntu

```
/home/.config/PhoXiInstantMeshing/config.txt
```

Parameter	Value	Description
crop_aabb_min	X1, Y1, Z1	Creates a rectangular crop of the scanning volume. All values are in millimeters.
crop_aabb_max	X2, Y2, Z2	
visual_logging_level		Adjusts the level of logging in the GUI. Possible options: "none", "debug", "info", "warning", "error", "critical"
auto_min_max_depth_enabled	true/false	Automatically detects device size (S, M, etc.) and adjusts the scanning volume accordingly (overriding device.min_depth and device.max_depth)
max_gpu_memory_usage	1 - 100	Maximum percentage of available GPU memory that can be used by the library in a standard scenario. If some other program that is also using GPU is running, the available GPU memory is smaller. This value can be exceeded in a few cases: 1.) Multiple devices with different resolutions are used. 2.) A device with a resolution higher than 1120 x 800 is used. 3.) If the GetVirtualScan method is used.
voxel_size	0.1 - 100	Size of one voxel (smallest unit of the internal volumetric structure). The smaller the value is, the more detailed will be the resulting mesh, but the worse performance and higher memory requirements will be.
streaming_enabled	true/false	Enables streaming data between CPU and GPU. This feature enables to scanning of much larger scenes by transferring data temporarily from GPU to CPU when they are not needed.
headless_mode_enabled	true/false	Mode for headless servers where OpenGL is not able to run. Warning: This is only an experimental feature, and it may have a significant impact on performance.
color_intensity_auto_minmax_enabled	true/false	Adjusts the color intensity range (based on the first scan). Overrides the device.min_color_intensity and device.max_color_intensity parameters
tracking_lost_tolerance	0 - 5.0	The transformation from tracking is considered invalid if the translation or rotation is too great. This number can lower or increase the threshold of how big the transformation can be before the tracking is lost. The higher this parameter is, the bigger the transformation can be found by tracking, but it also increases the chance that a wrongly aligned scan will be added.

device.min_depth	0 - 10000	Adjusts the distances of the intersecting planes that crop the scanning volume used for meshing. (independent from the ROI set in PhoXi Control)
device.max_depth	0 - 10000	
device.min_color_intensity	0 - 1022	Manually adjust the minimum and maximum color intensities. (only applicable if color_intensity_auto_minmax_enabled = false). Max_color_intensity must be higher than min_color_intensity.
device.max_color_intensity	1 - 1023	
device.tracking_enabled	true/false	Toggle all tracking types
device.texture_tracking_enabled	true/false	Toggle the texture-based tracking. Introduces a slight performance impact but greatly improves tracking of partially planar objects
device.movement_prediction_enabled	true/false	Toggle th Movement prediction can be beneficial with a continual movement with rather small speed and direction derivations.
device.force_camera_space_enabled	true/false	When set to true, 3D Instant meshing treats the coordinate space as camera space despite the settings in PhoXi Control.

Advanced parameters found in the `config.txt` file allow for improving the meshing in general, however, for advanced applications, using the API is recommended.

Note: Changes in the `config.txt` file are reflected only after restarting the 3D Instant Meshing application or clicking *Reload config* (or pressing R). Keep in mind this completely restarts the meshing process.

API

3D Instant Meshing API provides tools necessary to control the model-creating pipeline through C++ code.

Detailed Documentation and API Examples for the PhoXi Instant Meshing API can be found in the installation folder:

C:\Program Files\Photoneo\PhoXiInstantMeshing\<Version>\API\documentation\PhoXiInstantMeshing.html

