User Guide

ARTEC STUDIO 11

Artec 3D

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Artec Studio is an industry-acclaimed software package for advanced 3D scanning and data processing. It enables you to scan countless objects using Artec scanners as well as third-party 3D sensors (Microsoft Kinect, Intel RealSense and PrimeSense Carmine, etc.) (Artec Studio Ultimate only). This manual will show you how to use the application as well as your 3D scanner to quickly and easily create great-looking 3D models.

Use the *Documentation Structure* outline to get an overview of the entire manual, or refer to the *Quick Start Guide*. To get the most out of the documentation, review the various *terms* we use throughout. Consult the genindex to find references for specific parameters that appear in processing algorithms. Also, take a look at the *Conventions and Acronyms* page for a key that describes how we highlight semantic elements.

In addition to this manual, you can find practical tips and other information at the Support Center. If you encounter an issue when using our 3D scanners or applications, please submit a request.

Documentation for earlier versions of the software is available here.

CHAPTER 1

3D Scanning at a Glance

Before you start using the guide, we want to show you how easy 3D scanning can be. Although this well-structured manual covers all the matters related to Artec scanners and software, you may find it helpful to have an overview at your fingertips. This brief summary will assist you in getting started right away! But if you prefer to begin with comprehensive and detailed information, you can skip this chapter.

1.1 Activate

The scanner case includes everything you need to start 3D scanning, except a computer. At a minimum, your PC must run the 64-bit version of Microsoft Windows 7 or 8 (10 is also supported). The more powerful the PC, the better. The main memory (RAM) and graphics card are the most critical components (visit our FAQ page for more information).

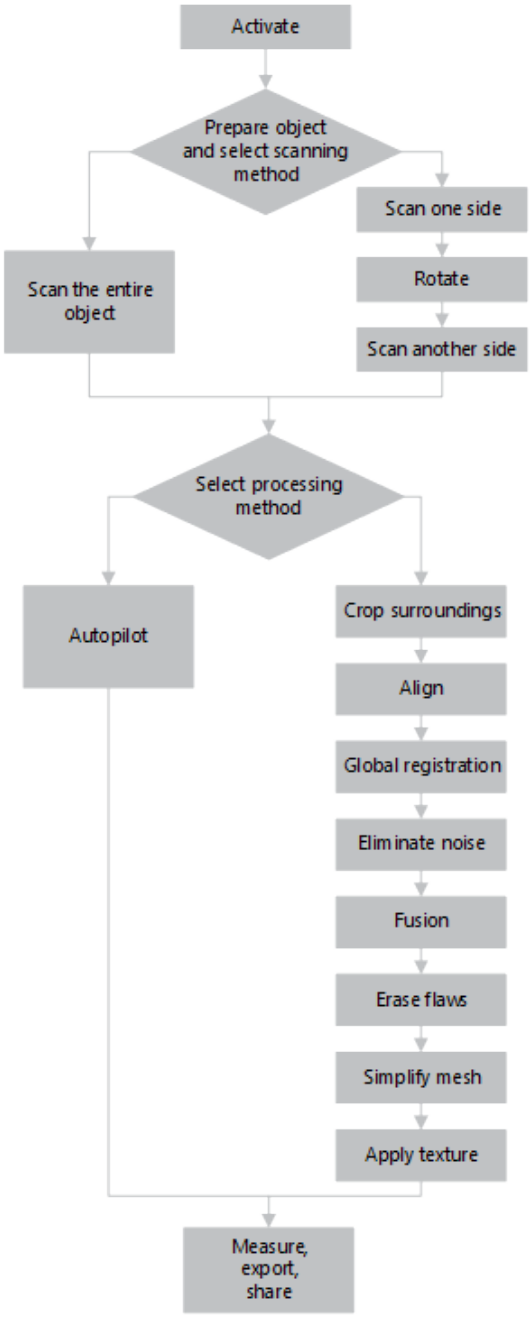
Warning: Don't connect the scanner just yet! Continue reading for more information.

1. Register for an account at *my.artec3d*
2. Sign in and download Artec Installation Center from the welcome page
3. Install Artec Installation Center. When prompted, enter your email and password.
4. Plug the scanner into a power outlet, then connect it to your PC using the USB cable
5. Wait for Windows to detect the scanner. Click *Activate*.
6. Click *Install* in the *Software* section to get Artec Studio running on your machine

(For more details, see *User Account*, *Scanner Activation* and *Offline Activation*.)

1.2 Prepare

Most objects are easily scannable. Before scanning transparent, reflective or black objects, we suggest applying a powder coating or a special anti-glare spray.


Activate
Prepare object and select scanning method
Scan the entire object
Scan one side
Rotate
Scan another side
Select processing method
Autopilot
Crop surroundings
Align
Global registration
Eliminate noise
Fusion
Erase flaws
Simplify mesh
Apply texture
Measure, export, share

To scan monochrome objects with simple geometric shapes, do the following:

- Add auxiliary objects (e.g., crumpled paper) to the scene
- Paint markers (e.g., “X” shapes) on the surrounding surfaces

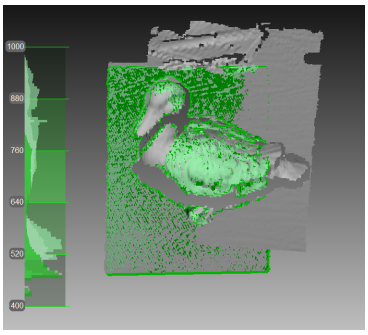
Be sure to provide good ambient light. (For more info, see *Selecting and Preparing Objects for Scanning*.)

1.3 Scan

1. Launch Artec Studio, then aim the scanner at the object.
2. Hit the `F7` key or press ▶ on the scanner to start *Preview* mode.
   - *Geometry* + *Texture* is the default scanning mode and is suitable for most cases
   - For older PCs, *Geometry* mode is a good alternative
   - The *Real-time fusion* mode creates a model in real time, allowing you to skip postprocessing; click *Stop*, then select the *Real-time fusion* checkbox and click *Preview*.
3. Make sure the object is visible, then press ▶ once again to initiate recording. If possible, scan all sides of the object in one go, slowly moving the scanner around it as pictured below.

   Note: While scanning, pay closer attention to the object on the screen than to the actual object.

4. If you hear an alert sound and the screen displays an error against a red background, smoothly aim the scanner at the area you just captured. Possible reasons for the “Tracking lost” error include the following:
   (a) You are scanning simple geometric shapes
   (b) The part of the object you are scanning is too small
   (c) Scanner movement is too fast
5. Press ■ to display the scan in the *Workspace* panel.



1.4 Turn and Scan (Optional)

Note: This part is optional.

Turn the object and capture any remaining unscanned regions (press ▶). Also, to facilitate alignment, record at least one previously scanned region.

(For more info, see *Artec Scanners: Buttons and LED Indicators*, *Tweaking Scanning Options*, *Scanning Procedure*, *Tracking Modes*, and *Scanning With Real-Time Fusion*.)

1.5 Autopilot

For beginners, the easiest way to obtain a 3D model is by using *Autopilot*. It's also a great time saver for advanced users. If you prefer performing all the steps manually, refer to the *Process Manually* section.

Autopilot is a special mode that helps users obtain a complete 3D model without learning all the ins and outs of postprocessing. It consists of two major parts: semiautomatic (editing and alignment) and automatic [1].

[1] Automatic steps may include the following:

1. Fine registration
2. Global registration
3. Outlier removal
4. Fusion
5. Small-object filter
6. Mesh simplification
7. Texturing

Tweaking Autopilot Settings

- *Hole-filling method* (available options are *Don't fill*, *Watertight* and *By radius*) instructs the algorithm to fill or not fill holes in the model.
- *Model resolution*—the lower the resolution value, the sharper the shape and the more details you will see. If you're unsure, leave the value as Auto. Effectively, it's the same as *Fusion* resolution. Note that the resolution should be no less than 0.5 for scans captured using EVA and no less than 0.1 for Spider.
- *Polygon count* determines how many polygons the resulting model will have. The greater the value, the better the quality and the larger the file size. If you're unsure, leave the value as Auto. For more information, consult the *Mesh Simplification* section.
- *Texture*—clear this checkbox if you don't want to apply texture to the model.
- *Texture resolution* takes specific values in the range of 512x512 to 8192x8192 or 16384x16384 pixels depending on the available GPU memory.

To produce a model,

1. Click *Autopilot* in the left panel or hit `F9` .
2. Become familiar with the steps that you will perform in this guided mode (listed in the welcome screen).
3. In the *Workspace* panel, use the flag to mark all scans that you intend to use, then click *Next*.
4. Then specify the input parameters for the model-creation step and click *Next*. Primary settings may include the following:

   Note: We suggest consulting the tool tips, which you can reveal by clicking the button next to the option name.

   (a) *Scan quality (geometry)*. Click to determine whether your scan of the object has the correct geometry by examining the tool-tip images.

   (b) *Scan quality (texture)*. Click , look at the images and decide whether your scan has sufficient texture.

   (c) *Hard-to-scan surfaces*. Select the checkbox if your object has surfaces that are difficult to capture. Consult the image samples by clicking the button.

   (d) Decide on the *Object size* by referring to the image samples.

   (e) Leave the default values for the remaining options in this window

8. Texture optimization (Texture inpainting)

(sufficient for most cases). For advanced scenarios, you can tweak these settings (more details appear in the *sidebar*).

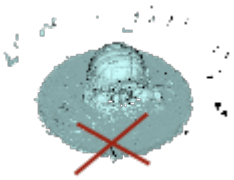
5. If necessary, erase any extraneous objects that can hinder postprocessing. Learn how to use Eraser by consulting the *Erasing Portions of Scans* section.
6. Once you're done, click *Next*. If the object was captured over several scans, Autopilot will align them and show you the result. You can approve it or align the scans manually (consult *Manual Rigid Alignment Without Specifying Points*).
7. Click *Next*.
8. Autopilot will begin postprocessing [1]. Once it's finished, a message will appear informing you that the model is ready. Click *OK*.

1.6 Process Manually

1.6.1 Crop Surroundings

Once you finish, click *File* and select *Save project*. Close the *Scan* panel; preliminary registration will start automatically. You can then crop the surroundings.

Purpose: To erase auxiliary surfaces (e.g., a table or floor).



Steps: Open *Editor* → *Eraser* → *Cutoff-plane selection*. Follow the instructions.

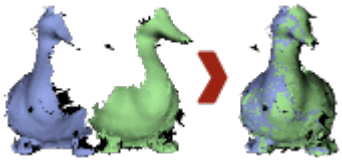
(For more info, see *Editing Scans*.)

1.6.2 Align

Purpose: To align several scans. Skip this step if only one scan is in the *Workspace* panel.

Steps:

1. Mark two or more scans using 👁, click *Align* and select those scans in the *Rigid* tab while holding the `Ctrl` key.



2. Click *Auto-alignment*.
3. If alignment fails owing a lack of texture or lack of overlapping areas, manually match the features among the scans and click the *Align* button.

(For more info, see *Scan Alignment*.)

1.6.3 Global Registration

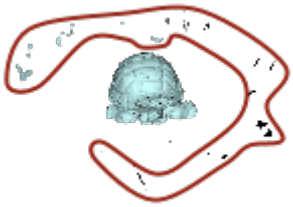
Purpose: To simultaneously optimize the frame position across all scans, thus preparing them for further processing.

Steps: Mark scans using 👁, then click *Tools* → *Global registration* → *Apply*.

(For more info, see *Global Registration*.)

1.6.4 Eliminate Noise

Purpose: To erase large outliers and some noise.



Steps: Open *Tools* → *Outlier removal* → *Apply*.

(For more info, see *Editing Scans* and *Outlier Removal*.)

1.6.5 Fusion

Purpose: To create a model (a single surface, as opposed to the multiple surfaces that constitute the source scan).

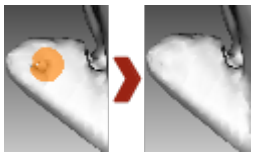
Steps: Select *Tools* → *Smooth fusion* → *Watertight* → *Apply*.

To obtain sharper surfaces, select *Sharp fusion*. In both cases, *resolution* can be adjusted: the smaller the value, the more precise the resulting surface.

(For more info, see *Fusion*.)

1.6.6 Erase Flaws (Optional)

Purpose: To erase any outliers and poorly scanned regions.



Steps: Click *Editor* → *Defeature brush*. Follow the instructions.

(For more info, see *Editing Scans*.)

1.6.7 Simplify Mesh

Purpose: To reduce the file size by decreasing the number of polygons without significantly distorting the actual 3D geometry.

Steps: Click *Tools* → *Mesh simplification* → *Apply*.

(For more info, see *Mesh Simplification*.)

1.6.8 Apply Texture

Purpose: To create a textured model.

Steps:

1. Click *Texture*.
2. Select fusion and its “parent” scan(s) in the corresponding fields.
3. Select *Generate texture atlas* → *Apply*.

(For more info, see *Texturing*.)

1.7 Measure, Export, Share

- Export the model: open *File* → *Export mesh*. Select the required format, specify the folder and file name, then click *OK*.
- Measure the model: open *Measures*, then select one of the following:
  - *Linear* for distance calculation (points are connected by lines)
  - *Geodesic* for distance calculation (points are connected by curves that pass over the model surface)
  - *Sections* for area and volume calculation
- Share the model on *viewshape.com* by opening the *Publish* toolbar

(For more info, see *Exporting Models and Scans*, *Publishing to the Web* and *Measurement Tools*.)

1.8 Tips and Tricks

- You can reset all settings to their defaults using `F10` → *Scan* tab → *Reset to defaults*
- To return any altered parameters in the *Tools* panel to their default values, click the adjacent ■ button. The □ button indicates a default value.

- Save screenshots by hitting `Ctrl+Shift+S`
- Apply annotations using *Measures* → *Annotations*, enter the tag label and type text, then click *Apply*.

CHAPTER 2

Introduction

2.1 Documentation Structure

The manual is divided as follows:

- *3D Scanning at a Glance* (Quick Start Guide) is a brief overview of scanning and processing basics. It also covers *Autopilot* mode.
- *Introduction* highlights general information on the structure and appearance of the guide.
- *Using the Hardware* covers scanner-related matters.
- *Installation and First Steps* describes how to install the software and start using it.
- *Scanning* explains the basic principles of object scanning and offers advice on how to conduct the scanning process to obtain the best results.
- *Viewing 3D Models* describes ways in which to control an object's appearance in the *3D View* window and obtain the best view of the 3D model.
- *Project Operations* contains information on data management, working with projects, exporting and importing data, undoing recent operations, and saving the history of project changes.
- *Data Processing* focuses on data-processing techniques: working with separate scans, alignment, fusion, filters, defect-elimination methods and texturing.
- *Additional Modes* demonstrates how to publish models on the Web; how to use additional features, such as employing several scanners to capture an object; and how to use measuring tools.
- *Settings* describes user-adjustable application parameters.
- *Scanner Calibration and Correction* discusses calibration and correction issues.
- The two *appendices* comprise a hot-key list and figures illustrating third-party 3D sensors.

2.2 Conventions and Acronyms

Portions of this user guide are highlighted to draw your attention. For example, important information appears in boxes. The following examples illustrate our conventions:

- **Note:** General information that warrants emphasis.

- **Important:** Important information.

- **Warning:** Practices to avoid.

- Panel and element names that appear in the application window use italics: e.g., *Workspace*, *File* and *Texture*
- Buttons, checkboxes and elements of dropdown lists in panels and application menus are italicized and underscored: *Invert*, *Apply* and so on
- Shortcuts, individual keys and hardware buttons use gray highlighting: e.g., `Ctrl + A`
- Characters that appear in a field, file extension, or directory or file path employ the following style: `Scan 1`, `SPROJ`, `C:\Program Files`, and so on.

Note the following abbreviations and icons:

- `LMB` —left mouse button
- `RMB` —right mouse button
- ⏯—*Play/Pause* button on the scanner body

2.3 Glossary

The following terms related to Artec Studio and 3D scanning appear regularly in this manual.

accuracy (general term) How closely a measurement matches the actual value of the quantity being measured.

Autopilot An advanced smart mode that guides the user through postprocessing in a few steps, automatically selecting the most effective settings and producing a 3D model.

bundle Capture of an object through simultaneous use of multiple scanners, whose numbers and relative positions are specified in the application.

CAD model Feature-based, editable solid model used in manufacturing. It can be created in a CAD system or reverse-engineering software package.

fine registration A thorough frame alignment using an algorithm for relative positioning of sequential frame pairs.

frames 3D surfaces captured during a scanning session. The maximum scanning rate is 15 frames per second (30 frames per second for Microsoft Kinect, PrimeSense Carmine and Asus Xtion sensors).

global registration Algorithm that optimizes the relative positions of all frames using a single coordinate system.

key frames Frames used by the global registration algorithm. The algorithm selects them automatically to fully cover the surface of the captured object using as few as possible.

mesh The surface geometry of a 3D model; it comprises a series of linked polygons.

model The 3D object that results from the fusion operation (in Artec Studio) or another modeling process in a different software package.

near and far cutting planes Planes that limit the space in which the scanner is capturing 3D frames. The device will ignore everything that is closer than the near cutting plane or more distant than the far cutting plane.

project A method of managing the scanned material, processed data and user operation history, either in memory or on disk. Artec Studio project files use the *SPROJ* extension.

resolution (general term) The ability of a scanning system to capture detail in an object.

rough registration Preliminary frame alignment performed during capture.

scan A sequence of frames captured in a single continuous movement of the scanner around an object or scene.

targets Stickers placed on the object being scanned to ease identification of the various regions. There are two types of targets: non-coded and coded. Unless the type is explicitly specified, the target is considered non-coded. Typically, a non-coded target is a round sticker that has a black ring with a white circle in the center; a coded target has a unique code ring that photogrammetry software can automatically recognize.

tracking Calculation of the scanner's position in a coordinate system relative to the scene.

CHAPTER 3

Using the Hardware

3.1 About Scanners and Sensors

Artec Studio can work with one or more Artec 3D scanners. It offers tools to quickly create 3D models of physical objects. Besides managing the process of capturing objects, it lets you perform full data postprocessing, optimize mesh tessellations and apply other operations to obtain a quality 3D model. You can then send the complete model to a CNC machine or import it to another 3D-modeling application.

Figure 3.1.: Features of Artec 3D scanners: Space Spider (left) and EVA (right).

Most Artec 3D scanners are specifically designed for handheld use, offering light weight and compact size. Being structured-light 3D scanners, they don't require you to place any special targets on the object you're capturing. Using them is easy—no special knowledge or skills are necessary. To obtain a complete 3D model, simply scan the object from different angles and fuse the resulting scans into a single model using Artec Studio.

Depending on the size of the object you're scanning, use either Artec EVA, Artec L2 or Artec Spider. The primary difference between these models is the depth and field of view. They also differ in 3D resolution as well as point accuracy; consult the Artec web site for details. We recommended choosing the scanner model that's best suited to the operations you will be performing:

- Artec L2—full body, monuments, architectural elements
- Artec EVA—full body or body parts, faces, automobile interior, large statues
- Artec Spider—pencils, keys and other small objects; fine details on large objects, such as architectural ornaments.

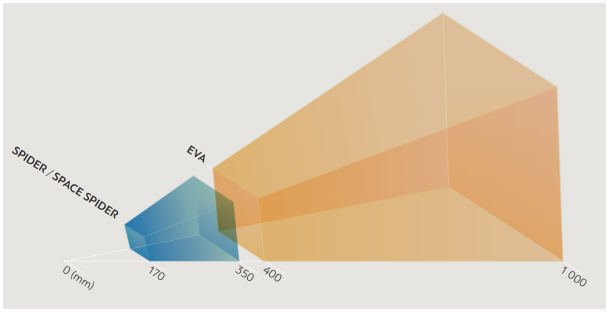


Figure 3.2.: Fields of view for various Artec 3D scanners.

You can combine several different scanner types while capturing a scene. In some cases when capturing complex shapes, this capability increases the scanning rate and enables you to achieve your desired precision.

3.1.1 About Third-Party 3D Sensors

Note: Artec Studio Professional supports only Artec scanners. To scan using third-party 3D sensors you need Artec Studio Ultimate.

Artec Studio Ultimate can work with the following third-party 3D sensors (see *Third-Party 3D Sensors*):

- Microsoft Kinect for Windows (v1 and v2)
- ASUS Xtion
- PrimeSense Carmine
- Devices featuring Intel RealSense 3D camera

When using the above-mentioned devices, however, the scan quality will be lower than what you can achieve with Artec 3D scanners.

3.2 Artec Scanners: Buttons and LED Indicators

3.2.1 LED Indicators

Artec scanners include built-in multicolor indicators. By explaining the meaning of these indicators, the list below enables you to keep track of the scanning process:

- **Steady blue**—scanner is booting up.
- **Flashing green**—Artec Studio cannot detect a 3D scanner.
- **Steady green**—scanner is connected to the application and ready to use.

- **Flashing red**—scanner is in *Preview* mode, or tracking in *Recording* mode is lost.
- **Steady red**—scanner is in *Recording* mode and object tracking is proceeding correctly.

3.2.2 Hardware Buttons

The Artec EVA and Artec Spider 3D scanners have three-position buttons on their bodies:

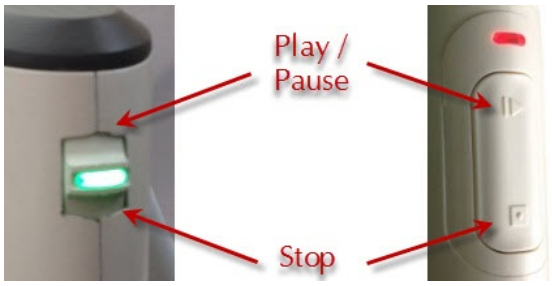


Figure 3.3.: Scanner buttons: Artec Spider on the left and Artec EVA on the right.

▶ —press this button once to open the *Scan* panel and start *Preview* mode; press it once more to switch to *Recording* mode. Subsequently, pressing this button will switch between *Preview* and *Recording*.

■ —press once during a scan to stop the scanning process; press twice to stop scanning and close the *Scan* panel.

3.3 EVA Scanners: Hardware Synchronization

Artec EVA is equipped with two jacks designed for 6P6C connectors (RJ12). By creating a bundle, you can link multiple Artec EVA scanners to each other. The master device is a leading scanner that sends signals to the next slave device. Each subsequent device is connected to the previous one sequentially as Figure 3.4. shows. To connect the devices, you can use a standard phone cable (*RJ12 6P6C*) or any other cable that uses the conductor scheme shown in Figure 3.4.. Each scanner should also connect to the PC via USB.

Warning: Only Artec EVA scanners can connect to each other. Do not connect Artec EVA to a telephone wall port!

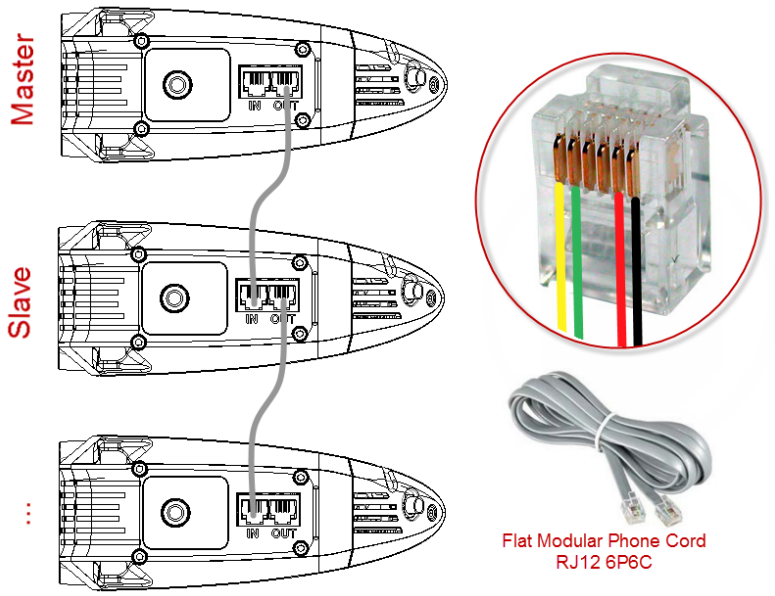


Figure 3.4.: Synchronization scheme.
Jacks on the Artec EVA scanner shown at left and conductors in a 6P6C connector shown at right.

CHAPTER 4

Installation and First Steps

4.1 System Requirements

Your computer must meet the system requirements to use Artec 3D scanners.

Note: Third-party scanners are only available in Artec Studio Ultimate!

In addition, take note of the following:

Real-time fusion mode (*Scanning With Real-Time Fusion*): ensure that your graphics card has at least 1 GB of memory or your Intel HD Graphics chipset is 4600 or higher (consult the FAQ article for more information).

Using Intel RealSense camera requires your computer to run Windows 8 (Windows 10 for SR300) and to feature at least 4th Generation Intel Core processor and USB3.0

Using Kinect v2 requires your computer to run Windows 8 and to feature 3.1 GHz (or faster) processor with physical dual-core (2 logical cores per physical) and USB3.0 based on Intel or Renesas chipset.

Using multiple scanners (*Multicapturing*) requires your workstation to integrate as many independent USB2.0 host controllers as connected scanning devices. Upgrading your hardware with PCI/PCI Express USB2.0 cards may provide the required number of hosts.

Stereo mode in Artec Studio: to view models rendered in 3D on stereoscopic displays, you need an Nvidia Quadro professional graphics card that supports OpenGL Stereo. Also consult the article.

4.2 User Account

To install Artec Studio and keep it up to date, register for a free account at *my.artec3d*. Registration is also required to activate an Artec 3D scanner. In addition, the site allows you to track all your Artec devices and products.

Your account at *my.artec3d* will be valid for all Artec sites and services (including *viewshape.com*).

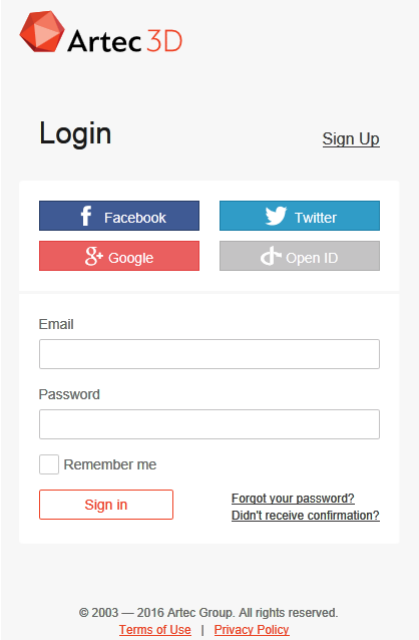


Figure 4.1.: *my.artec3d* welcome screen.

To register, follow these steps:

1. Go to *my.artec3d* and click *Sign up*
2. Fill in all the fields in the registration form and click *Create account*
3. Receive a registration email that contains a confirmation link.
4. Click the link or copy it to your browser to confirm your registration and go straight to your *my.artec3d* account.

4.3 Scanner Activation

Before using your new Artec 3D scanner, you must activate it and link it to an account at *my.artec3d*. You can do so with the help of Artec Installation Center—a standalone utility available for download from *my.artec3d*. If you're a new user and don't yet have Artec Installation Center, please read *Running Artec Installation Center* below. Otherwise, proceed to *3D Scanner Activation Using Artec Installation Center*.

Warning: Do not connect your scanner to the USB port before installing Artec Installation Center.

4.3.1 Running Artec Installation Center

To use Artec Installation Center, first ensure that your computer is connected to Internet. Any computer with USB2.0 or USB3.0 ports will work. If necessary, you will be able to install and activate Artec Studio on a separate computer later. Also make sure that you already have a *my.artec3d* account; if not, see *User Account*.

1. Log into your *my.artec3d* account and download Artec Installation Center. The link for the Artec Installation Center executable is available on site's the main screen.
2. After downloading, open the folder that contains the executable and run it. Follow the instructions on the installation screens. Once Artec Installation Center is installed, you will see a dialog requesting your username and password. Use your *my.artec3d* account to log in as Figure 4.2. shows.

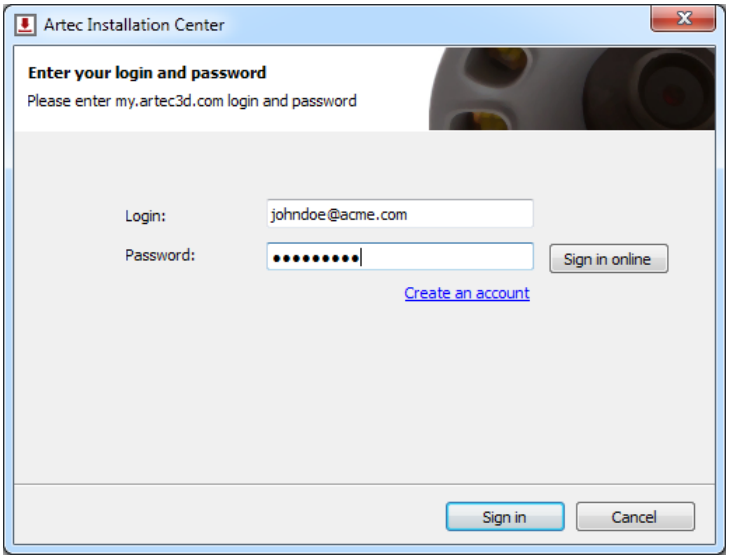


Figure 4.2.: Authentication for Artec Installation Center

4.3.2 3D Scanner Activation Using Artec Installation Center

To activate a 3D scanner using Artec Installation Center, make sure your computer is connected to the Internet and that you have installed the application.

1. Run Artec Installation Center (go to the Start menu: click *Start* → *All Programs* → *Artec Group* → *Artec Installation Center*) to bring up the window shown in Figure 4.4..
2. Connect your new Artec 3D scanner to the computer and wait until Windows detects the device and installs the necessary drivers. You may see a notification similar to one shown in Figure 4.3..
3. Go to Artec Installation Center, click *Refresh* and wait for the new 3D scanner to appear in the hardware box (see Figure 4.4.). Click *Activate* (to the right of the serial number) to enable your 3D scanner. The status of the device should change to *Activated*, as Figure 4.5. shows.

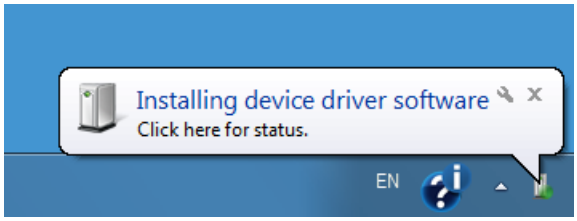


Figure 4.3.: Windows notification indicating device installation.

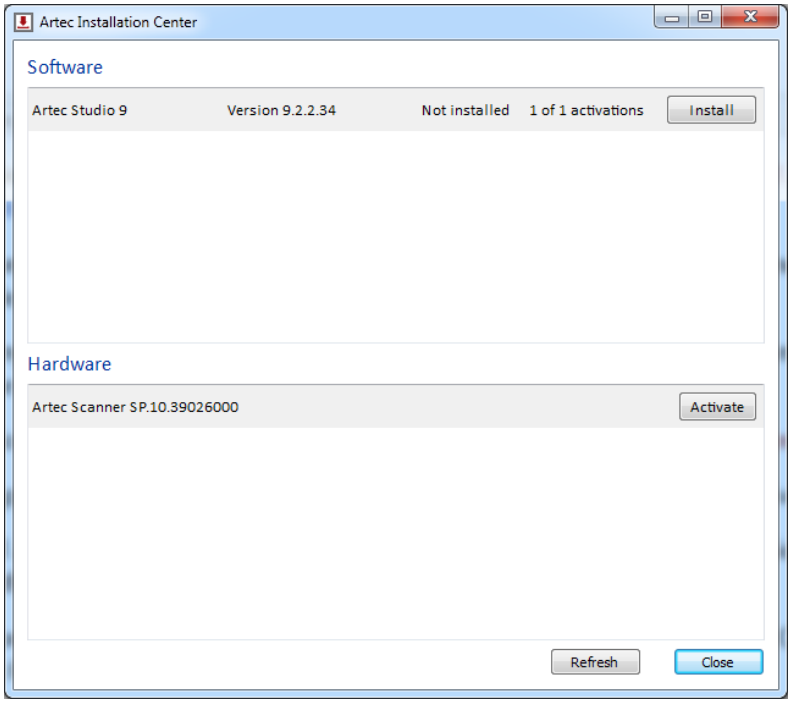


Figure 4.4.: Activate button for 3D scanner

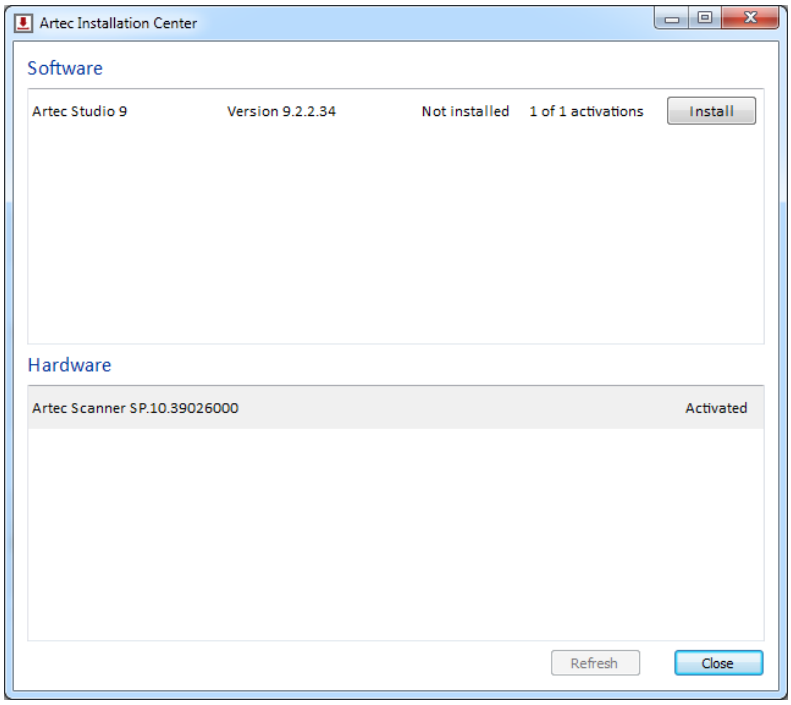


Figure 4.5.: 3D scanner activated

4.4 Artec Studio Installation

There are two ways to download and install Artec Studio:

- Through Artec Installation Center (either during the installation process or by clicking *Install* in the application, as Figure 4.6. shows)
- From *my.artec3d*—log into the site, go to the *My applications* page and download the executable (see Figure 4.7.)

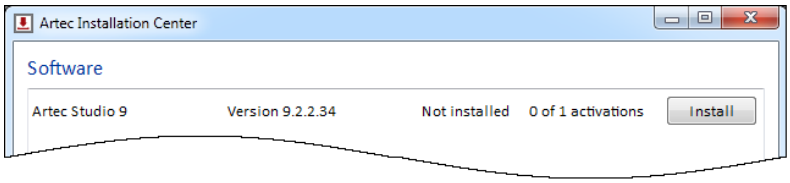


Figure 4.6.: Artec Installation Center is ready to install Artec Studio.

If you download the executable, run it to begin installation; otherwise, click *Install* in Artec Installation Center. To continue with the installation, click *Next* and proceed to the license agreement (see Figure 4.8.). After reviewing the agreement, accept it by clicking *Yes*.

Specify the path to the installation folder (we recommend using the default location) as Figure 4.9. shows, then select the components you would like to install (see Figure 4.10.):

Program-menu shortcuts —create icon in the Start menu

Desktop shortcut —create icon on the desktop

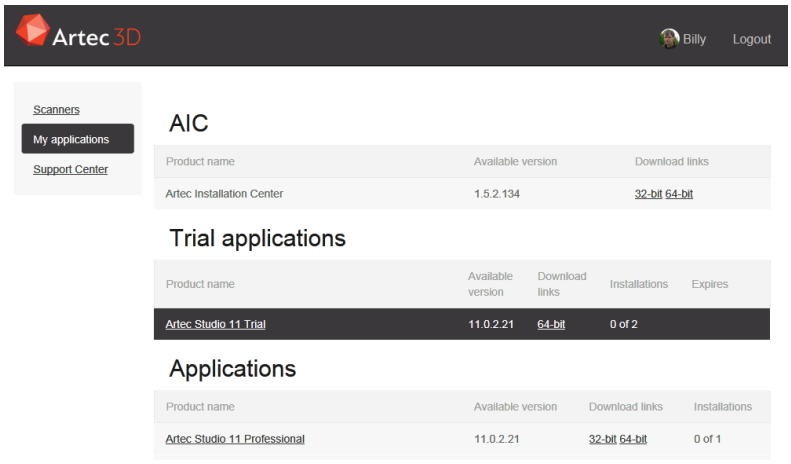


Figure 4.7.: Portion of *My applications* page at *my.artec3d*.

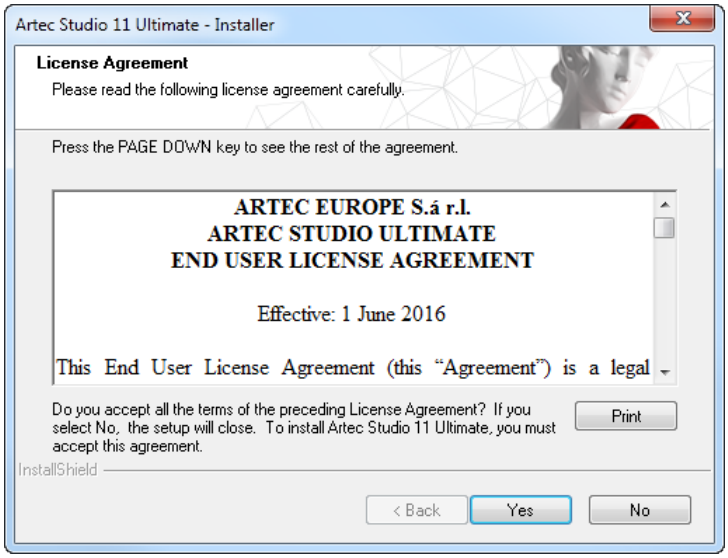


Figure 4.8.: License agreement

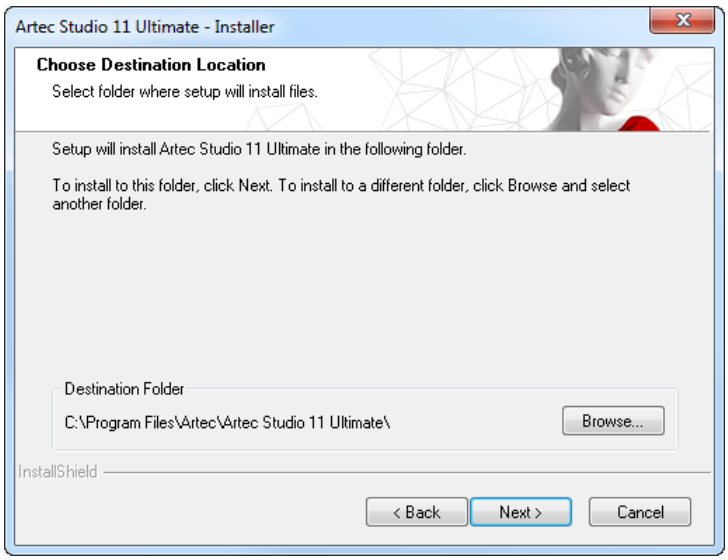


Figure 4.9.: Installation location

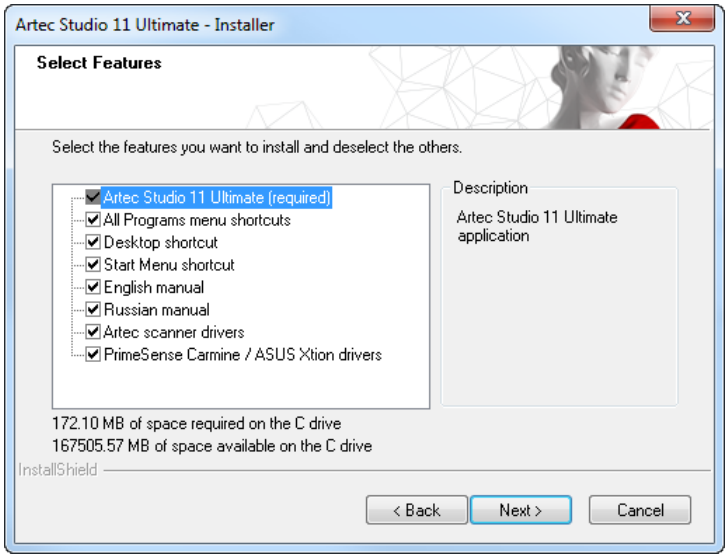


Figure 4.10.: Select components to install

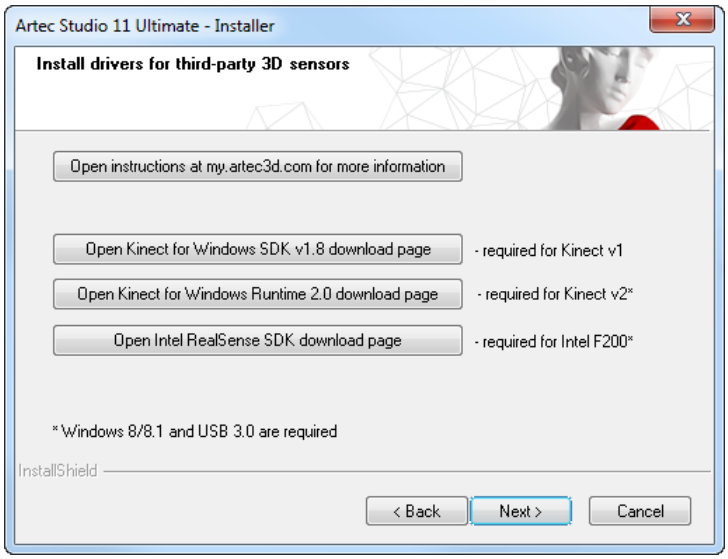


Figure 4.11.: Third-party 3D-sensor driver selection

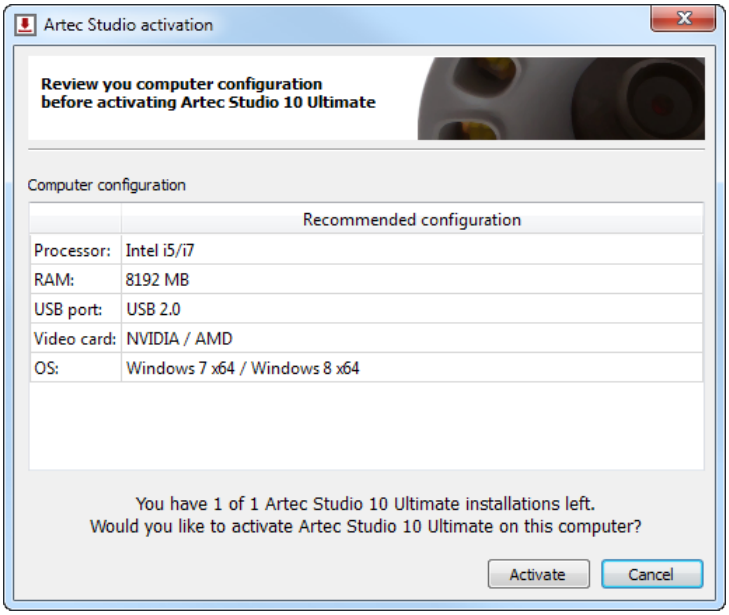


Figure 4.12.: Artec Installation Center showing Artec Studio activation window

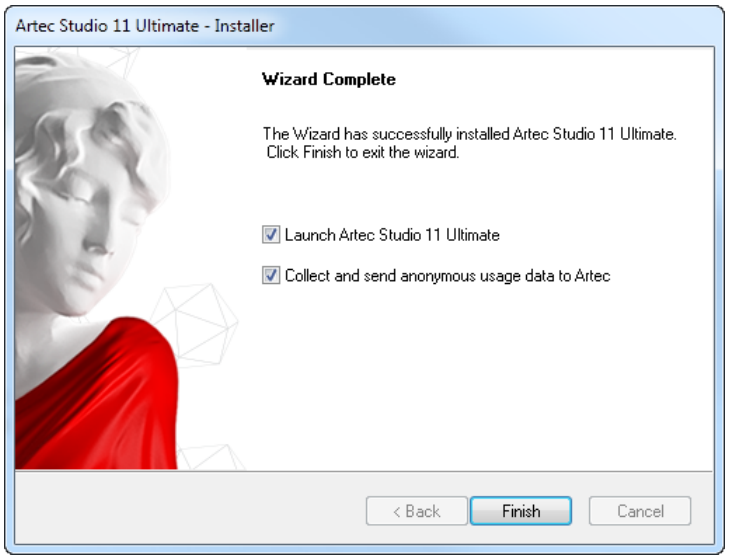


Figure 4.13.: Finish installation

Start-menu shortcut —add shortcuts to the Start menu and Quick Launch panel

English manual —install user manual in English

Install Artec Scanner Drivers —install drivers for Artec 3D scanners

PrimeSense Carmine / Asus Xtion drivers —install drivers for PrimeSense/Asus 3D sensors

By default, the application will create all of the above icons and install the user manual and Artec 3D-scanner drivers. To continue with the installation, click *Next*.

If you have yet to install Artec Installation Center, a login dialog will appear, as Figure 4.2. shows. If you are not connected to the Internet, consult *Offline Activation* regarding offline activation of Artec Studio.

If you have yet to link to your account the computer on which you are installing Artec Studio, you will see the activation confirmation shown in Figure 4.12..

When the installation is complete (see Figure 4.13.), the installer will offer to launch Artec Studio.

4.5 Offline Activation

If the computer on which you are installing Artec Studio lacks an Internet connection for security or other reasons, you may use the offline activation procedure to activate the software.

Note: Copies of Artec Studio activated offline cannot be deactivated, so use this option only if absolutely necessary.

Note: Before conducting offline activation, make sure the scanner (see *Scanner Activation*) and Artec Studio are tied to your *my.artec3d* account.

For offline activation, you need the following:

- Another computer connected to the Internet
- Artec Studio installation package (preferably, download it from *my.artec3d*)
- Flash drive or another storage medium to transfer files from the Internet-connected computer to the computer that will run Artec Studio

Installation and activation procedure:

1. Start Artec Studio installation.
2. During installation the login/password dialog will be displayed as Figure 4.14. shows. Click *Activate offline*

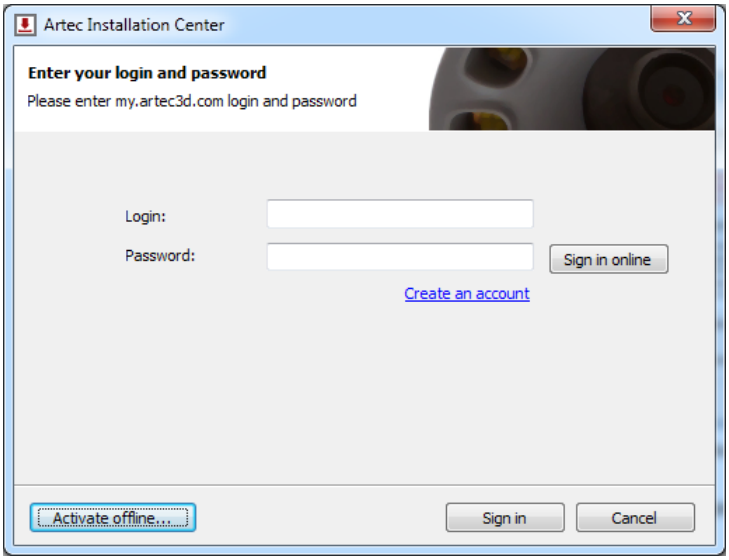


Figure 4.14.: Artec Installation Center authentication dialog

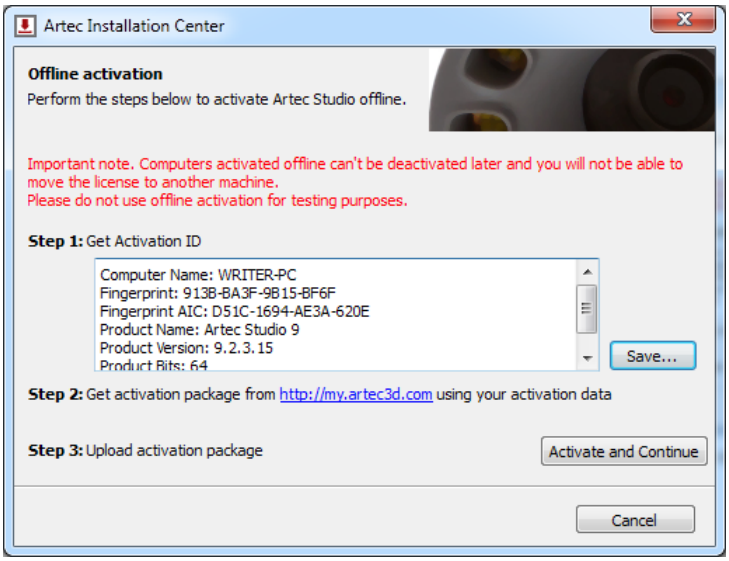


Figure 4.15.: Offline-activation window

3. In the offline-activation dialog (Figure 4.15.), click *Save...* and save generated Activation ID file to a flash drive or other storage medium.
4. Log into your *my.artec3d* account and open *My applications* page using the Internet-connected computer.
5. Find Artec Studio and click on it. A new page will appear, as Figure 4.16. shows.
6. Click the *Activate application offline* link then the *Select file* button and specify the Activation ID file path. Next, click *Activate*.
7. A new dialog will allow you to download an Offline Activation Data file; save it to the flash drive.
8. Return to the computer on which you are installing Artec Studio. Click *Activate and Continue* and specify the Offline Activation Data file.

Note: Once you create the Offline Activation Data File, *my.artec3d* will decrease the number of available activations by one.

Once you complete all the steps described above, your copy of Artec Studio will be activated and all of your Artec 3D scanners will be installed on the non-Internet-connected computer.

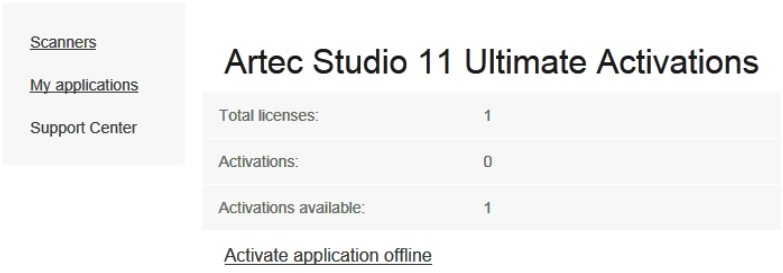


Figure 4.16.: Offline activation at *my.artec3d*.