C:\Program Files\Photoneo\PhoXiInstantMeshing\<Version>\API\examples

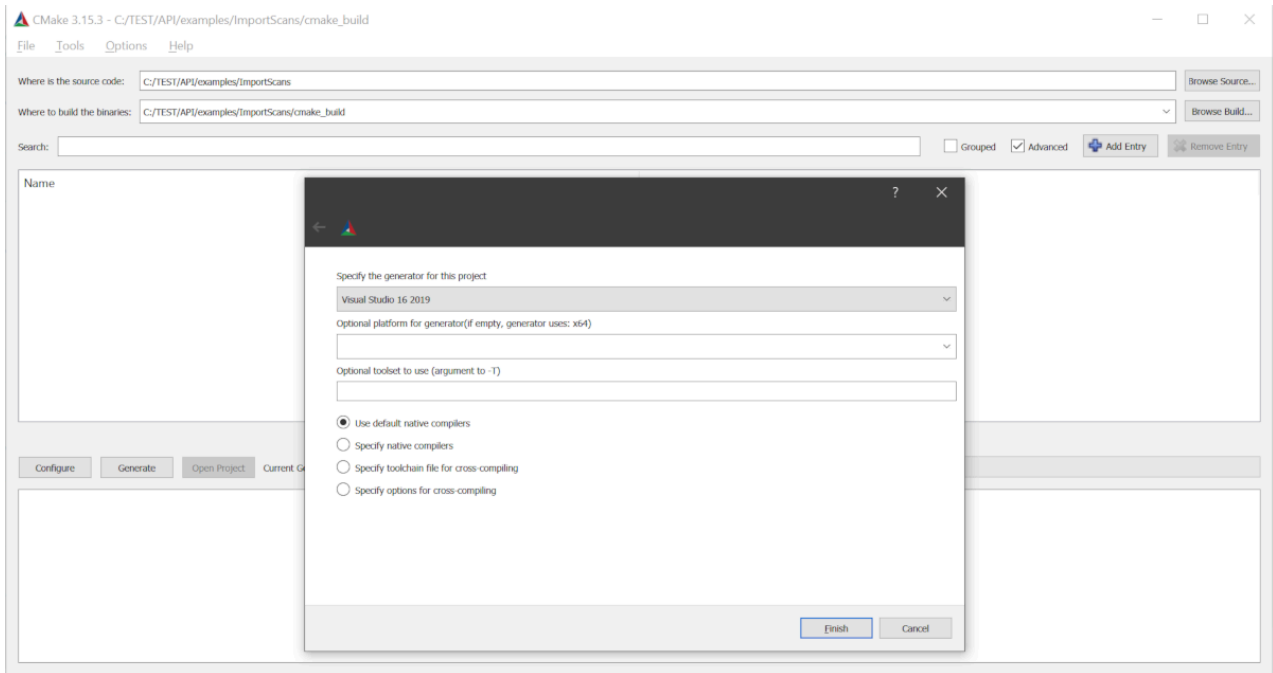
Example name	You will learn how to
Basic	<ul style="list-style-type: none"> ■ Connect to a Photoneo 3D Sensor and start the acquisition. ■ Configure an Instant Meshing algorithm with specific device and settings parameters. ■ Capture 3D scans from the device and pass them to the Instant Meshing algorithm for processing. ■ After processing the scans, export the generated mesh to a PLY file.
MultiDevice	<ul style="list-style-type: none"> ■ Use multiple PhoXi cameras to create a 3D mesh by performing instant meshing. ■ Calibrate each camera to transform them into a common space. ■ Use PhoXi's API to acquire frames and add scans to the meshing process. ■ Configure and use the PhoIM library for instant meshing. ■ Export the final mesh as a PLY file.
Union	<ul style="list-style-type: none"> ■ Capture 3D scans from a Photoneo 3D Sensor ■ Perform real-time 3D alignment of multiple scans ■ Export a final 3D model of the object ■ Save camera views of the object during scanning ■ Display error messages and warnings during the scanning process.

You can start your own development based on the example and modify it to suit your needs.

To run the example:

- If you want to modify the code, it is recommended to copy the folder API with all of its subdirectories into your custom directory.
- Launch CMake:
 - Choose the source and destination directory.

- Click the **Configure** button, specify **Visual Studio** as the generator for the project, and confirm with the Finish button.



- Wait until the configuration is completed, then click the Generate button.
- Click the Open project button or open the file *Main.sln* in the destination directory.
- Set the project as a StartUp Project in the right context menu.
- Rebuild the solution in Visual Studio (Menu → Build → Rebuild Solution).
- Make sure that the PhoXi Control application is running.
- In Visual Studio, hit **F5** to run the example (Menu → Debug → Start Debugging)
- If you are using the trial license key, the basic example prompts the user to enter the license key to use the software.

Using with PhoXi API. application has to retrieve data independently and supply the data to the Instant Meshing library for further processing. The provided examples, as well as any other custom applications implementing the Instant Meshing library, should take the following logical steps:

1. Connect to the PhoXi API
2. Create an *InstantMeshing* object and *DeviceParams* according to the PhoXi API and add them to the *InstantMeshing* Object.
3. Add scans with small perspective changes or provide transformation matrices for them
4. Display or export the mesh using *GetMesh* or *ExportMesh*, or display just a virtual scan of the 3D structure using the *GetVirtualScan* method.

Note: For reference, PhoXi Control API examples can be found at

C:\Program Files\Photoneo\PhoXiControl-<VERSION>\API\examples\CPP

Troubleshooting

If the following section does not help in solving the difficulty you are experiencing, contact our support team contact us via the [Help Center](#) with the **log files** attached which can be found at

C:\Users|<User>\AppData\Local\PhoXiInstantMeshingGui|<Version>\logs

The more information you provide, the faster and more accurate the answer can be. Additionally, please describe what you have been trying to do, what the result was, and what you expected. Depending on the nature of the problem, please also report the version of the operating system being used, your PC configuration, and other additional information that would be helpful in replicating the problem and identifying its root cause.



| Focused on 3D

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