Note: If later you purchase another Artec 3D scanner, you must reinstall the application and repeat the activation procedure described above to copy the new scanner's data files to your computer.

4.6 Deactivation

Note that deactivation is only possible for computers on which you activated Artec Studio online as *Artec Studio Installation* describes. Artec Studio installations activated offline cannot be deactivated.

Note: The number of deactivations may be limited, so deactivate Artec Studio only if you absolutely must move it from one computer to another.

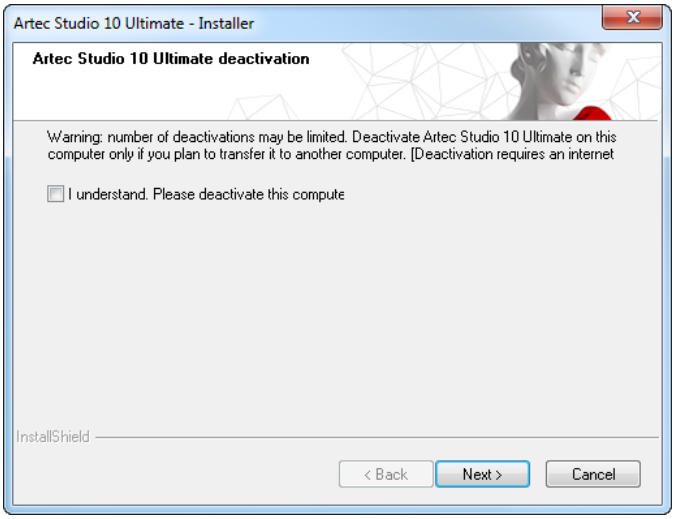


Figure 4.17.: Deactivation of Artec Studio.

To deactivate a license on your computer, follow these steps:

1. Make sure the computer is connected to the Internet.
2. Go to *Control Panel* → *Uninstall Applications* and click on Artec Studio. The uninstallation process will start.
3. The dialog shown in Figure 4.17. will appear. Select the *I understand. Deactivate Artec Studio on this computer* checkbox.
4. Click *Next* to complete the uninstallation.

4.7 Managing Artec 3D Scanners and Products

Artec Installation Center manages applications and 3D scanners linked to your account.

It's a multifunctional supplement to Artec Studio that connects with *my.artec3d* and helps you install new applications, download updates and manage your 3D scanners. To launch Artec Studio for the first time, you must log into *my.artec3d*. After this one-time authentication, you need not provide your username or password each time you launch the application.

When Artec Studio launches, Artec Installation Center checks for new updates; if an update is available for any installed product, the software will display a notification like the one shown in Figure 4.18..

Once you log in, Artec Installation Center displays information about your products.

The *Software* section of Artec Installation Center provides all information about your software products:

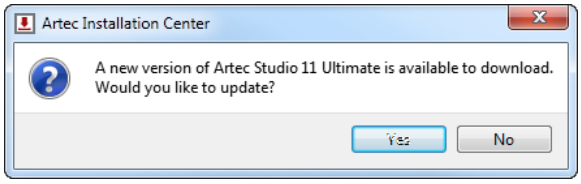


Figure 4.18.: An Artec Studio update is available for download.

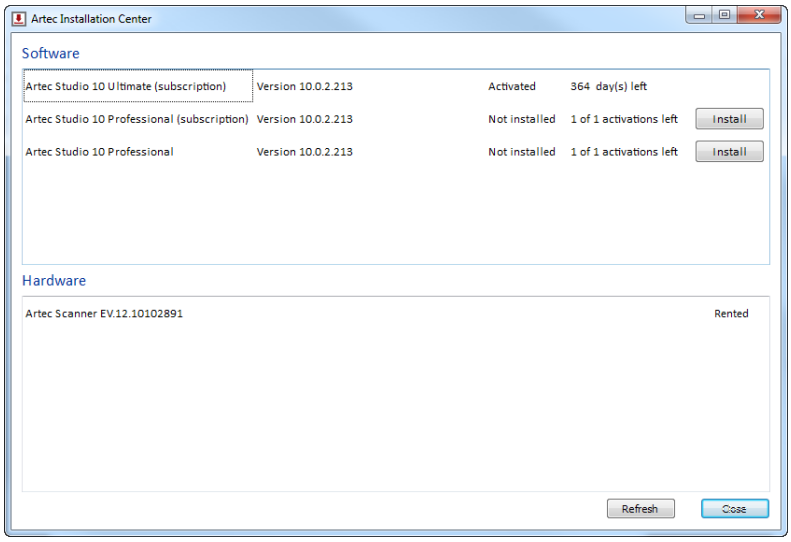


Figure 4.19.: Artec Installation Center.

- A list of all applications available to you
- Activation status of each application (application may or may not be activated)
- Total number of activations and number of activations you've used so far
- *Activate*, *Install* or *Update* buttons for any of these actions that are currently available to you
  - *Install*—appears if the software is not installed on the computer (installation usually means activation)
  - *Activate*—appears if the software is not currently activated on the computer. Activation decreases number of licenses by one for each computer.
  - *Update*—appears if a new version of installed software is available for download

The *Hardware* section contains a list of the scanners that you own or have otherwise connected to your computer. For the first case, the *Activated* status or *Activate* button will be displayed, while in the second case, the *Rented* status or *Rent* button will be displayed.

A row of buttons appears at the bottom of the Artec Installation Center window:

Refresh —refresh the data displayed by Artec Installation Center

Close —exit Artec Installation Center

4.8 Getting Started With Artec Studio

4.8.1 Main Window

You can launch Artec Studio in several ways:

- Click the desktop icon
- Using the Start menu, click *Start* → *All Programs* → *Artec Group* → *Artec Studio Professional/Ultimate 11*.

When you launch Artec Studio, you will see the main application window, which allows you to perform all operations on scans and models. The main window is divided into several sections (see Figure 4.20.): *3D View*, *Side panel*, Left panel (figure depicts optionally open *Tool panel*), *Workspace* and *Log* as well as menu bar and status bar (not marked in the figure). Other windows may appear temporarily as well.

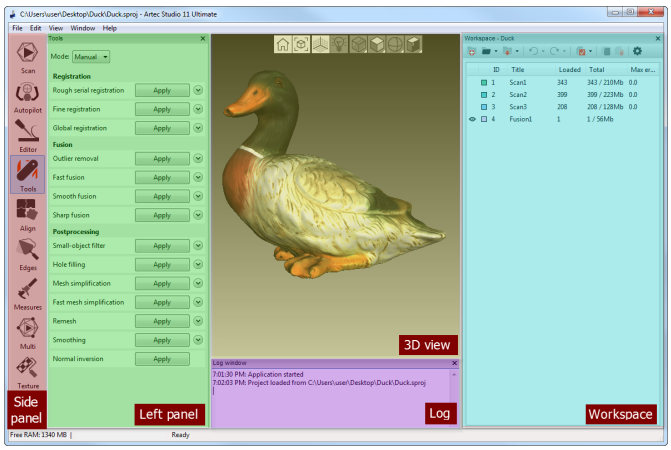


Figure 4.20.: Main window of Artec Studio.

The *3D View* window displays all 3D data. You will use this window regularly. When the application launches, a coordinate grid with coordinate axes will appear in the center. Your scans and models will employ this global coordinate system.

To the left of the *3D View* window is a side panel that contains icons for various application modes, including *Scan*, *Autopilot*, *Editor*, *Tools*, *Align*, *Edges*, *Measures*, *Multi*, *Texture* and *Publish*. These modes are mutually exclusive: the application can work only in one of them at any given time, except for *Autopilot*. Some modes will lock the *Workspace* panel when you use them. The main application modes are *Scan*, *Autopilot*, *Editor*, *Tools* and *Align*.

At the top of the *3D View* window is a context-dependent *3D Tools* panel containing the following commands: *Home*, *Fit to view*, *Grid*, *Lighting*, *Color*, *Render mode*, *Shading* and *Backface*. *Editor* mode includes several additional tools: *Select through*, *Positioning*, *Move/Rotate/Scale*, *Smoothing brush*, *Eraser*, *Defeature brush* and *Texture-healing brush*.

The *Workspace* panel displays and manages all data uploaded to the application. Here you will find your scans as well as project-manipulation commands, such as saving, erasing,

moving and renaming. You can reveal the hidden *Workspace* panel by clicking  at the top right of the *3D View* window (see Figure 4.21.).

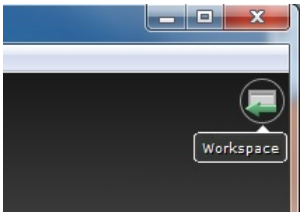


Figure 4.21.: Button to reveal *Workspace* panel.

The *Log* panel sits at the bottom of the application window. The log is the software's report on any executed commands, specifying the time and details of each operation. It also stores all error and troubleshooting messages generated by the algorithms.

The status bar contains information on memory availability and current usage by Artec Studio. It also has a progress indicator for any currently running task, such as algorithm execution, model and scan exporting, and so on.

4.8.2 Primary Settings

To access the settings dialog, select *Settings...* in the *File* menu. The settings window has several tabs for various groups of application settings. To switch between the tabs, click the icon at the top of the dialog. For a detailed description of the tabs, see *Settings*.

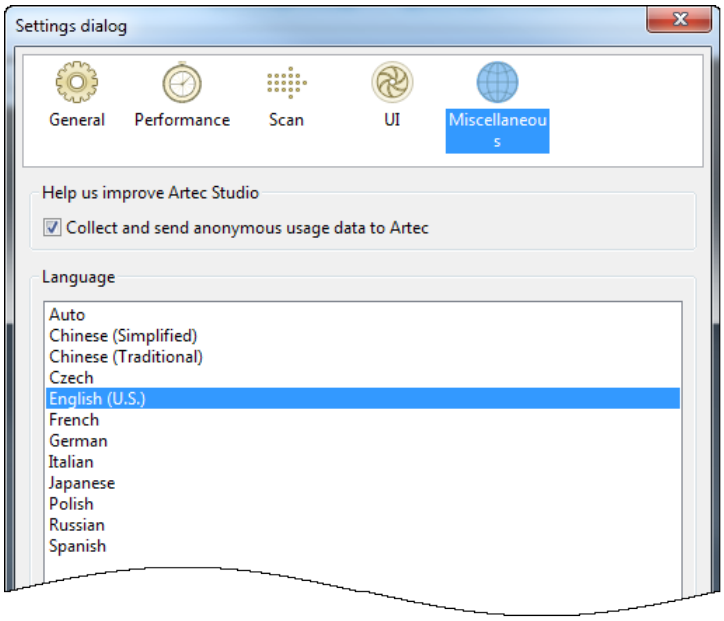


Figure 4.22.: Language selection through *Settings*.

Under the *Performance* tab you can specify the maximum number of alterations to be saved, or specify maximum the size (in MB) of the history to be saved. The *Data-compression level* slider enables you to adjust the compression level when saving project data to a disk.

To change the language, select the *Miscellaneous* tab (Figure 4.22.) and then the required language from the list and click *OK*. You will be asked to confirm the operation and restart the application. Once you agree, Artec Studio will automatically restart using the new interface language, but you will lose all unsaved data. If you choose not to restart, the changes will be applied the next time you start the application.

CHAPTER 5

Scanning

5.1 Scanner Buttons and Capture Modes

Your 3D scanner may be in one of the following capture modes (each of which has a corresponding color and flicker rate of the LED indicator on the device if you're using an Artec scanner):

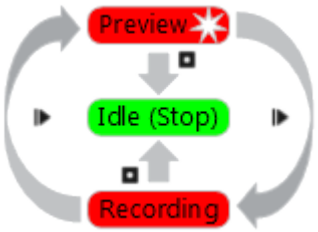


Figure 5.1.: Understanding capture modes (colors correspond to scanner LED indicator colors).

Idle—the LED is steady green . This mode indicates either that the application has detected the scanner or that the user has clicked the *Stop* button in the *Scan* panel or pressed the ◘ button on the scanner body (see Figure 3.3.). In this case, the 3D scanner is not flashing.

Preview—the LED is flashing red . In this mode, the 3D scanner is capturing images, but the software is neither performing alignment nor recording captured frames. To start this process, either click the *Preview* button in the *Scan* panel (see Figure 5.13.), press the ▶ button on the scanner body or hit the `F7` key on the keyboard. This mode is useful when doing the following:

1. Checking the 3D scanner's field of view
2. Determining the best position for the object
3. Preparing to recording and developing a scan procedure
4. Adjusting texture brightness

Recording—the LED is steady red Scanning takes place in this mode, with the software storing 3D data to disk or RAM. Activate this mode either by clicking the *Record* button in the *Scan* panel, hitting the `Space` key on the keyboard or pressing the ▶ button (do so once for *Preview* and a second time for *Recording*). To pause recording, either click *Pause* in the *Scan* panel, press ▶ on the scanner body or hit the `Space` key.

5.2 Selecting and Preparing Objects for Scanning

Artec 3D scanners employ is based on the structured-light method of 3D reconstruction. Since they capture 3D frames using optical technology, some types of objects are difficult to scan. Certain techniques, however, enable successful scanning of such objects. For example, you can cover a transparent or dark object with a light paint or dust it with talcum powder. You can also use other easily removable substances or a special anti-glare spray.

Table 5.1.: Hard-to-scan Surfaces

Surface Features	Possible Solutions	
Black or very dark	Dust with anti-glare spray	
Shiny or reflective objects	Dust with anti-glare spray	tilt scanner when capturing
Transparent (glass, certain kinds of plastic, etc.)	Dust with anti-glare spray	
Thin edges	Add background geometry (e.g., crumpled paper)	

5.3 Technique

Artec 3D scanners capture objects at a rate of 15 frames per second to ensure that adjacent frame areas overlap as you gradually move the scanner. Artec Studio uses features in overlapping areas to automatically align captured frames. It performs this task in real time, providing immediate access to the frames in a single coordinate system. You can evaluate the captured area after the scanning session to determine which parts of the object require additional scanning.

To accurately capture an object or scene, follow these steps:

1. Pay closer attention to the object on the screen rather than looking at the actual object.
2. Ensure that Artec Studio can accurately register frames from the scanner. To this end, do the following:
   - Don't move the scanner too fast
   - Keep the object as close to the center of the field of view as possible

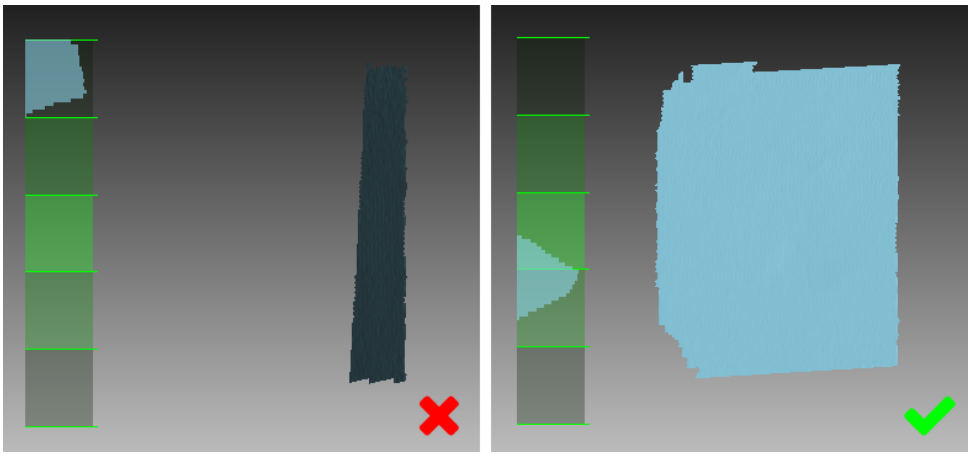


Figure 5.2.: Scanner orientation and reconstructed surfaces.

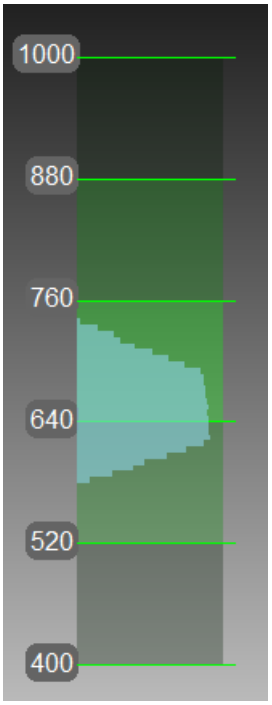


Figure 5.3.: Distance meter in *3D View* window showing surfaces that fall within the optimal range for Artec EVA.

- Maintain the scanner orientation in such a way that the field of view is sufficiently filled with surfaces (see Figure 5.2.)
- Try to position the scanner as close as possible to the center of the range meter [1] or a little below it (closer to the object; see Figure 5.3.)

3. If you're capturing an object over several scans, remember to capture a common area in each one to ensure successful alignment
4. If you're capturing an object in one scan, do so all the way around the object—regardless of direction—plus a little more (360+ degrees)
5. Avoid capturing any objects that may change shape during the scanning process. When the geometry of the scene is changing, the system may fail to find the correct position of new frames relative to previously aligned ones. If you have captured unwanted objects, you must remove them later during the editing stage (see *Editing Scans*).
6. Don't record too many frames: ensure that you have sufficiently scanned all regions, but avoid scanning them twice, except when providing overlapping areas for subsequent alignment.

5.4 Scanning Procedure

Ins and Outs

- Artec Studio creates a new scan in the *Workspace* panel at the beginning of each session.
- When you start *Preview* mode, Artec Studio will hide all uploaded scans. This mode helps you to determine how well the 3D scanner sees the object, and it helps you to identify areas that may cause trouble during the scanning session. To begin the scanning process, click the *Record* button in the *Scan* panel or press the ⏯ button on the device body.
- If your 3D scanner is equipped with a texture camera, Artec Studio will activate the scanner's texture flash and capture color images that it will later use to texture the 3D model.

1. Prepare the object and make sure it has enough geometry and texture details (see *Selecting and Preparing Objects for Scanning*).

[1] Technically, the center of the range meter is the center of the depth of view. The 3D scanner has near and far cutting planes (see Figure 3.2.) that determine the optimum distance between the scanner and the target object. Artec Studio offers the *Range meter* feature so you can easily visualize the distance between the scanner and the object during the recording process. The *Range meter* comprises a set of semitransparent diagrams located on the left side of the *3D View* window (see Figure 5.3.). Each histogram displays the distribution of captured surface points by distance from the scanner. The color corresponds to the set of surfaces from which it was obtained: by default, gray indicates registered key frames, light green indicates the last few frames of a registered sequence, dark green indicates the last successfully registered frame and red indicates a registration error.

2. Provide even lighting without using direct sunlight.
3. If you have connected just one 3D scanner to the computer, Artec Studio will select it automatically; otherwise, you must select the appropriate device from the dropdown list under the *Advanced* section of the *Scan* panel.
4. Create a new project before getting started: use the button in the *Workspace* panel, select *File* → *New project* from the menu, or use the shortcut `Ctrl + N`. Once you have saved the project, you will be able to load or unload the scans as necessary and thereby limit RAM usage (see *Project Operations* for details).
5. Decide how many sessions you need in order to capture the entire object. By using a special third-party rotating table, you may be able to avoid interrupting the session and eliminate the need to turn the object by hand. Depending on your choice, you may
   - Turn the object
   - Position yourself to gain access to the other area
   - Use a rotating table
6. Click *Preview* or press ▶ on the scanner. Direct the scanner at the object and practice your movements around the object, taking into account the proper *Technique*.

   Note: If you wish to use the *Enable automatic base removal* option, first direct the scanner at the surface that supports the object.

7. Click *Record* to start capturing.
8. Gradually move the scanner while monitoring the process in the *3D View* window
9. Capture what you can and pause or cease recording by clicking the *Pause* or *Stop* button, respectively. Choose *Stop* if you must make adjustments to the object's positioning (see the next step).
10. Turn the object or otherwise adjust it as necessary, then capture any remaining unscanned regions.
11. Once you have successfully captured the object from all sides, click the *Stop* button or press ■ on the scanner body.

5.5 Tracking Modes

Ins and Outs

- Artec Studio still records texture in *Geometry* tracking mode if the scanner incorporates a texture camera

- Continuous scanning in the hybrid tracking mode is easier with the *Scan using auto-alignment* option.

The software provides three *tracking* modes and one option:

Geometry + Texture, or hybrid The optimal (and default) algorithm for 3D scanners equipped with a texture camera. It uses features from images obtained using the texture camera as well as geometrical features of the object and thus is more likely to successfully capture flat or textureless objects. The only possible drawback is greater CPU utilization compared with other algorithms, potentially decreasing the frame rate for less powerful computers. You can use this mode with Artec MHT, Artec EVA, Artec Spider and third-party 3D scanners.

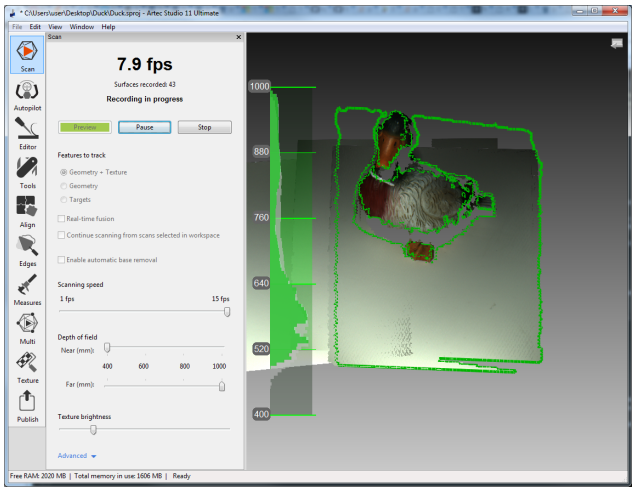


Figure 5.4.: Texture tracking renders color object (scanner's current field of view outlined in green).

Geometry The default algorithm for all 3D scanners that lack a texture camera (Artec EVA Lite). It uses only object geometry to align the scanned frames, making it suitable for objects that have a rich geometry but not objects with large flat, spherical or cylindrical parts. The Geometry tracking algorithm is the least CPU hungry.

Targets A special algorithm for scanning objects with special targets placed on their surfaces.

Real-time fusion (option) Available for both Artec 3D scanners and third-party 3D sensors, this option fuses the results immediately after scanning.

See also:

Tweaking Scanning Options

5.5.1 Base Removal: Erasing a Supporting Surface

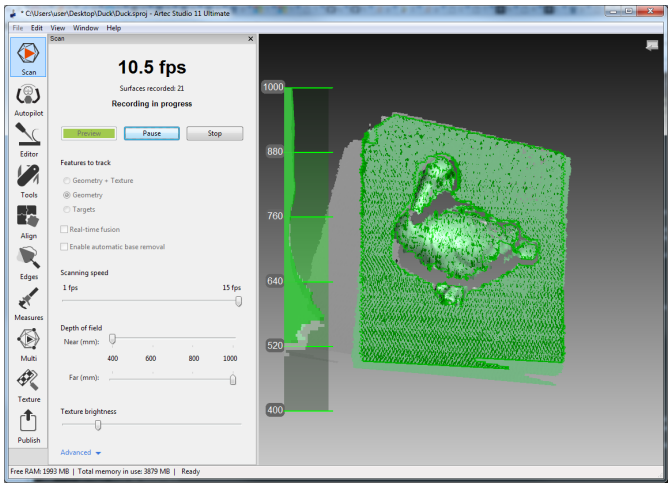


Figure 5.5.: Main window when using Geometry tracking to scan objects.

Ins and Outs

- Base removal is available for all tracking modes.
- If you click *Stop* or press ◘, you should again identify the supporting surface.
- If the scene remains changed, you can also use the *Continue Scanning From Scans Selected in Workspace* option. In this case, the application won't prompt you to identify the base.
- If base detection is successful, the base will always render in *Recording* mode.

When you capture an object, you can often omit from the scan any surface that supports the object. The *Base removal* option serves this purpose. To employ this option, first indicate the surface on which the object is resting and then capture the object. If this approach is unsuitable for your situation, clear the *Enable automatic base removal* checkbox.

1. Open the *Scan panel*.
2. Make sure the *Enable automatic base removal* checkbox is selected.
3. Click *Preview* and direct your scanner at the surface that supports object (e.g., a table or the floor). A gray wireframe plane will appear, indicating the scene's base.
4. Once the application detects the base, it will display a message: "Now scan the object."

> **Important:** If Artec Studio fails to detect a supporting surface, you can still start recording.

5. Direct the scanner at the object and click *Record* (I▶)
6. Scan the object freely. You can pause and resume the session as necessary.
7. Click *Stop*; all scans will move to the coordinate system with the Z axis normal to

the base.

8. Close the *Scan* panel. After Artec Studio performs *Fine registration*, the *Base removal* algorithm will remove the previously detected supporting surface.

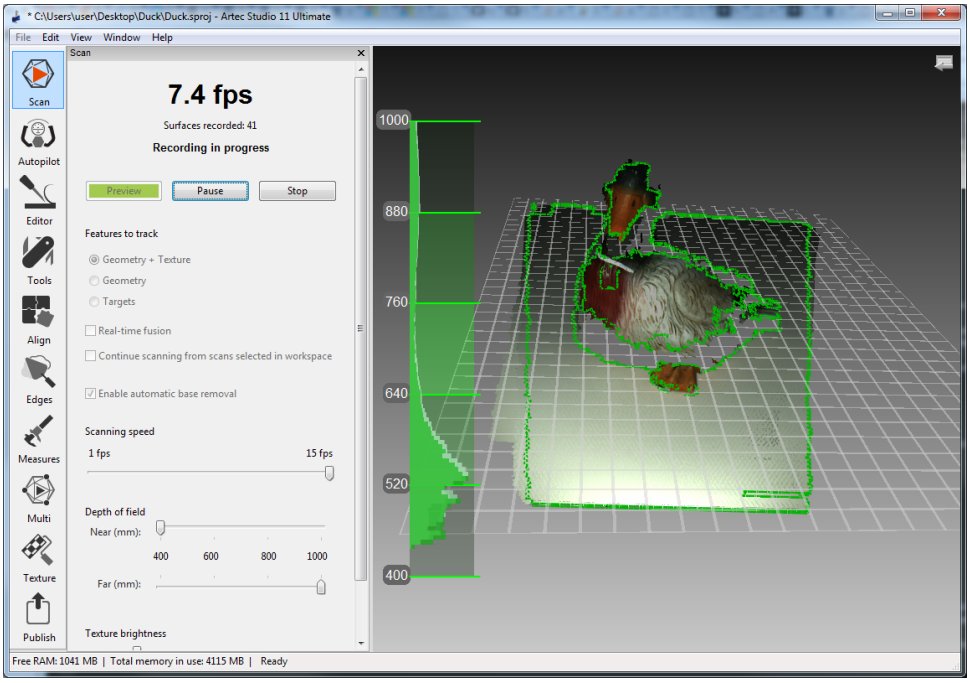


Figure 5.6.: Scanning with the *Enable automatic base removal* option.

5.5.2 Resuming Scan After Lost Tracking

Artec Studio records adjacent frames on the basis of common surface features. If the scanner stops recognizing common features, it will stop capturing the scene. This situation is called lost tracking; if it happens, just direct the scanner at a recently captured region. There are, however, nuances, which we address below.

Table 5.2. lists several causes of lost tracking. The most common is moving the scanner too fast.

Table 5.2.: Causes of lost tracking.

Reason	Possible Solutions
Moving the scanner too fast	Move the scanner more slowly or increase the *Scanning speed*
Scanner sees too few surfaces	Increase *Sensitivity*, apply an anti-glare spray or direct the scanner at a larger part of the object
Object doesn't have enough features for successful tracking	Apply masking tape or draw markers on the surrounding surfaces, and/or move the scanner more slowly

The *Scan using auto-alignment* option may ease the process of resuming tracking (this option is enabled by default in the application settings). Note the following:

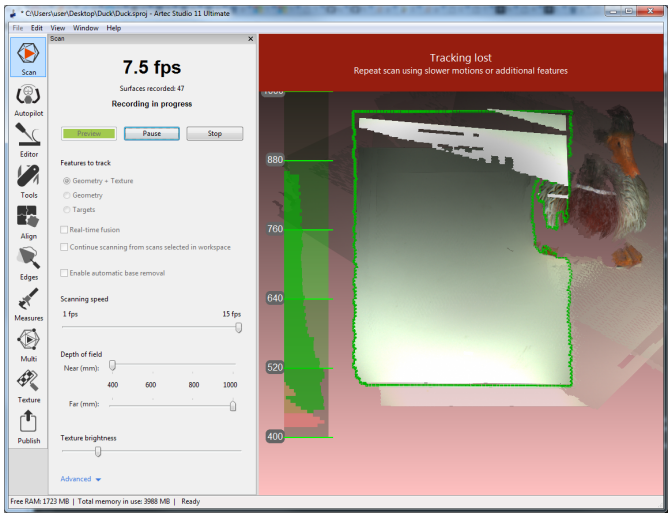


Figure 5.7.: Alert message: tracking lost.

- Artec Studio switches almost instantly from displaying *Tracking lost* mode (see Figure 5.7.) to *Searching for position*, which appears on a green background.
- To continue scanning, direct the scanner at a region you've already captured.
  - Try to maintain the original scanner orientation toward this region
  - You need not necessarily use the most recent one, but it should have sufficient texture features.
- If the application successfully resumes tracking, it will start recording in a newly created scan. This new scan will already be aligned with the previous one.

The *Scan Using Auto-Alignment* section describes system behavior when this option is disabled.

5.5.3 Continue Scanning From Scans Selected in Workspace

Auto-alignment is a great timesaver and may help simplify further processing. But for projects that involve scans using *Geometry + Texture tracking* and for which the actual scene is unchanged, you can continue scanning immediately:

1. Ensure that the *Scan using auto-alignment* option is turned *on* in *Settings* (see *Capture*).
2. Mark previously captured scans using the icon in the *Workspace* panel.
3. Select *Geometry + Texture tracking* as well as the *Continue scanning from scans selected in workspace* checkbox in the *Scan* panel.
4. Click *Preview*, direct the scanner at a textured region you've already captured textured region—maintaining the original scanner orientation—and then click *Record*.
5. If tracking resumes successfully, Artec Studio will align the newly recorded scan with the selected ones.

5.5.4 Scanning With Real-Time Fusion

Real-time fusion is a special mode in which Artec Studio builds a 3D model in real time while you're scanning. It's the easiest and fastest way to obtain a model, but it cannot completely replace the normal workflow for processing raw scans after capturing them. Thus, we recommend avoiding *Real-time fusion* in the following cases:

- The scene is large and the amount of GPU memory is limited
- Objects have complicated shapes that cannot be captured in one scan session
- The object has small geometric details
- Extra-high accuracy is required

The *Real-time fusion* feature is available for each tracking method.

1. Open the *Scan panel*.
2. Select the required tracking mode.
3. Select the *Real-time fusion* checkbox [2].
4. Click *Preview* and then *Record*. Observe the recommendations in *Scanning Procedure*.
5. Pause and resume the session as necessary.
6. When you stop scanning, the *Workspace* panel will add one or more raw scans named `Scan1` , `Scan2` , `Scan3` and so on, as well as one model named `Scan1-Fusion` . The number of these raw scans corresponds to how many times you pause and resume scanning (see Figure 5.8.).

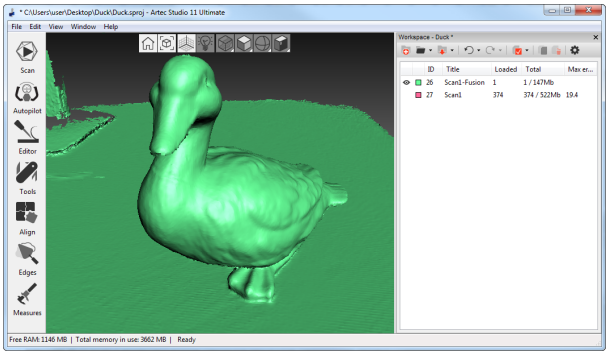


Figure 5.8.: *Workspace* panel after using Real-time fusion.

You can access the *Settings* window and use the *Performance* tab to configure the following *Real-time fusion* settings (see *Real-Time Fusion Settings*):

Voxel size 3D resolution of the model (i.e., the size of the triangulation-grid step in millimeters). The smaller the value, the more geometric details you can detect and capture in 3D.

[2] If you selected the *Targets* mode and cleared the *Disable hybrid tracking for .obc* checkbox (see the *Photogrammetry Settings* section), Artec Studio will clear the *Real-time fusion* checkbox because it doesn't support this combination of options.

5.5.5 Target-Assisted Scanning

Generally, you don't need any special equipment to record using an Artec scanner. If the object has hard-to-scan regions, however, *targets* may be useful. In some cases, they can improve tracking and further registration.

Placing Targets

Whatever the method chosen, you should place at least non-coded *targets* on the object.

Attach non-coded targets (Figure 5.9.) to the object using the following rules:

- Try to place them on flat elements
- Avoid uneven surfaces
- Avoid obstructing significant geometric elements

Figure 5.9.: Non-coded targets placed on an object.

Note: You can specify the target size in the *Settings* dialog of Artec Studio, as *Photogrammetry Settings* describes. If you use non-coded targets from the *Scan Reference* kit, specify `5` mm for the inner diameter and `10` mm for the outer diameter. You should measure targets from other suppliers and specify both diameters in the appropriate fields of the *Settings* dialog.

Place coded targets if your choice is photogrammetry (*Using Photogrammetry Solution (Scan Reference)*).

1. Prepare the objects and surrounding scene. All objects must remain stationary during measurement and capture.
2. Place the cross (Figure 5.11.) on the scene, ensuring that it rests firmly, and it is seen from most points of view. Also double check that all targets on the cross are clearly visible.
3. Place the coded targets on the object and the surroundings. Note that you should distribute them such that at least six to eight coded targets are visible in each image. Random placement is preferable; avoid symmetry and target alignment.

Figure 5.10.: Coded targets.

Using Artec Scanners Only

You don't necessarily need a photogrammetry kit to benefit from targets placed on the object you're scanning; Artec 3D scanners can do all the work. This mode employs extra-hybrid (Geometry + Texture + Targets) tracking and doesn't require you to upload an `OBC` file.

1. Open the *Scan* panel in Artec Studio. Select *Targets* under *Features to track*.
2. Scan the object from all sides
3. Run *Global registration*

Note: As you scan (without having uploaded an `OBC` file), the application registers the target coordinates. You can then *save an OBC file* and use it in later scanning sessions. We strongly recommend running *Global registration* first, however.

Using Photogrammetry Solution (Scan Reference)

By using a combination of special reference *targets* and photogrammetric measurements, you can scan large areas in one session, improve the accuracy of captured surfaces and boost productivity by reducing postprocessing time. The only downside of this method is the preparation. After scanning, however, you need not align the scanned surfaces, so you can immediately proceed to *Fusion* (see the order of postprocessing steps in *3D Scanning at a Glance*).

This synergy of technologies is possible thanks to Artec 3D-scanner and photogrammetry solutions. Several third-party photogrammetry offerings are available on the market. *Scan Reference* photogrammetry is one example. The *Scan Reference* kit includes hardware and software (see Figure 5.11.), a digital camera, a reference-scale cross, non-coded sticky *targets* (which Artec Studio uses to match the captured 3D data to the photogrammetric measurements), and reusable magnetic coded targets (required to automatically carry out measurements in the *Scan Reference* software).

To perform scanning using targets, follow these steps:

1. Take several photos of the object from different angles. To determine the appropriate number of photos, angles and targets for each image, as well as required settings for a calibrated digital camera, consult the *Scan Reference* user manual and FAQ article. General recommendations are as follows:

1. Take photographs at a distance of 0.5–1.5 meters with enabled flash

Figure 5.11.: *Scan Reference* kit
The kit includes (from left to right) coded targets (foreground), a digital camera, a scale cross, a roll of tape with non-coded targets and a carry case.

2. Each photograph should contain as much targets as possible and each target should be captured at least in 10 photos
3. Entire cross should be captured in first 10–12 photographs
4. Capture the object from all sides

1. Move the cross and the coded targets away from the scene.
2. Connect the camera to a PC, then transfer and process the photos using the *Scan Reference* software. Once the calculations are complete, the software will display measurement results on the screen. These results can appear as a point table or a 3D model.
3. Save the point model in an `*.obc` file. This format is the software's default.
4. Open the *Scan* panel in Artec Studio. Select *Targets* under *Features to track*.
5. Click *Load targets from file* and specify the `OBC` file path.
6. Scan the object. When you finish, the software will align all scans.

Important: If you don't want the texture and geometry features to assist target scanning, select the *Disable hybrid tracking for .obc* checkbox (*Photogrammetry Settings*).

5.6 Using Certain Scanner Types

5.6.1 Notes on Scanning With Spider

Because Artec Spider has smaller field of view and provides higher accuracy in comparison with Artec EVA, scanning using it can pose difficulties. Consider the recommendations

given in *Technique* and also the following:

- Opt for rotating table if possible
- Use a piece of paper with text on it as artificial texture
- Double check that objects don't change their shape and position
- Try tuning sensitivity in particular cases (see *Sensitivity*). Avoid extreme values.

We recommend using the Artec Spider scanner only after it reaches its normal operating temperature. As soon as you plug Artec Spider in or connect it to a PC, it starts warming up. If you open the *Scan* panel, you will see two lines that provide the device's current and optimal temperatures. Artec Spider will warm up faster when it's in *Preview* mode. The *Scan* panel also displays additional information about the time remaining until the scanner reaches its optimal temperature.

Note: Artec Spider can operate at temperatures beyond its optimal range, but the accuracy of captured surfaces may be lower.

5.6.2 Notes on Scanning With Third-Party 3D Sensors

Important: Support for third-party 3D sensors is only available in Artec Studio Ultimate.

Third-party 3D sensors (see *Third-Party 3D Sensors*) are not specifically designed to serve as 3D scanners. Because they are multipurpose devices made from inexpensive components, they can scan objects, but the texture and surface quality is far worse than that of professional Artec 3D scanners (see Figure 5.12.). The operating ranges and fields of view for all Artec Studio Ultimate–supported third-party sensors are shown in Figure 12.6..

When using third-party 3D sensors, bear in mind the following:

Providing good lighting is critical because none of the sensors offers built-in flash. Also, use of these devices precludes the ability to adjust the brightness of the texture you are scanning, so good lighting is crucial to obtaining a decent model. Avoid using too much illumination, and avoid using direct light or fluorescent lamps. Intel RealSense R200 is particularly sensitive to direct sunlight.

When using PrimeSense and Asus Xtion sensors, a special technique can help you capture surfaces with consistent brightness:

1. Click the *Preview* button
2. Direct the sensor at the object and hold it for 5 seconds while the sensor adjusts white balance and exposure
3. Click the *Record* button
4. Move the scanner slowly to capture the scene
5. While scanning, keep the sensor as close to the object as possible

Most third-party devices work in the Real-time fusion mode, except for *Kinect v2*. Moreover, this mode is default for Intel RealSense 3D sensors.

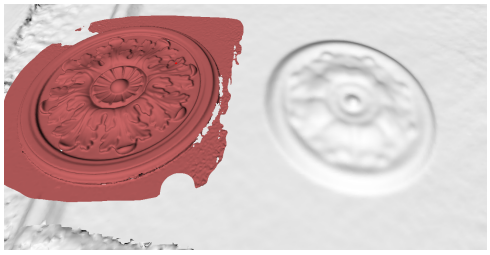


Figure 5.12.: Object captured and processed
(Artec EVA scan on left and *PrimeSense* on right).

5.6.3 Notes on Scanning With MHT

The flash feature in an Artec MHT scanner has a very large but limited number of operation cycles, so ensure that you disable the scanner when it's not in use. Avoid leaving the Artec MHT on for a long time when using the maximum capture rate (15 frames per second). Artec Studio will automatically turn off the Artec MHT after five minutes of continuous operation. Normally the active mode/rest mode is 3 minutes of scanning and 7 minutes of rest; this mode is optimal and significantly increases the lifetime of the flash.

5.7 Tweaking Scanning Options

5.7.1 Tuning Texture Brightness

Note: This option is available only for Artec 3D scanners equipped with texture cameras.

You can adjust the *Texture brightness* setting in *Preview* mode. Use the slider to increase or decrease the brightness of frames captured by the color camera (see Figure 5.14.). Note that the texture brightness affects texture quality as well as tracking steadiness. Observe the recommendations in the Table 5.3..

Table 5.3.: Adjusting texture brightness.

Surface Color	Recommendation
Dark or black	Increase brightness
Light-colored or white	Decrease brightness

5.7.2 Sensitivity

You can tune the *Sensitivity* of Artec 3D scanners if the application fails to reconstruct particular surfaces. Increasing this setting enables the scanner to more easily capture black,

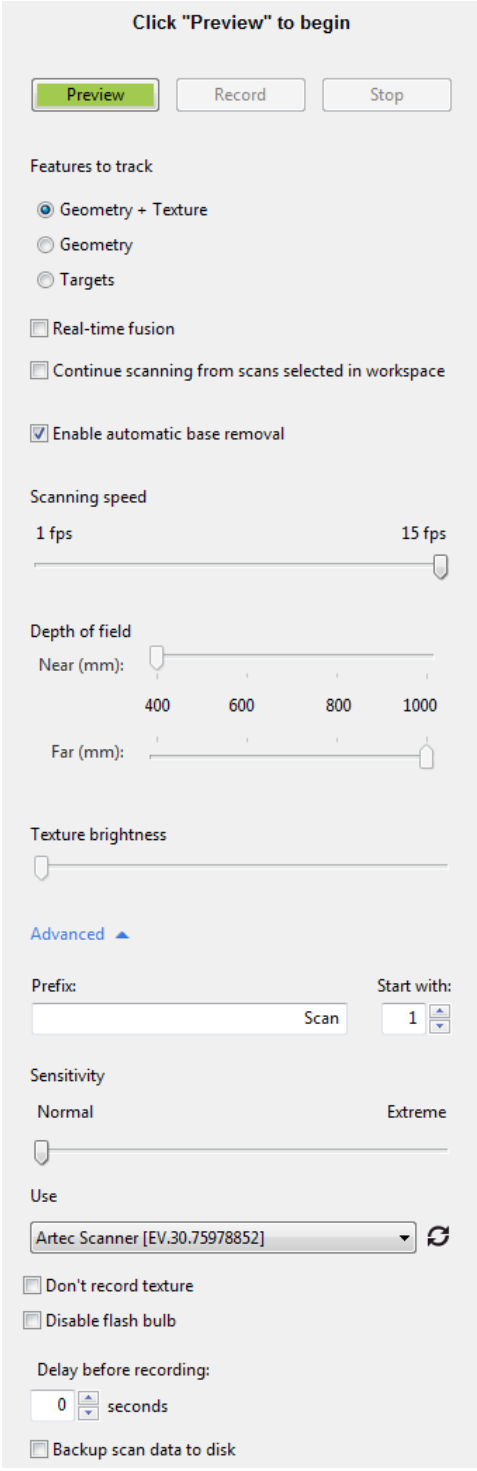


Figure 5.13.: Scan panel in Artec Studio.

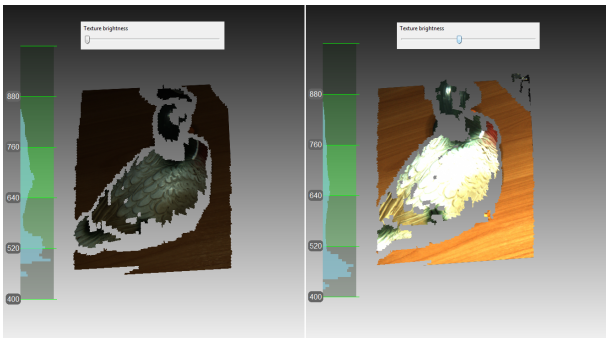


Figure 5.14.: Color-camera brightness adjustment
The brightness is lower on the left and higher on the right (slider positions exaggerated for clarity).

reflective, translucent and fine objects (such as human hair). The higher the sensitivity, the noisier the recorded surfaces will be. Higher values may also reduce the scanning speed.

5.7.3 Frequency for Capturing Texture Frames

Specify the frequency for capturing texture frames by using the corresponding spinner in the *Settings* dialog (see *Texture-Recording Mode* and Figure 10.5.).

5.7.4 Deactivating Scanner Flash

If circumstances prohibit you from using the scanner flash, follow the directions below.

Figure 5.15.: Influence of ambient light on captured results.
On left: flash is turned off; ambient light is poor; results—dark texture. On right: flash is turned off; lighting conditions are improved; results—good texture.

Note that if you disable the flash, you should compensate by using bright ambient light. According to our tests, acceptable texture quality is obtainable with the flash disabled if the surface illuminance is at least 1 000 lux. Compare the models shown in Figure 5.15., which were recorded under different lighting conditions.

The following procedure captures the textured model without using the scanner flash:

1. Open the *Scan* panel and click the *Advanced* link
2. Turn off the texture flash by selecting the *Disable flash bulb* checkbox

3. Use good illumination. Avoid fluorescent lamps.
4. Click *Preview* and direct the scanner at the object
5. Adjust *Texture brightness* and *Texture exposure time*. In most circumstances, values should be as low as possible, because increasing the brightness also increases a texture noise, whereas increasing exposure time can blur the texture. Instead of adjusting sliders, try to further improve the lighting conditions.
6. Capture the scene
7. Perform required postprocessing as described in *Data Processing* to get a textured model
8. Adjust texture parameters for this fusion as described in *Texture Adjustment*. Pay particular attention to the *Hue* and *Saturation* sliders. The *Hue* slider allows you to correct unwanted texture color.

5.7.5 Tuning Exposure Time

You can alter texture exposure time in the *Preview* mode. Adjust this parameter in tandem with the *Texture brightness*. Increasing exposure time can blur the texture. Don't alter the default value unless it's necessary.

5.7.6 Disabling Texture Recording

Clear *Don't record texture* checkbox if you don't want to store texture information in your scans. It is located in the *Advanced* section of the panel and disengages both texture camera and texture flash in the scanner. Note that this option is unavailable for Artec EVA Lite. Don't forget to select this checkbox once you have completed textureless scanning; otherwise, next time you want to start regular scanning the hybrid tracking mode could be unavailable.

Important: Just using the *Geometry* tracking mode it is still not sufficient for the application to don't record texture. Make sure you clear the eponymous checkbox.

5.7.7 Decreasing Scanning Speed

Artec EVA captures objects at up to 15 frames per second, whereas Artec Spider at 7.5. Default values ensure comfortable scanning with smooth movements. However, if you find scanning speed inappropriate, you can decrease it. In this case, Artec Studio will record fewer identical frames and register them faster. To this end, use the *Scanning speed* slider in the *Scan* panel.

Important: Decreasing scanning speed may hinder scanning. Don't use this slider unless it is absolutely necessary.

5.7.8 Supplementary Settings

Customize scan names and starting number by entering your own values in the *Prefix* and *Start with* fields. The software uses these values to create a scan title in the *Workspace* panel (see Figure 8.2., left). You can change the default values `Scan` and `1` to, for example, `Capture` and `14`.

Set backing up scan data to disk Trigger a capture mode that simultaneously records scanning results to a disk by selecting the *Copy scan data to disk* checkbox. This option is enabled when you're working with an existing saved project (see *Saving a Project*) and can be useful when capturing large amounts of data on a computer with insufficient RAM.

Specify a delay (in seconds) before recording using the *Delay before recording* spinner under the *Advanced* section of the *Scan* panel. The countdown begins as soon as you click the *Record* button. To eliminate the delay, set the value to zero.

Decrease specified operating-zone by using the *Near (mm)* and *Far (mm)* sliders in *Scan* panel. Here you can only decrease range within the specified boundaries.

Specify the operating-zone boundaries (in millimeters) By default, Artec Studio provides the correct values for the minimum and maximum limits within which the cutoff planes are to be positioned. These values are different for each 3D scanner model, and they ensure that you capture good-quality 3D data. If high accuracy is a secondary concern, you can manually adjust the depth boundaries, allowing you to capture objects using an Artec L scanner or third-party 3D sensors positioned closer to or further from the object than is recommended. To do so, select the *Override default depth range* checkbox in the *Settings* dialog in the *Scan* tab, then specify new boundaries for the scanning range (For more details about scan settings, see *Capture*).

> **Warning:** Custom depth-range settings may reduce accuracy.

5.8 Troubleshooting

Issue	Possible Resolution
Geometry + Texture radio button missing from *Scan* panel.	You were probably scanning without texture. Clear the *Don't record texture* checkbox in the *Advanced* section.
Final model contains noticeable noise.	You likely scanned the affected areas improperly, or the scanner was too far from the object. Rescan those areas.
Tracking lost error persists.	Make sure *Scan using auto-alignment* is enabled in the *Settings* dialog and use *Geometry + Texture tracking*.

CHAPTER 6

Viewing 3D Models

6.1 3D Navigation

When you have finished scanning, Artec Studio displays the results in the *3D View* window.

6.1.1 Moving, Rotating and Scaling

You can control the observer's perspective in the *3D View* window by moving or rotating the observation point, or by zooming in or out. Use the mouse to control these effects:

Move move the mouse pointer over the *3D View* window. Hold down the left (LMB) and right (RMB) mouse buttons simultaneously, then move the mouse to relocate the model. You can also use the middle mouse button to perform the same operation.

Rotate move the mouse pointer over the *3D View* window. While holding down LMB , move the mouse to rotate the model.

Zoom in and out hold RMB and move the mouse. Moving left or up will zoom out, whereas moving right or down will zoom in. You can also use the mouse wheel to produce the same effect.

6.1.2 Setting Rotation Center

When you rotate the model, the scene always turns around a certain point—the rotation center. Artec Studio will display three small coordinate axes at this point (see Figure 6.1.). When you launch the application, the rotation center will coincide with the origin of the main axis grid. To change its location, double-click LMB at any point on the 3D model: the rotation center will move to this point. Setting the rotation center can be useful when you wish to view a particular object from all sides. In this case, set the rotation center on the object and rotate the view using LMB .

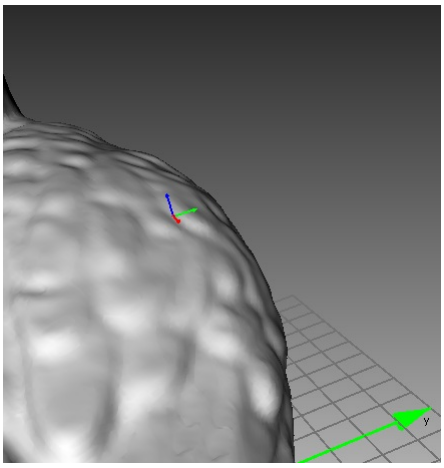


Figure 6.1.: Rotation center.

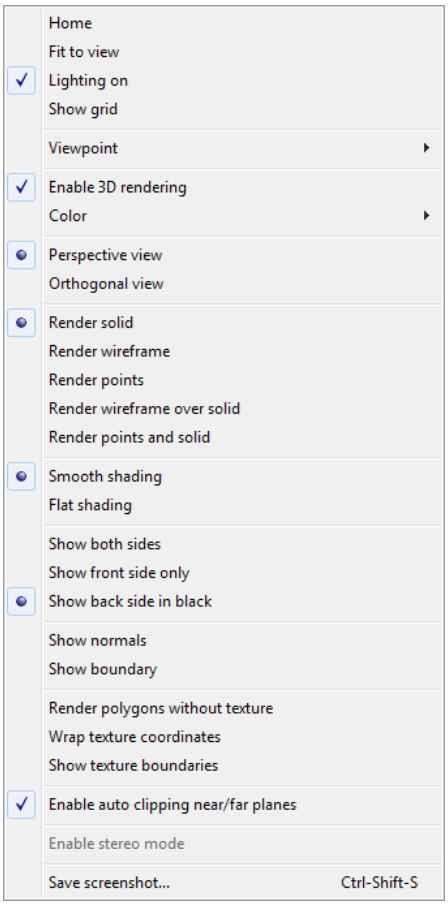


Figure 6.2.: *View* menu options.

6.2 Choosing Projections

The *View* menu (see Figure 6.2.) allows you to choose between perspective and orthogonal projections when displaying the model in the *3D View* window.

Perspective projection is the central projection on a plane produced by direct rays that focus on one point: the projection center. This method produces a visual effect similar to human eyesight.

Orthogonal projection is when the projection center resides infinitely far from the plane of projection; in this case, the projection rays are perpendicular to the observation plane. This method preserves parallel lines and is more commonly used for measurement (see *Measurement Tools* for details).

You can also change projection type in other ways:

- Hit `Ctrl + 5` on the main keyboard
- Hit `5` on the extended numeric keypad (numpad)

6.3 Viewpoints

To quickly toggle a camera view between several predefined positions, use the *View* menu or the keyboard combinations listed in Table 6.1..

Table 6.1.: Key combinations for switching viewpoints.

Viewpoint	Keyboard	Extended Numpad
Front	`Ctrl + Shift + 1`	`1`
Back	`Ctrl + 1`	`Ctrl + 1`
Left	`Ctrl + Shift + 3`	`3`
Right	`Ctrl + 3`	`Ctrl + 3`
Top	`Ctrl + Shift + 7`	`7`
Bottom	`Ctrl + 7`	`Ctrl + 7`

6.4 Displaying 3D Models

The toolbar at the top of the *3D View* window features controls for data-display modes. All the commands for viewing and switching between modes are also available in the *View* menu (see Figure 6.2.).

The  (*Home*) button (or *View* menu option of the same name) restores the view to its original position.

The *Fit to view* command (the  button or *Fit to view* menu option) automatically fits the object to the *3D View* window.

To enable or disable the global coordinate-system axes, select the *Show grid* option in the *View* menu, or press the button on the *3D View* panel.

6.4.1 Rendering and Shading Modes

The *View* menu allows you to choose one of the following 3D rendering options for scanned frames (see Figure 6.3.):

Render solid the most common way to render with a solid fill on all faces using your selected shading method

Render wireframe display polygonal-mesh edges without applying a solid fill to the faces

Render points display polygonal-mesh vertices

Render wireframe over solid apply a solid fill to the faces and use a different color to display edges. This method enables you to visually assess the quality of the polygonal model (see *Mesh Simplification* for details).

Render points and solid automatically display scans in point view, but display models in solid-fill view. This mode eliminates the need to switch to another mode in order to find the best rendering approach for each surface type. It is enabled by default for the Artec Spider scanner.

You can activate any rendering mode from the *3D View* toolbar. Click the button to enable solid-fill mode, to display the wireframe model, to display a point model, to display the wireframe over the solid fill and to display the point or solid-fill model, depending on the selected surfaces.

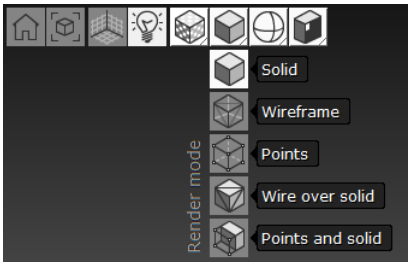


Figure 6.3.: Available rendering modes.

For some examples of the various model-rendering modes, see Figure 6.4..

Also, you can use the *3D View* toolbar (Figure 6.5.) to choose a shading method for the solid fill (Figure 6.6.), or select one from the *View* menu:

Smooth shading (in the toolbar) the color value for each point in a triangular face is calculated using color interpolation at the vertices

Flat shading (in the toolbar) all the points on a triangular face are assigned the same color

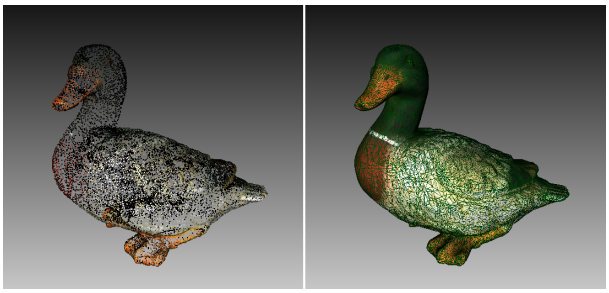


Figure 6.4.: Examples of model using different rendering modes.
Point model on left and wire over solid on right.

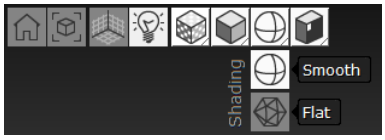


Figure 6.5.: Available shading modes.

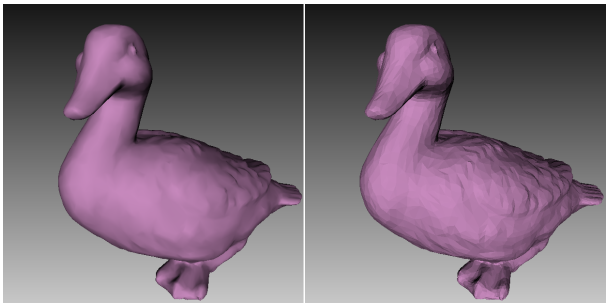


Figure 6.6.: Smooth versus flat shading (respectively).

6.4.2 Lighting, Color and Texture

The *Lighting on* option in the *View* menu—or the  button in the toolbar—toggles the lighting in the *3D View* window. This option may be useful when you must turn the lighting off to see only the outline of the model or to assess texture quality.

The *Texture* option in the *View* menu selects the method for assigning colors to the captured frames. Artec Studio offers the following methods:

- *Texture*—displays textured data; otherwise, the software uses the scan's default color
- *Scan color*—displays the default color of the scan
- *Surface color*—displays each frame in a scan using a different color
- *Max error*—colors the frames in accordance with their registration quality; red indicates a registration error

You can choose among the above-listed options for assigning colors by clicking the corresponding button in the toolbar:  ,  ,  or  , respectively (see Figure 6.7.). Examples illustrating the different color-assignment options are shown in Figure 6.8..

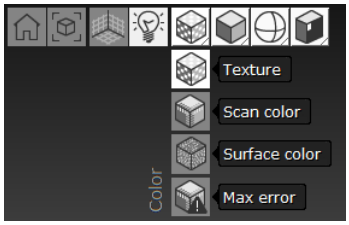


Figure 6.7.: Methods of assigning colors to frames.

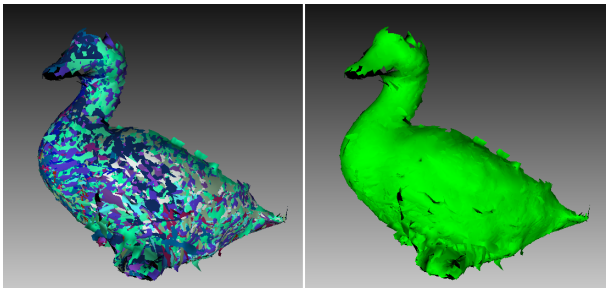


Figure 6.8.: Different color modes for scanned frames.
Individual color for each surface (*Surface color* mode) on left, highlighting registration errors (*Max error* mode) on right.

6.4.3 Back-Face Rendering

Artec Studio offers three methods for rendering a frame's back face:

Show assigns the back face the same color as the model

Cull the back face is not displayed

Black renders the back face in black

You can choose the mode from the *View* menu, or click the  ,  or  button, respectively, in the *3D View* window (see Figure 6.9.). *Black* is the default mode.

Figure 6.9.: Back-face rendering options.

See Figure 6.10. for examples that illustrate the different methods of back-face rendering.

Figure 6.10.: Examples of different methods for back-face rendering.
Show back-face mode on the left, hide (*Cull*) in the middle and *Black* on the right.

6.4.4 Representation of Normals and Boundaries

The *Show normals* option in the *View* menu enables or disables rendering of normals for each vertex. By default, the normals point away from the model surface and toward the 3D scanner. You can change this direction using the *Invert normals* command. You can also switch between modes for displaying normals by hitting the `N` key with the *3D View* window active.

When working with edges, the *Show boundary* feature in the *View* menu allows you to enable and disable highlighting of the model's edges. To toggle this feature, hit the `B` key with the *3D View* window active.

6.4.5 Rendering and Texturing Untextured Polygons

Textured models may have some untextured areas (for instance, the green area in the middle of Figure 6.11.). The *Render polygons without texture* option in the *View* menu allows you to toggle rendering of such areas.

If the texture of the imported model is smaller than the model itself, Artec Studio can wrap it to fill the untextured areas (see Figure 6.11. (on right); for details on importing

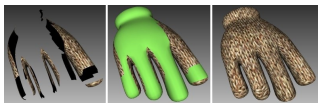


Figure 6.11.: Texture rendering for *Render polygons without texture* and *Wrap texture coordinates* options enabled or disabled.
Polygons without texture not rendered (left), rendered (middle and right) and *Wrap texture coordinates* turned *on* (right).

models, consult *Importing Models and Scans*). The wrapping effect is similar to floor tiling or a repeating wallpaper pattern—that is, the texture repeats periodically. To activate this option, enable the *Wrap texture coordinates* option in the *View* menu.

Note: To display untextured polygons, you must activate the *Render polygons without texture* option as described above; otherwise the wrapping texture will not appear (see Figure 6.11. on left).

6.4.6 Displaying Boundaries of Texture Atlas

Textures applied to 3D models are obviously two-dimensional. You may, however, want to see the boundaries of each texture element on the actual 3D surface. Artec Studio can display a texture-atlas file, such as the the middle image in Figure 8.51., with its boundaries highlighted (see Figure 6.12.). Identifying the way in which the boundaries lie on the surface may, for example, help you determine whether you must simplify the model to get better texture application.

To enable boundary display, access the *View* menu and select *Show texture boundaries*. To disable this feature, make sure this menu command is unchecked.

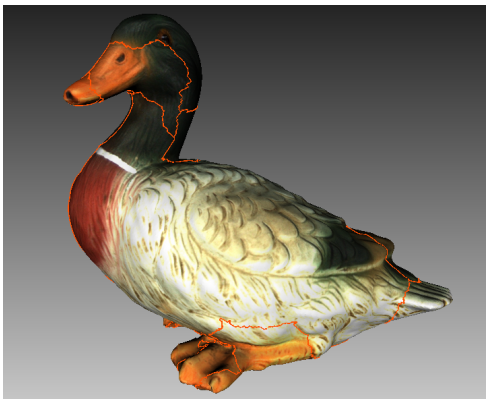


Figure 6.12.: 3D model with texture-atlas boundaries.

Technically, this command also works for textures produced by triangle methods, but it provides no usable information.

6.4.7 Stereo Mode

Stereo mode (the *Enable stereo mode* command in the *View* menu) is for operations designed to work with stereo displays and stereoscopic-3D-enabled equipment. To enable this mode, your system must support OpenGL Stereo. The Nvidia Quadro family of professional graphics cards is one example of such equipment. When stereo mode is unavailable, the menu option will be grayed out.

For more information on compatible equipment, see the Nvidia website.

6.5 Saving Screenshots

You can capture surfaces displayed in the *3D View* window and save them in a graphics file. Unlike the conventional system `Print Screen` command, this option saves only the contents of the *3D View* window (see Figure 6.14.) and ignores any background. It also captures the following objects with the surfaces:

- Coordinate axes
- Points, lines and planes
- Annotations
- Surface-distance maps and their histograms (see *Measurement Tools*)
- Measurement results (points, lines and labels)

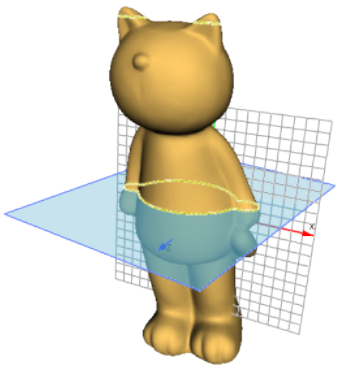


Figure 6.13.: Example screenshot featuring section

To capture a screenshot, follow this procedure:

1. Select the *Save screenshot...* option in the *View* menu, or hit `Shift+Ctrl+S` .
2. In the dialog, specify the destination folder and file name, then click the *Save* button. Artec Studio will save the file in `PNG` format.

Note: If you save a screenshot using an existing file name, Artec Studio will overwrite that file without warning. Be sure to specify a unique file name to avoid overwriting other files.

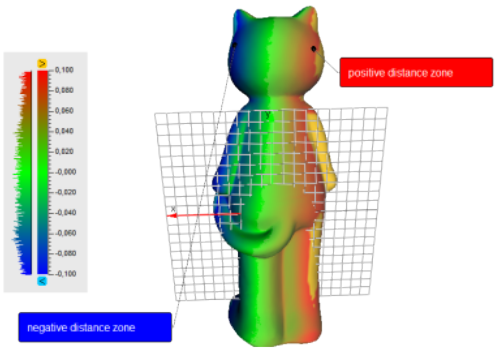


Figure 6.14.: Example screenshot featuring sirface-distance map with annotations

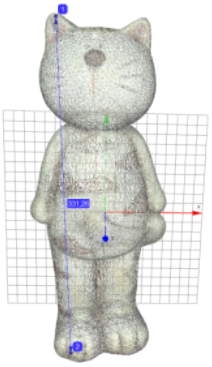


Figure 6.15.: Example screenshot featuring linear measurement

CHAPTER 7

Project Operations

A project encompasses all 3D data obtained by scanning and postprocessing that can be saved to disk and accessed for later use. In addition, it contains measurement results (see *Measurement Tools*). For each project, a corresponding folder contains all project data as well as a project file describing the structure of that data.

7.1 Creating a Project

We recommend creating and naming a project before you start scanning (see *Scanning Procedure*). You can create a new project using the *File* → *New project* menu option. Click the  button at the top of the *Workspace* panel, or use the shortcut `Ctrl + N`. Then, in the subsequent dialog (see Figure 7.1.), enter the project name and specify the path for the folder to which you want to save your project. While you're working with a given project, the header of *Workspace* window will display its name.

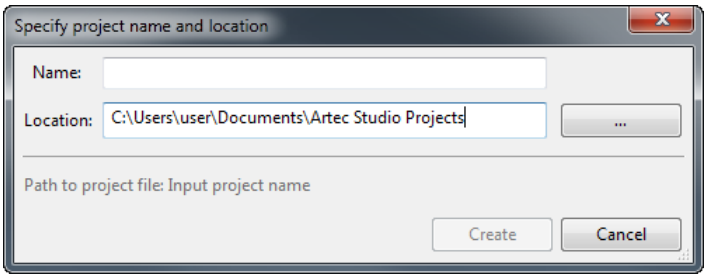


Figure 7.1.: Project-creation dialog.

Creating a project is unnecessary if you don't plan to process or otherwise use the scanned material in a future session.

7.2 Saving a Project

You can save your project using the *File* → *Save project* menu option, by clicking  at the top of the *Workspace* panel or by hitting `Ctrl + S`. For unsaved projects, a project-

creation dialog will appear (see *Creating a Project*).

Artec Studio saves data incrementally, meaning that if you save an existing project, the application will only save newly changed or added data.

7.3 Opening a Project

To open an existing project, use the *File* → *Open project* menu option, click at the top of the *Workspace* panel or hit `Ctrl + O`.

Note: Files from Artec Studio versions 8, 9, 10 and 11 are mutually compatible. Earlier versions, however, may be unable to open projects saved in a later version using the `SPROJ` format.

By default, when you open a project, the application will restore it to the state in which it was last saved (the three scan-loading states include loaded, unloaded and key frames only—see *Selectively Loading Project Data*). To load faster by opening the project without loading any scans, use the *Open project (scans not loaded)* dropdown menu option under the button. Alternatively, use the same option from the *File* menu or hit `Ctrl + Shift + O`.

Note: When Artec Studio opens a project, it will determine the amount of available memory. If the scan you are trying to load requires more memory than is available in your system, the application will process it as an "unloaded" scan.

7.4 Exporting Models and Scans

When you want to store data for future processing, the best approach is to save the project as an `SPROJ` file or to export the data to the `SCAN` format. Any Artec Studio version can open the latter format. If you plan to use the data in other applications, however, you should save scans and individual frames in another format.

You may also need to perform one of the following tasks:

Export one or more scans. Select the *Export scans...* command. Doing so will save all frames to folders with names that match the corresponding scan names. An exception is the `SCAN` format; in this case, Artec Studio not only stores the frame-by-frame scan structure, but it does so in a single file.

Export a single surface. The best approach here is to select the *Export meshes...* command. If you marked several scans, models or frames using the button, Artec Studio will suggest merging them.

7.4.1 Exporting Scans

To export scans:

1. Mark any scans you want to export using the button.
2. Select the *Export scans...* command in the *File* menu or the corresponding dropdown menu option using in the *Workspace* panel.
3. Click the ... button to open and specify the destination folder.
4. Select *Scan export format* using the eponymous dropdown list (see Figure 7.2.).
5. If the selected format supports textures, also specify the texture format.
6. Select the *Apply transformation* checkbox, or leave it cleared (for more information, consult *Understanding How Artec Studio Applies Transformations*).
7. Click *OK*.

7.4.2 Exporting Meshes

To export a mesh:

1. Mark one or more models using or select frames in the scan by clicking on them while holding the `Ctrl` key.
2. Select the *Export meshes...* command in the *File* menu or select the corresponding dropdown menu option by clicking the triangle near the button in the *Workspace* panel.
3. Click the ... button in the current window.
4. Specify the destination folder, enter the file name, and select the appropriate format from the dropdown list.
5. Click *Save*.
6. If required, specify the *Texture export format* (see *Storing and Exporting Color Information*).
7. Click *OK*.

See also:

Model Placement

Note: The export process for models and scans runs in the background, so the application will allow you to continue working with the scans. The progress indicator for the export operation will appear at the bottom of the main application window. To abort the operation, click *Cancel* in the bottom-right corner.

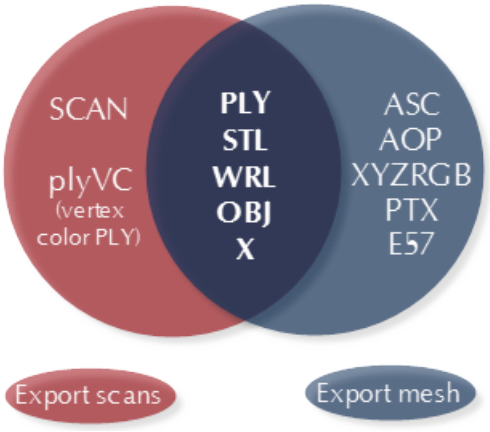


Figure 7.2.: Formats available for each command as well as for both commands.

7.4.3 Understanding How Artec Studio Applies Transformations

Artec Studio offers two options for exporting surfaces:

1. Store surfaces using the scanner coordinates and create `XF` text files that contain the coordinates calculated during registration. To use this approach, clear the *Apply transformations* checkbox.
2. Store surfaces that are relocated to the positions calculated during registration. In this case, `XF` files contain no relevant data. To use this approach, select the *Apply transformations* checkbox.

Special Aspects of Scan Placement

In most cases when you're exporting a scan to a common 3D-graphics format, you should select the *Apply transformations* checkbox. By doing so, you instruct third-party applications to display surfaces in the same way that Artec Studio does: that is, with the origin at the center of mass. If for some reason you need to store a scan in the scanner's coordinate system—in other words, with surfaces located at a distance from the origin that is equal to scanner's operating range—clear the *Apply transformations* checkbox.

Technically, Artec Studio saves scans in the scanner's coordinate system, but it displays them in a user-friendly manner by placing the origin at the center of mass. The actual positions of surfaces calculated during registration are stored in text (`XF`) files. Therefore, when you're importing files using Artec Studio, it makes no difference whether the checkbox was cleared when Artec Studio exported them. It does make a difference, however, for third-party applications that cannot read `XF` files simultaneously with 3D geometry.

7.4.4 Storing and Exporting Color Information

You can transfer color information for 3D surfaces in three ways. The most common is through a texture using a separate bitmap file (see *Applying Texture*). Another option is

to save color information in each vertex of a mesh. The third is to assign a small textured fragment to each polygon. The two latter methods produce no texture files.

Colors stored in a vertex are blended throughout the polygon. As a result, you should avoid oversimplifying the exported mesh; otherwise, colors blended over a large face may fail to render true texture information.

Table 7.1.: Formats that support color-information transfer.

Texture stored as a bitmap	PLY, VRML (*.wrl), OBJ, X, e57
Model file contains separate texture for each face	PTX
Formats that support vertex color	plyVC, XYZRGB

When exporting texture as a bitmap image, you can select one of the following formats: PNG, BMP or JPG. PNG format provides the best quality for a given file size thanks to its lossless image compression. JPG is the most compact format.

7.4.5 Exporting Target Coordinates

If you scan while in the *Targets* tracking mode *using only Artec scanners*, you can save an OBC file containing the target coordinates. Once you finish scanning, run *Global registration*, then do the following:

1. Use the button to mark any scans that you captured without having uploaded an OBC file.
2. Select the *Export scans...* command from the *File* menu, or select the corresponding dropdown menu option using in the *Workspace* panel.
3. Click the ... button to open and specify the destination folder.
4. Select *obc* from the *Scan export format* dropdown list.
5. Click *OK*. The targets.obc file will appear in the folder you specified.

For more information on the OBC file structure, consult the FAQ.

7.4.6 Exporting to Leios

Artec Studio enables you to export files to *Leios* by accessing the *File* menu if the *Leios* software is already installed on your computer.

1. Select a model in the *Workspace* panel
2. Open *File* → *Export to Leios*
3. Then, in *Leios*, select millimeters as the length unit for the imported files.

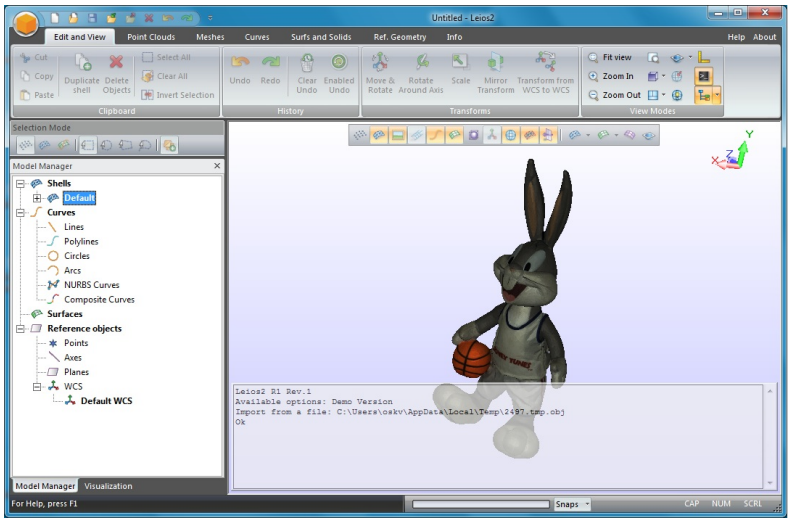


Figure 7.3.: Model exported to *Leios*

7.4.7 Exporting to Geomagic Design X

Polygonal models created in Artec Studio are insufficient for most design needs. Geomagic Design X (formerly Rapidform XOR) is purpose built to create manufacturing-ready *CAD model*s directly from meshes.

To export a model,

1. Make sure Geomagic Design X is installed on your computer
2. In the *Workspace* panel, mark one model using the flag
3. Select the *Export to Design X* command from the *File* menu
4. Wait for the model in `OBJ` format to open in the reverse-engineering system.

7.4.8 Exporting to SolidWorks

Artec Studio allows you to export models to SolidWorks by using third-party plug-ins. It supports the following plug-ins:

- Geomagic for SolidWorks
- DezignWorks for SolidWorks

Note: If you have installed both plug-ins, Artec Studio will use Geomagic for SolidWorks.

To export a model,

1. Make sure SolidWorks and either of the plug-ins are installed on your computer
2. In the *Workspace* panel, mark one model using the flag
3. Select the *Export to SolidWorks* command from the *File* menu

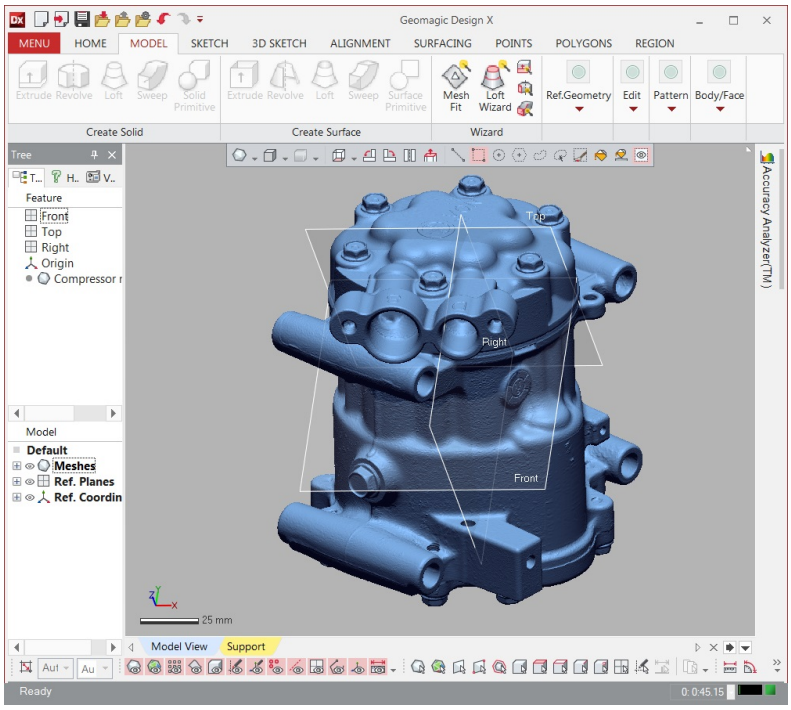


Figure 7.4.: Model exported to *Geomagic Design X*

4. Wait for the model to open in the CAD system.

7.5 Importing Models and Scans

Importing is another way to load data into Artec Studio in place of capturing or opening a project. You can import scan files created in earlier versions of the software, as well as individual frames, in the following formats: `PLY` , `STL` , `VRML` , `OBJ` and `PTX` . To do so, use the *File* → *Import...* menu option, `Ctrl + I` or the dropdown menu option for the button. Next, select a file for importing. You can also drag and drop a file into the main Artec Studio window, or just double click on it.

Note: The import process runs in the background, so you can continue working with the scans you've already loaded. The progress indicator for the import operation will appear at the bottom of the main application window. To abort the operation, click *Cancel* in the bottom-right corner.

Artec Studio will import frame files as individual single-frame scans. After importing each scan, the application calculates the *key frames* for any scan that contains more than one surface. Also, the application will check the surfaces for defects when the appropriate setting is enabled (see *Surface-Consistency Detection During Import*). If it finds defects, it will show a dialog with a list of defective surfaces once the import operation is complete. You can then choose which ones should be corrected (see Figure 7.5.).

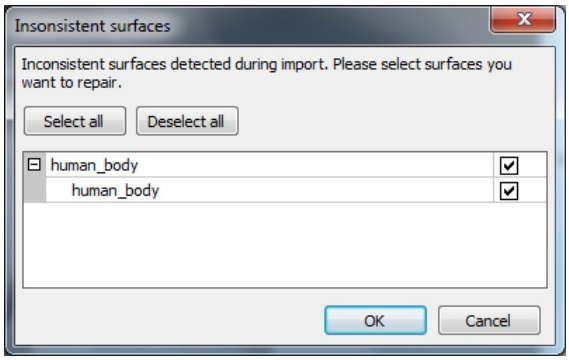


Figure 7.5.: Dialog for selecting surfaces to correct.

7.6 History of Project Changes

Artec Studio stores all data changes, so you can undo them later. To undo an operation, click the button in the *Workspace* panel, or click to perform the previously undone operation. You can also use `Ctrl + Z` or `Ctrl + Y`. Use the dropdown menu buttons or, respectively, to undo or redo several operations at once.

When you save a project, Artec Studio stores 3D data together with the history of changes. You can select the maximum length of the history in the settings window under the *Performance* tab (see *Command History*). In addition, the *Compact memory* button allows you to save the history of changes on a local drive and thus free up RAM. Also, the *Clear command history* button clears the change history, likewise freeing up RAM, and makes the undo operation for the most recent changes unavailable. To clear the history, you can use the *Edit* → *Clear history* menu option in the main window or hit `Ctrl + Alt + H`.

7.7 Selectively Loading Project Data

When working with a large data set, you may often find it necessary to free up RAM without deleting any of the project data. To this end, Artec Studio implements a mechanism for selectively loading scans. You can move to disk any currently unused scans to free up extra RAM. If a particular algorithm later requires any of the unloaded scans, the application will automatically reload them. Frames that are not currently loaded into the memory won't show in the *3D View* window.

Any scans or frames that are completely unloaded from memory will appear in a gray italicized font in the *Workspace* window (see Figure 7.6.).

Note: Before you can change a scan's loading status, you must save the project.

To change the loading status, select the scans in the *Workspace* window (using the `Ctrl` key), click `RMB` and then select one of the scan-loading options in the pop-up menu (see Figure 7.6.):

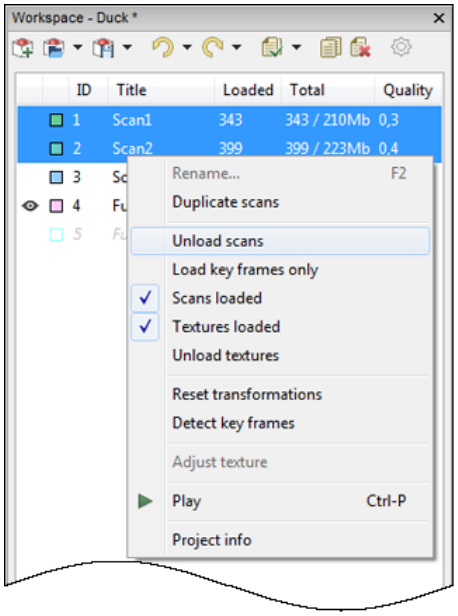


Figure 7.6.: Selectively unloading scans.

Table 7.2.: Workspace menu commands and icons

Menu Command	Function	Icon Appearance
Unload scans	Fully unload scans from RAM	☐
Load key frames only	Only load key frames into RAM	◪
Load scans	Fully load scans into RAM	■
Load textures	Fully load texture images into RAM	–
Unload textures	Fully unload textures from RAM	–

Algorithms may automatically change the loading status of project data in the following cases:

You have selected unloaded scans for processing by clicking the 👁 button. Artec Studio will load these scans into memory.

Execution of the algorithm requires large amounts of memory. Artec Studio will unload unused scans, frames, textures or a combination thereof.

Note: In addition to 3D data, the change history can also consume a large portion of memory. For information on how to control the history size as well as how to unload or clear it, consult *History of Project Changes*.

7.8 Autosaving a Project

A project can be saved by either the user or Artec Studio. The latter case is called autosaving. For temporary (i.e., unsaved) projects, autosaving is unavailable. The application autosaves a project in the following cases:

- Before running the texturing algorithm (see *Texturing*)
- When scanning is complete and the *Backup scan data to disk* option is selected (see *Scanning Procedure*)
- When unloading scans with unsaved changes (see *Selectively Loading Project Data*)
- When the *Save project before starting algorithms* setting is selected (see *Autosave Options*):
  - Before launching algorithms from the *Tools* panel
  - Before and after running the Global registration algorithm (*Global Registration*)
  - Before starting *Autopilot* (*Autopilot*).

CHAPTER 8

Data Processing

Once you have captured an object from all desired angles and created a sufficient number of scans, you can then build a 3D model. This chapter offers a detailed description of the process. Most of the examples herein use a decorative plastic duck figure as the test object (see Figure 8.1.).

Figure 8.1.: Target object: a decorative duck figure.

The process of creating the final model includes the following stages:

See also:

3D Scanning at a Glance.

- Revising and editing the data (*Revising and Editing Scans*)
- Scan alignment (*Scan Alignment*)
- Global data registration (*Global Registration*)
- Fusion of data into a 3D model (*Fusion*)
- Final editing of the 3D model (*Editing Models*)
- Texturing (*Texturing*)

8.1 Revising and Editing Scans

After each scanning session, Artec Studio saves the sequence of frames as a separate scan. The list of all scans for a given project appears in the *Workspace* panel (see Figure 8.2.).

Data in the *Workspace* panel is arranged in several columns:

Selection flag —scans marked with a in this column will appear in the *3D View* window and will undergo processing by all Artec Studio algorithms and tools.

Color —in this column, each scan has a colored square next to it. The square's fill depends on the number of scan frames loaded into the application. When all frames are loaded, the square will be completely filled in. When only key frames are loaded, it will be half filled, and when all the scan data is unloaded, it will be unfilled (see *Selectively Loading Project Data*). You can change the scan color by clicking on the corresponding square and selecting the desired color from the palette.

ID —ID number of the scan.

Title —when a scan is created, Artec Studio automatically assigns it a name, such as Scan1, Scan2 and so on, according to the values in the *Prefix* and *Start with* fields in the *Scan* panel. To rename a scan, select it by left-clicking on its name. Then either hit `F2` or right-click on the scan name to open the dropdown menu. Select the *Rename...* option. Both approaches open a dialog that allows you to specify the new name.

Loaded —number of scan frames loaded into memory (see *Selectively Loading Project Data*).

Total —total number of frames and size of a particular scan (in MB).

Max error —the largest registration-error value among all frames in the scan.

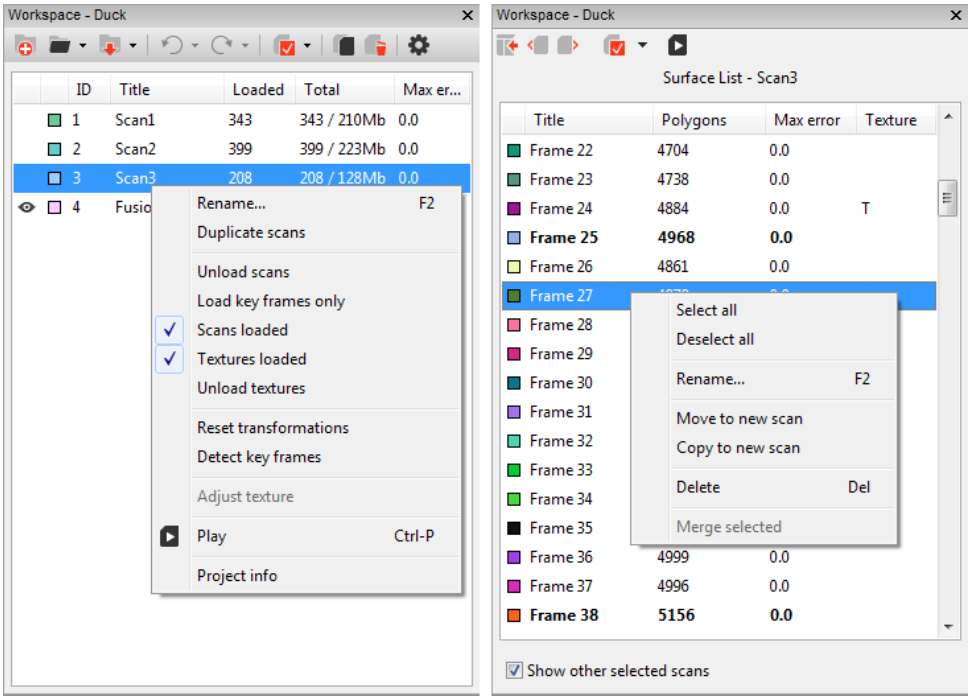


Figure 8.2.: *Workspace* panel: scan list (original view) on left and surface list on right.

8.1.1 Selecting Data

Selecting Scans

Note: To view a scan in the *3D View* window or to process it using a tool, first mark it with the icon.

Purpose	Method	Alternate Method
Select scan in *Workspace*	Left-click on the scan name	–
Display scan in *3D View* window and activate it for processing	Left-click in the empty area of the leftmost column	Select scan name using `Shift + Alt + LMB`
Hide scan in *3D View* window and deactivate it for processing	Left-click on icon	Select scan name using `Shift + Alt + LMB`
Batch selection (deselection) of scans for display and processing	Click	Hit `Ctrl + A` (`Ctrl + D`)
Select a single scan for processing and deselect others	Select the scan name using `Ctrl + Alt + LMB`	Use `Ctrl + LMB` in the empty area of the leftmost column

In addition to the methods in the table above, you can use commands from the dropdown menu of the button. See also the full list of hot keys in *Hot Keys*.

Selecting Frames

Double-clicking the scan name opens the *Surface List* panel, revealing all frames in that scan (see Figure 8.2., right). If the scan has only one frame, a panel with frame data will appear in place of a list (see Figure 8.3.).

Highlighting specific frames will make them (and only them) appear in the *3D View* window. When the *Show other selected scans* option at the bottom of the panel is checked, the selected frames from other scans will also appear in the *3D View* window. You can select frames in a number of ways:

- Click `LMB` on the frame name to select it while clearing other selections.
- Click `LMB` while holding the `Ctrl` key to select several frames at once.
- Click `LMB` while holding the `Shift` key to select a sequence of frames in the specified range.
- Click the icon in the *Surface List* panel to select all frames or to clear the selection.
- Use the dropdown menu for to quickly select all key frames or all textured frames.
- Click `Ctrl + A` to select all frames.

By using the or `Ctrl + P` shortcut you can start a sequential frame demonstration, which you can then stop by pressing or hitting `Ctrl + P` again.

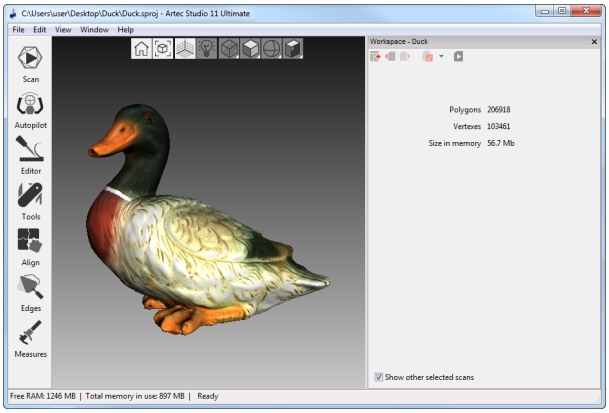


Figure 8.3.: Single-frame scan (model) representation.

8.1.2 Revising Scans

As you begin building a 3D model, you should start by preprocessing your scans: remove unwanted frames, separate misaligned areas (if any) into separate scans and cut out unwanted objects from the scene.

You may, however, encounter the following problems:

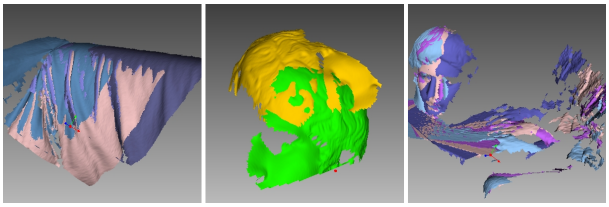


Figure 8.4.: Possible scan errors.
Bad geometry on the left, scan misalignment in the middle and hands captured in frames on the right.

- Misaligned frames (see Figure 8.4., left)—may occur because of small size, an insufficient number of geometrical features on the object or an insufficient number of polygons in a frame.
- Misaligned parts (see Figure 8.4., middle)—occurs when the real-time alignment algorithm incorrectly determines the position of the new frame relative to previous ones.
- Unwanted objects in the frame (see Figure 8.4., right).

A visual inspection of the frames can be very helpful in determining problematic areas. To perform a visual inspection, select the scan and view all the frames that it contains by holding `Up Arrow` or `Down Arrow` on the keyboard. This technique can easily detect misaligned frames.

See also:

Misalignment Detection.

Removing Unwanted Frames

You must delete from your scans any misaligned frames as well as frames with an insufficient number of polygons. To do so, select the frames from the list and hit `Delete` .

Note: The system will not ask you for confirmation before performing this operation; it will delete data instantly once you hit `Delete` . You can restore deleted data by clicking the (*Undo*) button.

Separating Scans

During the fine-alignment process, frames in certain scans may be misaligned. Sometimes it's possible to divide the problematic scan into several scans, where each part is registered fairly well. In this case, divide the scan. To move some of the frames into a new scan, use the following procedure:

1. Select in the *Surface List* panel the frames you want to move (see *Selecting Frames*).
2. Click `RMB` and select *Move to new scan* (Figure 8.2., right).

You can also fix alignment errors in another way: reset the current frame-transformation values and repeat the registration, making any appropriate changes to the settings. Select the desired scan in the *Workspace* panel, click on it using `RMB` and select *Reset transformations* from the dropdown menu. Doing so will reset the computed positions of individual frames in the scan. A dialog will then appear, prompting you to confirm the operation. To compute new positions, run the *Rough serial registration* and then *Fine registration* algorithms (see *Fine Registration*).

8.1.3 Editing Scans

To edit selected scans, open the *Editor* tools from the side panel. The , , , , , and icons will appear alongside the icon bar in the *3D View* window. These buttons correspond respectively to the *Positioning*, *Transformation*, *Smoothing brush*, *Eraser*, *Defeature brush* and *Texture-healing brush* tools.

Moving, Rotating and Scaling (Transformation Tool)

The *Transformation tool* allows you to move, rotate or scale objects in the *3D View* window.

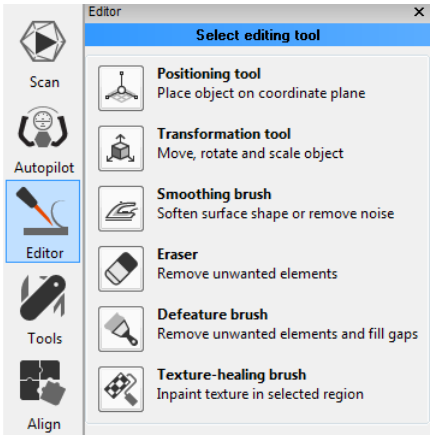


Figure 8.5.: *Editor* panel.

To access this tool, open the *Editor* panel and select *Transformation tool* by either clicking  or hitting `T`. The panel will open, displaying three tabs that correspond to different modes for altering the object position in the global coordinate system. The name of the active mode appears at the bottom of the *3D View* window.

To enter translation mode, click the *Translate* tab or hit `T`. Three input fields will appear in the *Editor* panel showing the current origin coordinates (in millimeters) of the local coordinate system. The initial position of the local coordinate system will be in the center of the global one. To translate an object, do either of the following:

- Enter the new coordinate values for the local system using the input fields in the *Editor* panel. To adjust the position only along a specific axis, first hit the corresponding `X`, `Y` or `Z` key.
- Freely translate the object in the *3D View* window by dragging the control square. Or translate the object along a specific axis by dragging only the necessary control arrow near the control square (see Figure 8.6.).

Note: Orienting the object may be easier if you first specify a new position for the origin of the local coordinate system: double-click on the desired surface point in the *3D View* window.

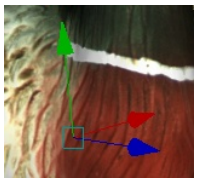


Figure 8.6.: Translation control

To enter rotation mode, click the *Rotate* tab or hit `R`. Three input fields containing the Euler-angle values will appear in the *Editor* panel. Initially, all values are set to zero. To rotate the object, do either of the following:

- Enter the new angle values (in degrees) using the input fields in the *Editor* panel.
- Drag one of the three circles (see Figure 8.7.) to rotate the object. Hitting the key that corresponds the required axis (`X` , `Y` or `Z`) will hide the controls for the other axes.

Note: Orienting the object may be easier if you first specify a new position for the center of the local coordinate system: double-click on the desired surface point in the *3D View* window.

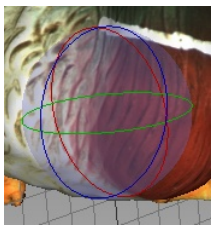


Figure 8.7.: Rotation control

To enter scaling mode, click the *Scale* tab or hit `S` . A single input field with the current scale value (1.000) will appear in the *Editor* panel. You have two options for scaling the object:

- Enter the new scale value in the field.
- Drag the origin of the control (Figure 8.8.) or either of its round ends in the *3D View* window.

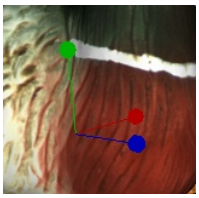


Figure 8.8.: Scaling control

After altering the object using any of the methods described above, confirm or cancel your changes by clicking *Apply* or *Cancel*, respectively. Each time you click *Apply*, Artec Studio will save the object position in the project history. Therefore, you can revert to the initial object position using the (*Undo*) button in the *Workspace* panel after you exit the *Editor* panel.

Placing Objects on Coordinate Plane (Positioning Tool)

You may need to place the model on one of the coordinate planes (e.g., for aesthetic reasons or when preparing the model for measurements, for capturing a screenshot, for

exporting and so on). Instead of adjusting the model position using the *Rotate* and *Translate* modes of the *Transformation tool*, you can use the special *Positioning tool*. To do so, follow these steps below.

Tip: The *Enable automatic base removal* option may come in useful to position scans automatically after the scanning completes (see *Base Removal: Erasing a Supporting Surface*.)

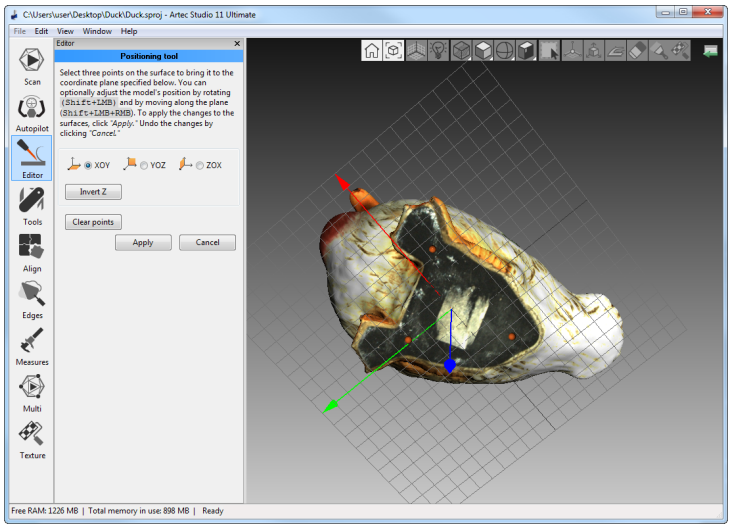


Figure 8.9.: Positioning the model in the global coordinate system.

1. Open the *Editor* panel from the side toolbar and click either *Positioning tool* or the  button in the upper part of the *3D View* window, or hit `P` .
2. Choose the coordinate plane in which you want to place the model by activating one of the following options: *XOY*, *YOZ* or *ZOX*. Note that you may skip this step and return to it after Step 3.
3. Use `LMB` to specify at least three points on the surface; the plane will automatically pass through their center of mass (see Figure 8.9.). The following conditions will then apply:
   (a) For each additional point you specify, Artec Studio rebuilds the plane. Click *Clear points* at any time to redefine the points.

   Note: Three points determine a plane. When you're dealing with nonplanar surfaces, however, three points may be insufficient. In that case, the more points you specify, the more precisely a plane will fit the surface.

   (b) In addition to the plane passing through the center of mass of the points you select, the coordinate origin will shift to that location as well.
   (c) The position of the coordinate origin is adjustable, as Step 5 describes.

4. Invert the direction of the coordinate axis, if desired, by clicking the *Invert Z* button for the XOY plane, *Invert X* for YOZ, or *Invert Y* for ZOX.
5. If appropriate, adjust the model's position relative to the coordinate origin:
   (a) `Shift + LMB` —rotate the model around the axis that is currently normal to the plane
   (b) `Shift + RMB` —move the model along the plane in a fixed direction
   (c) `Shift + LMB + RMB` —move freely along the plane
6. Hit *Apply* to fix the model on a specified plane or *Cancel* if you are dissatisfied with the position.

Smoothing Brush

The *Smoothing brush* is a tool that you can employ selectively in specific areas without touching areas that require no alteration (for more information about automatic smoothing, consult *Smoothing*).

To use the *Smoothing brush*,

1. Select just one surface
2. Open the *Editor* panel, and click the  icon or hit `S` .
3. Hit `Ctrl` , an orange region will appear around the cursor in the *3D View* window.
4. Change brush size if necessary:
   - Use either the `Ctrl + [` and `Ctrl + ]` shortcuts or
   - Use `Scroll wheel` .
   - Enter a size (in millimeters) in the *Brush size* field.
   - Alternatively, you can adjust the slider bar in the *Smoothing brush* panel.
5. Set the smoothing strength if necessary:
   - Enter the desired value in the *Smoothing strength* field or
   - Adjust the slider bar.
6. Hold `LMB` and paint the surface region in order to smooth it. The tool will smooth the affected areas (see Figure 8.11., right).

Once you're done, click the *Apply* or *Cancel* button.

Erasing Portions of Scans

Nearly always, the scanning process will capture unwanted elements, such as walls, the operator's hands, surfaces on which the object is located and other extraneous objects. This unwanted data can hinder postprocessing. To avoid this problem, we recommend

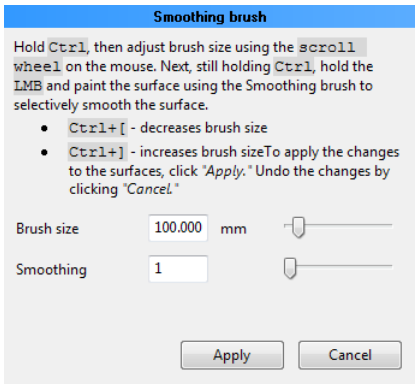


Figure 8.10.: *Smoothing brush* panel.

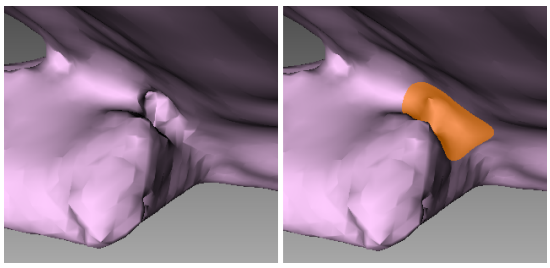


Figure 8.11.: Before smoothing (left) and smoothing out a poorly captured area (right).

eliminating these objects before processing. We designed several options to quickly and easily remove unwanted elements from the scene (see Figure 8.13.).

2D selection —is designed for deleting areas and elements of medium size.

3D selection —is useful for accurately cleaning small object areas.

Rectangular selection —allows you to select large rectangular regions.

Lasso selection —allows you to create a selection by freely outlining it with the cursor.

Cutoff-plane selection —is a special mode for removing flat surfaces (table, floor or base) on which the object is resting. This mode uses a cutting plane that divides the scan into two parts: the first will remain and the second will be erased (see Figure 8.16.).

Tip: The *Enable automatic base removal* option deletes the supporting surface automatically after you close the *Scan* panel (see *Base Removal: Erasing a Supporting Surface*.)

Use the following general procedure to erase unwanted elements:

1. In the *Workspace* panel, select the scan you want to edit and open the *Editor* panel by clicking its icon in the side toolbar. Editor icons will appear alongside the existing ones in the *3D View* toolbar.
2. If the scan is rendered with no texture, make sure its color is neither red nor any shade of red. Assigning non-red colors to the scan will help you easily identify the polygons you have selected for erasure. If necessary, change the scan's color by clicking the colored square (■) near its name.

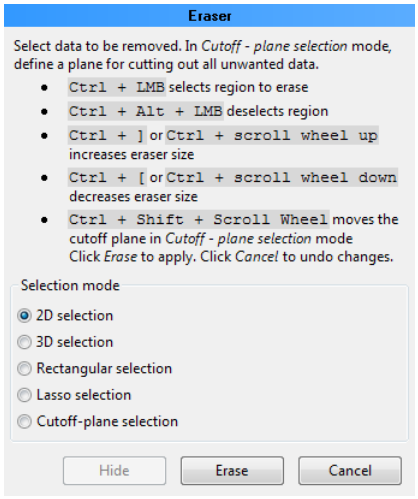


Figure 8.12.: *Eraser* panel.

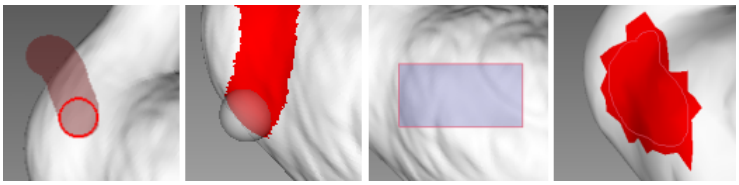


Figure 8.13.: Various *Eraser* modes (from left to right): *2D*, *3D*, *Rectangular*, *Lasso*.

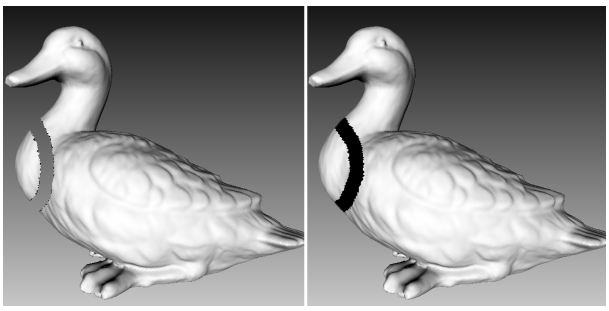


Figure 8.14.: *Select through* in *2D* Eraser: enabled on left and disabled on right.

3. Open the *Eraser* tool by clicking  or by hitting `E`.
4. Select the desired erasure mode (consult the list above).

> **Note:** If you intend to use *Cutoff-plane selection*, make sure the *Select through* toggle is in the  position in the *3D View* window.

5. Mark the elements you want to erase. Hold down the `Ctrl` key and do any one of following, depending on the active mode:
   - *2D/3D selection*—adjust the tool size (see Table 8.1.) and paint over the area using `LMB`.
   - *Rectangular selection*—drag the cursor to select a rectangular region.
   - *Lasso selection*—drag the cursor to freely outline an irregular region.
   - *Cutoff-plane selection*—adjust the tool size (see the table) and paint over the flat area. Once you have released the mouse button, a plane will appear (see Figure 8.16.). If necessary, adjust the plane level by using `Scroll wheel` while holding down `Ctrl+Shift`.
6. Click *Erase* to eliminate the area highlighted in red or to apply cutting plane.

Table 8.1.: Basic actions in the Eraser mode.

Purpose	Procedure
Deselect region	Reselect the region while holding down `Ctrl+Alt`
Undo operation	Hit `Ctrl+Z` or click 
Adjust tool size	Use `]` and `[` keys or `Scroll wheel` while holding down `Ctrl`
Protect backface from erasure	Use *Select through* toggle:  —backface is protected (see Figure 8.14., right); mandatory for *Cutoff-plane selection*  —backface is affected (see Figure 8.14., left)
Reach difficult-to-access regions	Select (in the same way as for erasure) occluding polygons and click *Hide*

Hiding Polygons When Using Eraser Tool

If polygons obstruct the region you want to erase, you can hide them. Before doing Step 5 of the *procedure* under *Erasing Portions of Scans*, do the following:

1. Ensure the *Select through* toggle is in the  position in the *3D View* window.

Figure 8.15.: Selecting a flat region in the *Cutoff-plane selection* mode.

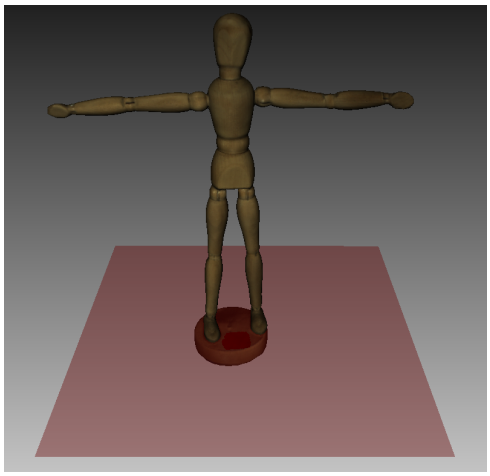


Figure 8.16.: Cutting plane

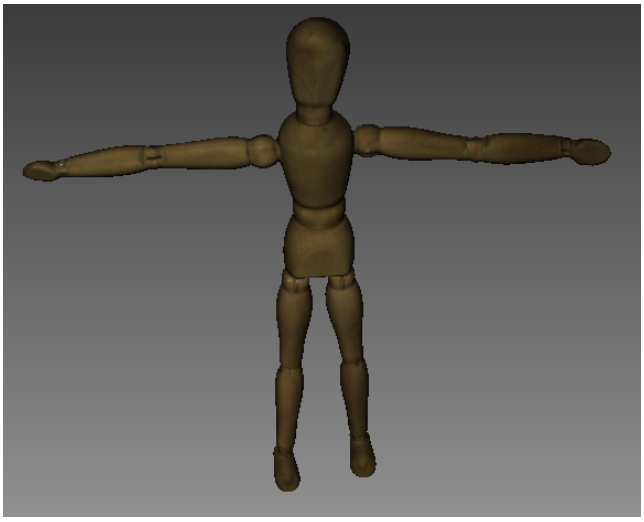


Figure 8.17.: Erasing results

2. Mark the obstructing region using the technique described in Step 5 of the *procedure*.
3. Click *Hide* to gain access to the obstructed region.
4. Mark the region you want to erase.

Defeature Brush

Erasing certain geometrical imperfections often demands further processing of the resulting holes in the model. The *Defeature brush* combines functions of the *Eraser* and *Hole filling* tools and may boost your productivity. To use it, follow these steps:

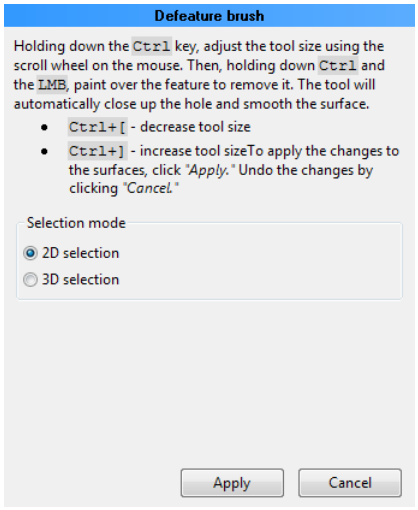


Figure 8.18.: *Defeature brush* panel.

1. Select the surface in the *Workspace* panel. You can only choose one model or one frame from the scan.
2. Open the *Editor* panel using the side toolbar and click either *Defeature brush* or the  button in the upper part of the *3D View* window, or hit `D`.
3. In the *Editor* panel, choose the selection type: *2D selection* or *3D selection*. The operating principle is the same as for the *Eraser* tool—that is, in 2D mode all surfaces throughout the model are affected (if  toggle is enabled), while in 3D mode the brush only works on the visible surface.

   Note: For most surfaces, results obtained in 2D mode with  toggle disabled will be approximately the same as those in 3D mode.

4. Hit `Ctrl` to activate the tool. Depending on the selection type, a red circle or an orange spot will appear in the *3D View* window.
5. While still holding down `Ctrl`, adjust the spot size (see Figure 8.19., 4) or circle diameter (see Figure 8.19., 3) using `Scroll wheel` or the `[` and `]` keys. Their size should match the size of feature you want to remove.

6. While still holding down `Ctrl` , press and hold `LMB` and paint over the area you want to modify. A red stroke will appear. When you release `LMB` , the software will delete the feature, close up the hole and smooth the surface.
7. If necessary, repeat Steps 3–6
8. Click *Apply* to implement all changes.

Note: If you are editing a textured model, don't forget to enable the *Render polygons without texture* option in the *View* menu (see *Rendering and Texturing Untextured Polygons*) to display the processed surfaces. Note that the texture will disappear, but you can restore it through texture mapping (see *Applying Texture*).

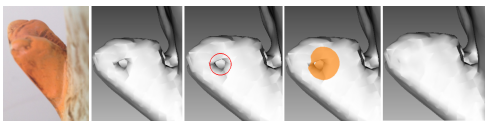


Figure 8.19.: *Defeature brush* in action.
From left to right: real object without any imperfection (1), imperfection on the scanned surface (2), *2D* brush cursor (3), *3D* brush cursor (4), results of applying the *Defeature brush*.

8.2 Fine Registration

Fine registration is an algorithm designed to automatically and precisely align captured frames. It starts once you complete scanning and close the *Scan* panel [1].

Note: Since the *Fine registration* algorithm runs automatically and uses the settings in the *Tools* panel, ensure that you have specified the proper (or, better, the default) values before you start scanning.

In a number of cases you can start the Fine registration algorithm manually using the *Tools* panel. To access a list of parameters, click the button in the *Fine registration* section. The algorithm affects all scans marked with the icon in the *Workspace* panel (see *Selecting Data* for more information on scan selection), but it processes them separately.

From two to three parameters may be available. You can redefine either of them:

registration_algorithm is a type of registration algorithm

Texture_and_Geometry takes both texture and geometry into account. If the scan lacks texture information, the algorithm will run on geometry only.

[1] There is another post-scanning algorithm: automatic base removal (see *Base Removal: Erasing a Supporting Surface*.)

Geometry uses geometry only. Unless your scan entirely lacks texture, we recommend avoiding this option.

refine_serial is enabled by default for *Geometry* mode and is available as an option for *Texture_and_Geometry* mode. It represents the conventional fine serial-registration algorithm and registers in-series captured frames.

loop_closure is an advanced algorithm that registers any frames not necessarily captured in series. Using any common regions in these frames, it compensates for cumulative error (see Figure 8.22.) caused by the peculiarities of handheld-3D-scanner movements. We highly recommend enabling this algorithm when you're using *Texture_and_Geometry* mode.

Figures below illustrate how each algorithm works if launched independently. The call-out boxes in each figure show two frames from the same corner of the door: one captured at the beginning and one at the end of the scanning session. The captured data (see Figure 8.20.) has a cumulative error that is noticeable in the call-out box. The serial registration algorithm improves frames' relative position (see Figure 8.21.), but misalignments remain. The loop-closure algorithm eliminates these misalignment completely (see Figure 8.22.).

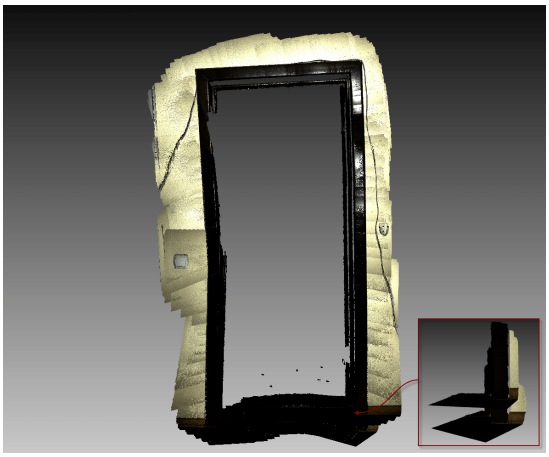


Figure 8.20.: Rough data as is

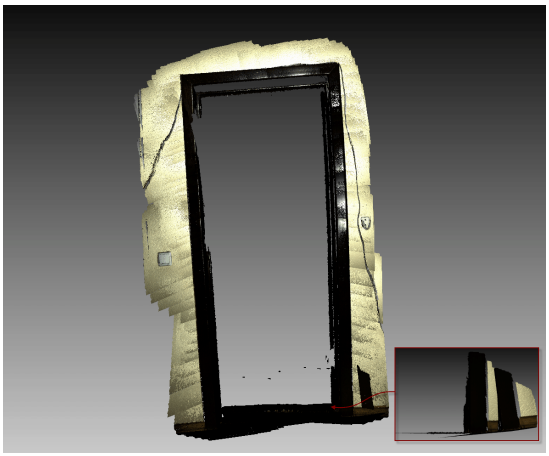


Figure 8.21.: Serial-registration results

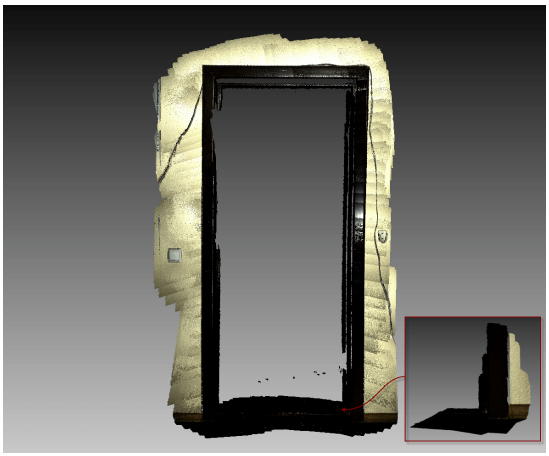


Figure 8.22.: Loop-closure results

8.3 Scan Alignment

Although Artec Studio features continuous scanning, there may be some cases where the application lack sufficient information about the relative positions of multiple scans. To assemble all scans into a single whole, you must convert the data to a single coordinate system—that is, you must perform alignment using the *Align* tool.

Hint: If you find the coverage too long, you can refer to *Auto-Alignment* first. Take a glance at the *Summary of Alignment Modes* as well.

8.3.1 Selecting Scans for Alignment

In the *Workspace* panel, use the flag to mark all scans that you intend to work with. Once you click *Align* in the side panel; the marked scans will appear in the left panel in the same order as they appear in the *Workspace* panel. During the *Align* operation, Artec Studio divides the selected scans into two sets: aligned (registered) scans and unaligned scans. The first set initially contains only one scan (the first one in the list), which is highlighted in blue. Its name appears in bold and uses the same color icon (). *Auto-Alignment*, however, may produce several groups of aligned scans.

The user's task is to align all scans to those that are already registered and to "assemble a model". In general, the procedure includes the following steps:

1. Click the required tab in the *Align* panel.
2. Select one scan from the unregistered group in the *Align* panel. The name of unregistered scan appears in a regular typeface. When selected, the unregistered scan is marked by the green icon . You can select several scans using either of the following methods:
    - Press and hold down the `Ctrl` key, and then click each scan that you want to select

- Click the first item, press and hold down the Shift key, and then click the last item.

3. If necessary, specify point pairs (for two scans) or sets of points (for more than two scans) and click the desired alignment-command button (*Auto-Alignment* is the most recommended one). The command affects all scans selected in the *Align* panel plus the first one ( ).

Since each mode varies in its effects, see the details in the corresponding subsections for more information. Note that you can use either one mode or a series of modes (see comparison table in *Summary of Alignment Modes*): drag alignment, rigid alignment with and without point specification, automatic rigid alignment, and alignment with surface deformations.

Changing Scan Status

If you have already aligned several scans, you should move them to the registered group. Select them in the *Align* panel using LMB . Next, click RMB on the name of any scan and select the *Mark as registered* option from the dropdown menu, or just double-click its name in the list. At this point, Artec Studio will treat registered scans as one, so you cannot move them independently.

If you accidentally mark a scan as aligned, remove it from the registered group by selecting the *Mark as unregistered* item from the dropdown menu, or just double-click it.

8.3.2 Displaying Scans in 3D View

Scans selected in the *Align* panel appear in the *3D View* window. Keys 1 , 2 and 3 switch among scans in the *3D View* window:

1 shows aligned scans and groups

2 shows scans that are currently under alignment

3 shows all scans

Navigation in align mode is similar to navigation in the *3D View* window:

Rotate hold LMB and move mouse

Zoom in/out use Scroll wheel , or hold RMB and move mouse

Move hold LMB and RMB simultaneously, or hold the middle button, and move mouse

8.3.3 Summary of Alignment Modes

The table below provides basic information on the various alignment modes (see *Scan Alignment*).

- **Scan type** lists which scans you can use in a particular mode.
- **Scans per operation** is the number of scans required to use a particular mode.

- **Markers in set** prescribes how many markers (points) you can map in one point set. Some modes require point (marker) sets, but some don't.
- "—" means that markers are unnecessary.
- "0 or 2" means point specification is optional and, if you do specify them, only marker pairs are allowed.
- "At least 1" means you can specify an unlimited number of markers in one set.

Table 8.2.: Parameters for alignment modes.

Mode	Scan Types	Scans per Operation	Markers in Set	Notes
Rigid (markers)	Any	2	2	Considers only coordinates, not geometry
Rigid (meshes)	Any	2	0 or 2	Considers geometric features
Rigid (texture)	Multiframe with poor geometry	2	0 or 2	High resource consumption
Rigid (auto)	Any	Any number	—	Works if surface is well textured
"Drag"	Any	2	—	Interactive
Non-rigid	Models	Any number	0 or 2	Deforms surfaces and textures; pre-alignment required
Complex	Any	1 (at least 2 for models)	At least 1	Precise and flexible

8.3.4 Drag Alignment

Drag alignment is always available, regardless of which tab is active in the *Align* panel. This mode allows you to align scans by manually dragging them in the *3D View* window.

Owing to the low accuracy of this approach, however, you can optionally use it for preliminary alignment before running more-accurate modes.

1. Select the scan you want to align, keeping in mind the recommendation at the beginning of *Scan Alignment*. Artec Studio allows you to select multiple scans, but note that it will align them with the registered scans as a single unit.
2. Holding down the `Shift` key and one mouse button, move and rotate the scan you're aligning (a green one ●) close to the registered scan (a blue one ●). *Scan Alignment* provides a list of allowed movements and corresponding buttons.
3. To confirm the alignment, release the mouse button(s) and the `Shift` key, then click *Apply*. Note carefully that any scans you are registering won't automatically

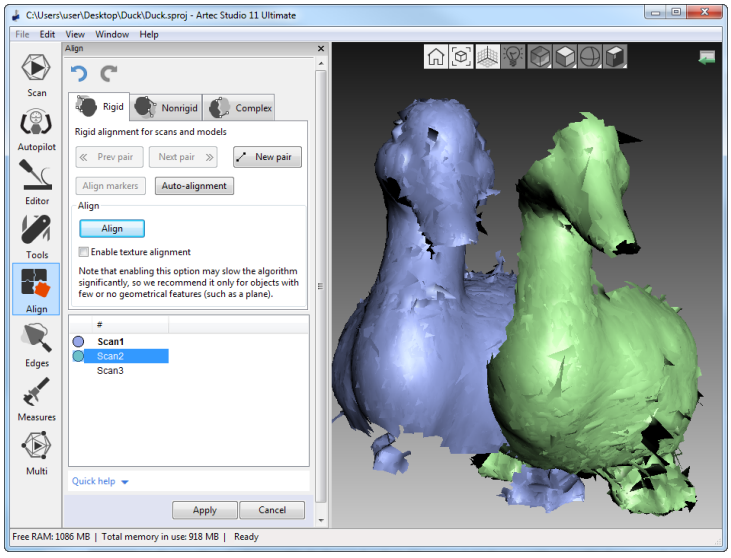


Figure 8.23.: Dragging a scan

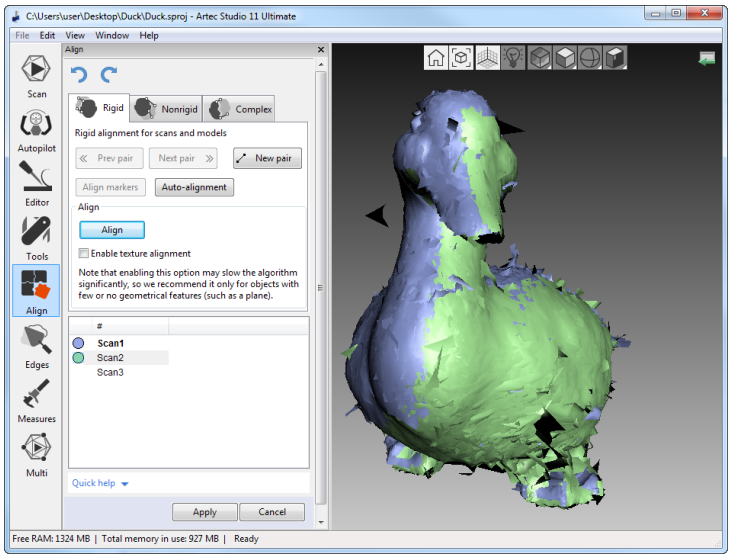


Figure 8.24.: “Drag” alignment result

move to the registered set (see Figure 8.24.). You can do so manually as the beginning of *Scan Alignment* describes.

4. If you have several scans to align, repeat these steps for each one individually.

8.3.5 Auto-Alignment

Rigid alignment is a universal mode suitable for aligning most scans. Auto-alignment is the easiest approach, however. The advantages of this latter mode include the ability to align several scans at once and avoid the need to specify points; the only disadvantage is minimum requirements for the size of the overlapping areas in the scans you're aligning.

To perform auto-alignment, follow these steps:

1. Make sure the *Rigid* tab is selected (see Figure 8.26.).
2. Select all the scans by using either `Ctrl` or `Shift` , as the *Scan Alignment* section mentions.
3. Click *Auto-alignment*. Ideally, Artec Studio aligns all the scans and marks them using the icon. It may, however, mark scans as registered even though the 3D surfaces failed to join properly.

Important: Auto-alignment may be unsuccessful if the scans have small overlapping area.

Auto-alignment may produce the following results:

- Aligned scans, marked with the icon (basic group of registered scans)
- Unregistered scans, marked with the icon
- One group ( ) or several groups (,) of registered scans. Scans forming this group failed to align with the basic registered group ( ), although they succeeded in aligning with each other.

We recommend resolving issues with unregistered scans or registered groups by aligning them manually as *Manual Rigid Alignment Using Point Specification* describes. Other methods may also help.

Managing Groups and Scans

You can perform the following actions on the scans from the list in the *Align* panel (right-click on the item to open the context menu):

Mark as registered Only available for single unregistered scans (→)

Mark as unregistered Use this command to discard the alignment state of a particular scan (unavailable for scans)

Select group Highlights the respective group (, , and so on)

Mark group as registered Converts all scans from the group into the basic registered group (→)

8.3.6 Manual Rigid Alignment Without Specifying Points

You can perform rigid alignment either with or without specifying points. If the scans are close to each other in distance (e.g., after "drag" alignment), or if they have a large overlapping area or rich texture, you can skip the task of point specification when aligning them.

Perform the following steps:

1. Make sure the *Rigid* tab is selected (see Figure 8.26.).
2. Select the scan you want to align, as the beginning of *Scan Alignment* describes.
3. Click *Align*. The result should be as Figure 8.28. depicts. If you are dissatisfied with this result, click and follow the recommendations in *Manual Rigid Alignment Using Point Specification*.
4. Select another scan from the list of unregistered scans and repeat the above procedure.
5. Click *Apply* to confirm your alignment results or *Cancel* to reject them.

Texture Alignment

If the object was scanned with texture, the texture-alignment feature may ease the alignment process. It uses texture-image characteristics of scanned objects and greatly decreases the possibility of incorrect alignment. This feature also helps to align objects with few or no geometrical features, such as round or flat objects with no corners. If an object has rich, nonrepetitive geometry, however, we recommend disabling texture alignment to reduce the algorithm's running time. Also keep in mind that texture alignment will be useless if the object texture is monochrome.

To enable texture alignment, select the *Enable texture alignment* checkbox at the bottom of the *Align* panel just before you perform Step 3 of the *procedure* above.

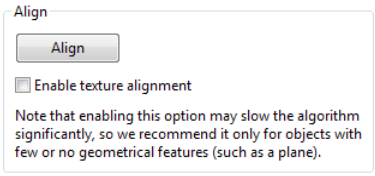


Figure 8.25.: Checkbox for texture alignment.

Note: Texture alignment is a resource-intensive algorithm that slows down the alignment process. We recommend using it only in cases where the object's geometrical features are insufficient.

8.3.7 Specifying Points and Editing Their Positions

Before considering how to align scans using points, it is helpful to highlight point-pair specification. The alignment algorithm uses pairs of point, or point sets in "Complex alignment" mode (*Complex Alignment*), to detect scan areas that should be brought close together.

To do point alignment, create several point pairs. To create one pair, mark one point on the aligned scan and then mark another one on the unaligned scan. Ensure that in each case the points for a given pair match a corresponding point on the surface of a real object; note, however, that high matching accuracy is unnecessary, since Artec Studio only uses the pairs to gain a rough approximation before performing precise registration. In the *Complex* mode, you can create a set of points (instead of just a pair), i.e. you can simultaneously specify more than two points in one or several unregistered scans and only one in the registered scan. All these points are connected by polylines and form a set.

When specifying points in the *Rigid* and *Nonrigid* modes, the application automatically creates pairs. Having specified one pair, you can immediately create the next one. In *Complex* mode you must confirm set creation by hitting `Space` or by clicking *New set* from the left panel, because the set may comprise multiple points (see Figure 8.27. and Figure 8.33.).

You can toggle between the point pairs (sets) by hitting `Space` and `Backspace`, or by clicking `RMB` in the *3D View* window and selecting the relevant options from the menu. You can also relocate points in the pair (set). Hover the mouse cursor over the point until the pair (set) is highlighted in white, then drag the point to the proper position using `LMB`, or select the pair (set) and specify a new position using `LMB`. To confirm your actions and deselect the pair (set), hit `Space`. You can also remove either a pair (set) or one of its individual points: click on the point using `RMB` and choose the appropriate command from the menu. Alternatively, you can use `Del` to remove the selected pair (set).

8.3.8 Manual Rigid Alignment Using Point Specification

We advise using this mode when scans are located at a significant distance from each other.

To use this approach, follow these steps:

1. Make sure the *Rigid* tab is selected (see Figure 8.26.).
2. Select the scan you want to align, as the beginning of *Scan Alignment* describes.
3. Specify several point pairs (Figure 8.27.), keeping in mind the recommendations from *Specifying Points and Editing Their Positions*.
4. Click *Align markers*. This mode takes into account only the coordinates of specified points and tries to reduce the distance between the markers for each pair.
5. Carry out Steps 3–5 of the *procedure* in *Manual Rigid Alignment Without Specifying Points*.

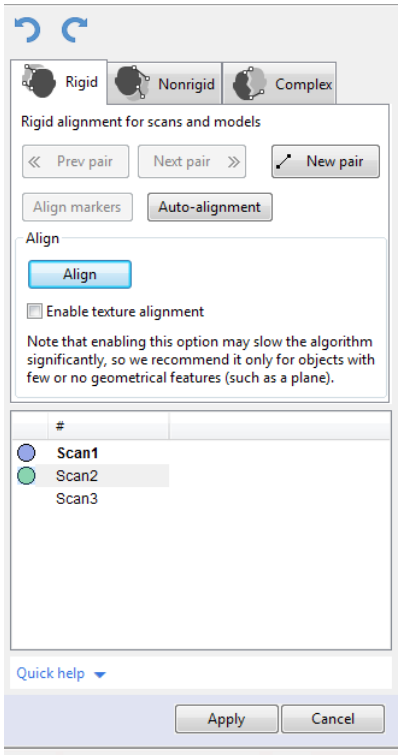


Figure 8.26.: *Align* panel: *Rigid* tab.

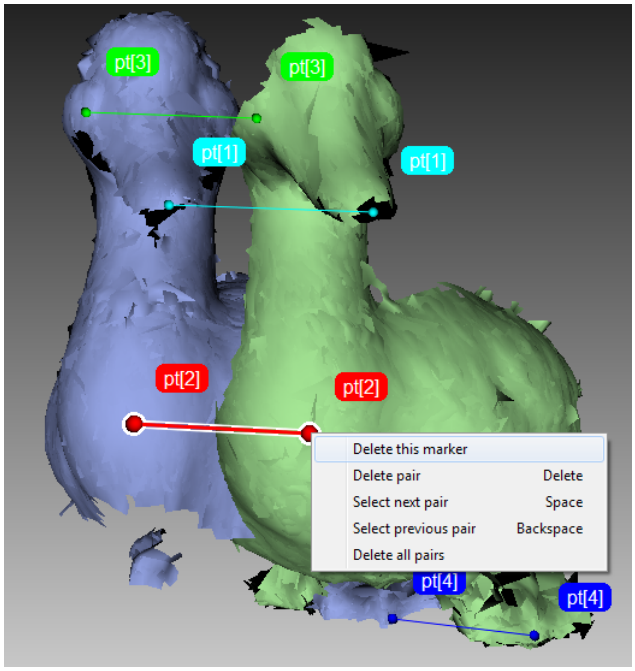


Figure 8.27.: Creation of point pair.

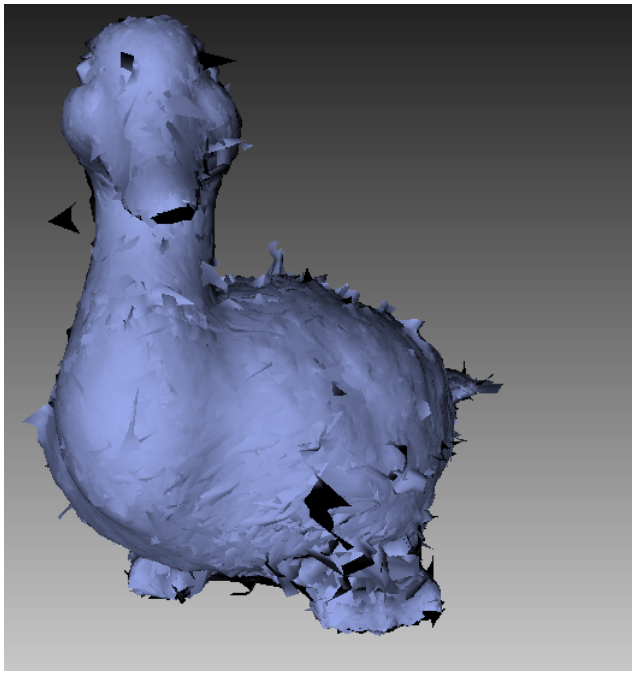


Figure 8.28.: Alignment result.

8.3.9 Nonrigid Alignment

Whereas rigid alignment can only perform such transformations as translation and rotation, the nonrigid algorithm can deform 3D data. This algorithm is intended to process so-called nonrigid objects: objects whose shapes have changed during the scan (e.g., models of animals or humans—see Figure 8.30., left). Keep in mind that the surface Artec Studio produces as a result of the deformation may differ from the surface of the actual object.

Note: Nonrigid alignment works on models only. Thus, before you run it, prepare models by fusing the source scans. It is also necessary to first align models in rigid mode (see *Manual Rigid Alignment Without Specifying Points*, *Auto-Alignment* or *Manual Rigid Alignment Using Point Specification*).

To run the nonrigid alignment, follow these steps:

1. Make sure the *Nonrigid* tab is selected (see Figure 8.29.).
2. Select the models you want to align, as the beginning of *Scan Alignment* describes.
3. If the models differ significantly from each other, we suggest that you specify several point pairs, keeping in mind the recommendations in *Specifying Points and Editing Their Positions*.
4. Where necessary, adjust the deformation degree using the flexibility slider. The greater the flexibility value (i.e., the more “flexible” the deformation), the longer the computation will take.

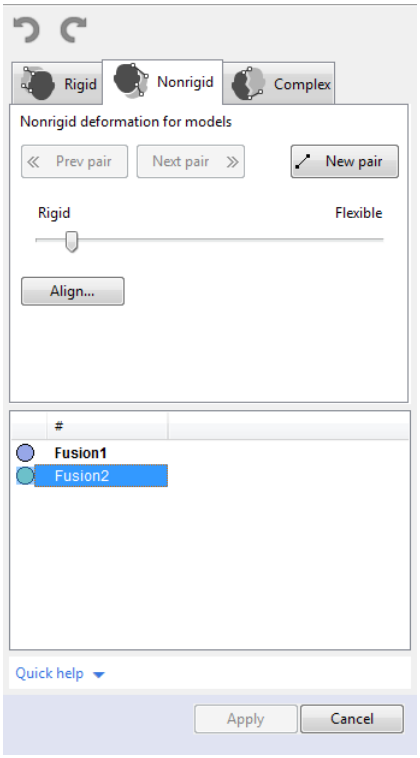


Figure 8.29.: *Align* panel: *Nonrigid* tab.

Figure 8.30.: Two models after rigid (left) and nonrigid alignment (right).

> **Warning:** Avoid extreme *Flexibility* values. Applying very large values may result in major surface distortions and may slow down the algorithm. Extremely low values, on the other hand, barely deform surface and often fail to produce the expected nonrigid-alignment results.

5. Click *Align*.... The algorithm will align models by deforming one of the model (see Figure 8.30., right). If you are dissatisfied with the alignment results, click ↺ and specify additional point pairs, or reposition the current pairs.
6. Select another model from the unregistered set and repeat the steps above.
7. Click *Apply* to confirm your alignment results or *Cancel* to reject them.

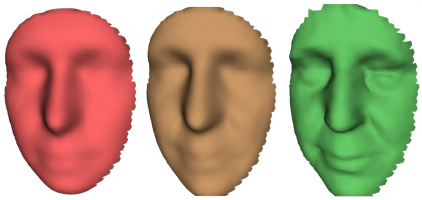


Figure 8.31.: *Flexibility* slider in action: original model (left), nonrigidly aligned model with low *Flexibility* value (middle) and with high value (right).

Note: This version of Artec Studio does not support texture mapping on nonrigidly aligned models.

8.3.10 Complex Alignment

Complex alignment allows you to align not only scan to scan, but surface to surface within a given scan (see the mode comparison in *Summary of Alignment Modes*). Relative to other modes, this one supports multipoint-set definition—that is, you can link more than two points. It's useful for aligning scans obtained during circular movements of the 3D scanner in cases where fine registration with the *loop_closure* option enabled fails to align them. To run the *Complex* alignment, perform the following steps:

1. Make sure the *Complex* tab is selected (see Figure 8.32.).
2. Select the scans you want to align, as the beginning of *Scan Alignment* describes. This mode allows you to work even with just one registered (●) scan.
3. Specify one or more point sets on the scan surface (see Figure 8.33.), keeping in mind the recommendations in *Specifying Points and Editing Their Positions*.
4. Click *Align*... to run the alignment with your specified constraints (Figure 8.34. shows example results). If you are dissatisfied with the alignment results, click ↺ and specify additional point sets, or reposition the current sets. To redo an operation that you have undone, click ↻.

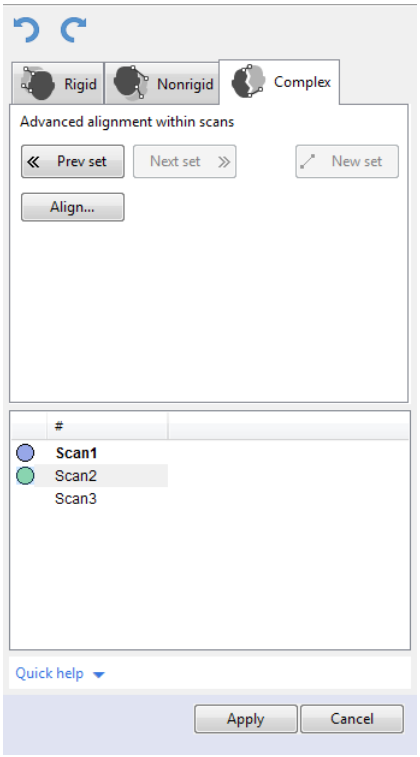


Figure 8.32.: *Align* panel: *Complex* tab.

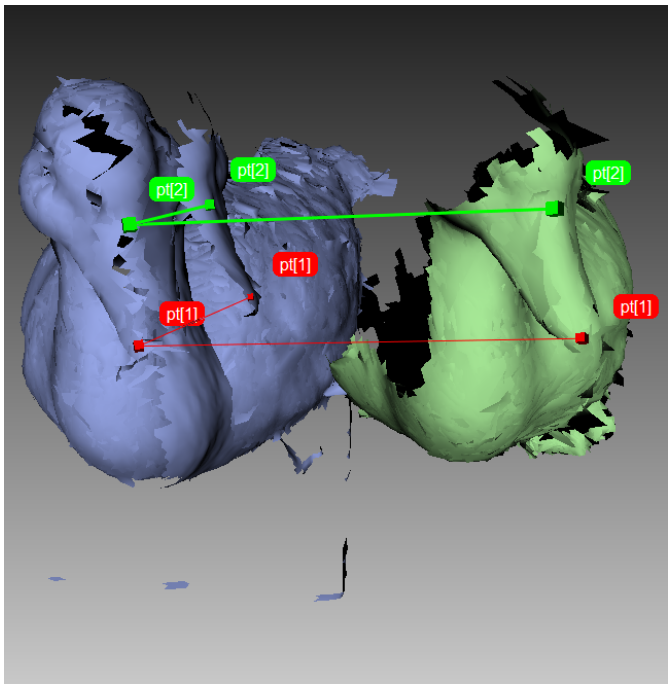


Figure 8.33.: Before alignment: two point-set added.

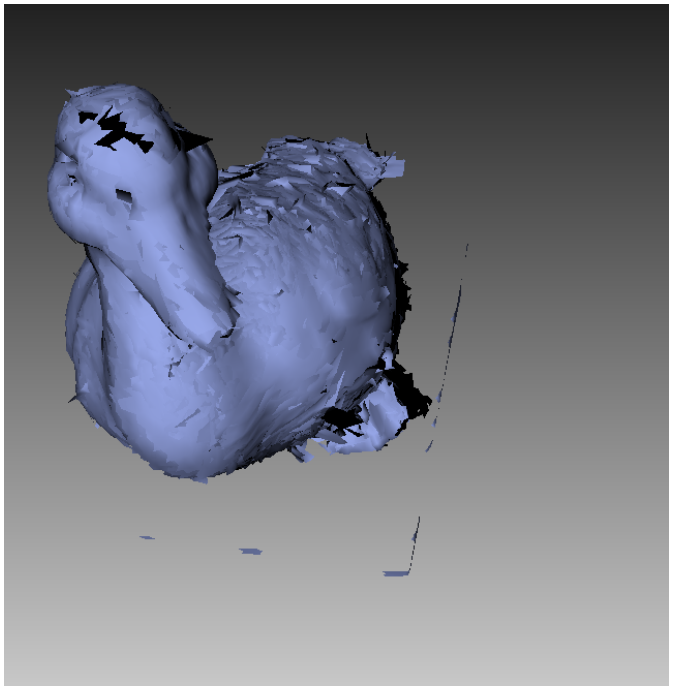


Figure 8.34.: Alignment result.

5. Click *Apply* to confirm your alignment results or *Cancel* to reject them.

8.4 Global Registration

Once you have aligned all your scans, proceed to the next stage: global registration. The global-registration algorithm converts all one-frame surfaces to a single coordinate system using information on the mutual position of each surface pair. To do so, it selects a set of special geometry points on each frame, followed by a search for pair matches between points on different frames. To perform correctly, the algorithm requires an initial approximation, which a user ensures in the course of the *Align* operation.

Note: Global registration is a resource-intensive operation. Processing of large data sets may take a long time and require a large amount of RAM.

To launch the algorithm, select all aligned scans in the *Workspace* panel. Next, open the *Tools* panel and locate the *Global registration* section. Click *Apply*.

8.4.1 Global-Registration Parameters

registration_algorithm the type of algorithm that will perform scan registration. If an object has rich texture and poor geometry, consider using the *Texture_and_Geometry* option. For objects with rich geometry, you can choose *Geometry* mode to increase the registration speed.

minimal_distance the minimum distance between adjoining feature points on the object (in millimeters).

iterations the number of iterations of the global optimization algorithm. Optimization is a part of the global-registration algorithm.

8.4.2 Possible Global-Registration Errors

- After the global-registration algorithm finishes, the frames are in disarray (see Figure 8.35., left) or the frame positions are unchanged. This error occurs because the application is configured for a different scanner type than the one that captured the data. Change the device type in the application settings (see *Algorithm Settings*).
- The algorithm has completed successfully, but a gap exists between two or more scans (see Figure 8.35., right). Select just these scans in the *Workspace* panel and run the global-registration algorithm. If the scans have drawn closer to each other but have failed to align after the algorithm finishes, increase the number of iterations and rerun the algorithm. Repeat this process until you achieve full alignment, then run global registration once again for all data. If you are unable to align several problematic scans, try aligning just two of them, then gradually increase the number of scans until all of them are aligned.

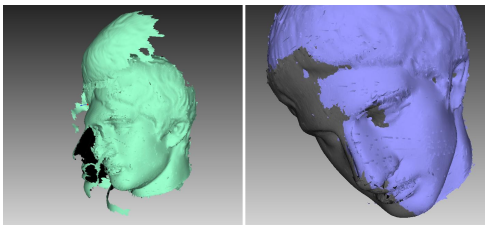


Figure 8.35.: Global-registration errors: wrong settings on left and gap between scans on right.

8.5 Outlier Removal

During the scanning process, so-called outliers may appear in the scene. Outliers are small surfaces unconnected to the main surfaces. They require removal because they may spoil the model or produce unwanted fragments. Artec Studio provides two ways to remove outliers: erase them before fusion (preventive approach) or after fusion ("furthering" approach—see *Small-Object Filter*). We advise using the former approach because it decreases the possibility of improper fusion by preventing noisy features from attaching to the main surface.

This outlier-removal approach is based on a statistical algorithm that calculates for every surface point the mean distances between that point and a certain number of neighboring points, as well as the standard deviation of these distances. All points whose mean distances are greater than an interval defined by the global-distances mean and standard deviation are then classified as outliers and removed from the scene.

For better results, we recommend running global registration before starting the algorithm. If you begin *Outlier removal* before doing so, a dialog will appear prompting you to perform global registration.

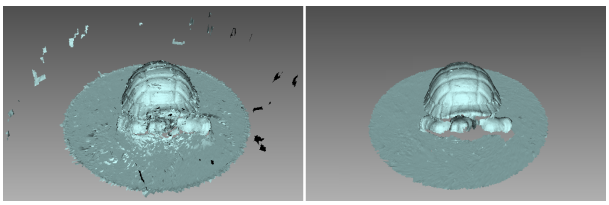


Figure 8.36.: *Outlier removal*: before and after.

In most cases, none of the parameters accessible through the ⌄ button requires adjustment. But if necessary, you can change the values of these parameters:

std_dev_mul_threshold a standard-deviation multiplier. We recommend choosing the value for this parameter according to the following guidelines:

2 for noisier surfaces

3 for less noisy surfaces

resolution should be set equal to the resolution of the *Fusion* process that you expect to run later.

Click *Apply* to run *Outlier removal*.

8.6 Fusion

Fusion is a process that creates a polygonal 3D model. It effectively melts and solidifies the captured and processed frames. Fusion is the most interesting part of the processing task because a polygonal 3D model is what most people expect to see when performing a 3D scan. To this end, you can use one of the following algorithms, each of which has a self-explanatory name (see also the summary in Table 8.3.):

- *Fast fusion* produces quick results.
- *Smooth fusion* is good for scanning the human body because of its ability to compensate for slight movements by the person you're scanning.
- *Sharp fusion* perfectly reconstructs fine features and is suited to both industrial objects and human bodies. It is the only mode that allows you to use all the capabilities of a Artec Spider scanner.

Figure 8.37.: Models of a human subject obtained using various algorithms: *Fast fusion* (left), *Smooth fusion* (middle) and *Sharp fusion* (right).

Figure 8.38.: Models of a shoe sole obtained using various algorithms: *Fast fusion* (left), *Smooth fusion* (middle) and *Sharp fusion* (right).

Table 8.3.: Comparison of fusion modes.

	Fast Fusion	Smooth Fusion	Sharp Fusion
Usage	Fast results for large data sets; also for measurements	Large, noisy data sets with patchy missing regions; scans of moving objects	Scans from Artec Spider; scans having regions with fine details and sharp edges
EVA	resolution no less than 0.4		
Spider	resolution no less than 0.1		
L	resolution no less than 1.5		
Fill_holes	Not applicable	Available	
Features	Resulting surfaces are relatively noisy. Offers an additional parameter, *radius*	Smoother results. Can compensate for slight movements, but not recommended for accurate measurements. Relatively slow.	Higher level of detail. Faster than *Smooth fusion*, but may intensify existing noise.

To obtain a model:

- Make sure the scans you intend to fuse have passed *Global registration*.
- Select the scans in the *Workspace* panel using 👁.
- Enter the *Tools* panel.
- Select the necessary mode; optionally, specify parameter values.
- Click *Apply*.

- View the model in the *3D View* window and in the *Workspace* panel once the algorithm finishes. The model name will match the algorithm name.

The fusion algorithms use the following parameters:

resolution —the step of the grid (in millimeters) that the algorithm uses to reconstruct a polygonal model. In other words, this parameter defines the mean distance between two points in a model. The lower the *resolution* value, the sharper the shape. When specifying values, keep in mind the default values and lower limits in Table 8.3..

radius —only for *Fast fusion*, a multiplier or integer factor that defines the surrounding space that the algorithm takes into consideration when adding each new minimum spatial unit. Note that the size of the spatial unit remains unchanged and is equal to the *resolution* value; the actual search radius is the product of *resolution* and *radius*.

Fill_holes —instructs the algorithm to fill holes in the mesh being reconstructed; option unavailable for *Fast fusion*. The methods for filling the holes are as follows:

By_radius —fills all holes with radius less than or equal to the specified value in the *max_hole_radius* text box (in millimeters)

Watertight —automatically fills all holes in the mesh

Manually —prompts you to fill holes manually in the *Edges* panel, which opens automatically

remove_targets —allows you to erase small embossments from surfaces on which targets are placed (see *Target-Assisted Scanning*). Parameter can assume either the *On* or *Off* value; unavailable for *Fast fusion*.

8.6.1 Fusion-Algorithm Errors

Occasionally, defects appear in the 3D model after fusion; some are correctable by creating additional scans, whereas others are correctable by using the model-processing tools described in the next section.

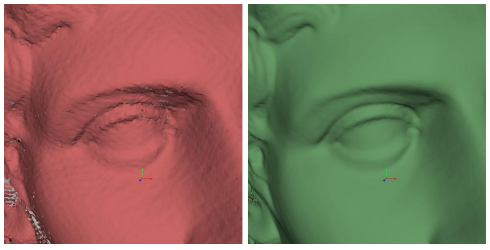


Figure 8.39.: Surface noise caused by insufficient data (left) and improved model after adding one more scan (right).

Errors that can be corrected by capturing additional scans include low-amplitude noise on the surface (see Figure 8.39., left). Normally, this error indicates that the affected area has a small number of frames. The number of frames needed to eliminate the noise depends on the reflective properties of the object's surface. To correct the error, you need one more scan to cover the noisy area (see Figure 8.39., right).

Sometimes the cause of noise is an insufficient number of scanning angles. Areas captured at a larger angle have more noise than areas captured at a direct angle (i.e., 90 degrees). You can correct this error by scanning the area again using a better angle.

When the scanning conditions or the object features are such that you are unable to capture additional data, you can correct errors using the *Edges* (see *Filling Holes and Smoothing Edges*) or *Smoothing* (*Smoothing*) tools. If such errors are frequent, reduce the speed at which you move the scanner around the object, or increase the capture rate (see *Decreasing Scanning Speed*).

8.7 Editing Models

The resulting fusion model may contain surface defects due to scanning or registration errors. Artec Studio provides a number of tools to correct such errors:

Repair —corrects the model's triangulation errors

Small-object filter —removes small objects located near the model surface

Edges —semiautomatically fills holes and smooths the model edges

Hole filling —fills holes in the model automatically

Smoothing —filters low-amplitude noise over the whole model

Smoothing brush —enables manual smoothing of the surface areas with the most noise

Mesh simplification —reduces the number of polygons in a model while minimizing lost accuracy

Remesh —creates isotropic mesh while keeping the processed mesh as close to the original as possible

Each algorithm processes all scans selected in the *Workspace* panel and replaces the original data with the results. If the algorithm is unsuccessful, you can restore the original data by clicking (*Undo*) in the *Workspace* panel.

8.7.1 Correcting Triangulation Errors

Some algorithms may introduce triangulation errors into the resulting model. These errors include the following:

Unattached vertices —points that are not vertices of any of the triangles

Vertices with identical coordinates —vertices that have the same coordinates

Faces containing invalid vertices —triangles that point to nonexistent vertices

Singular faces —triangles for which at least two of the three vertices coincide.

Faces with equal signature —faces with fully coinciding sets of vertices

Edges incident to three or more faces —edges that are adjacent to three or more faces

Faces with wrong orientation —faces whose normals point in a direction opposite to those of the adjoining faces

To correct these errors, mark a model in the *Workspace* panel by using the flag and hit `Ctrl + R` or select the *Window* → *Repair* menu command. If the algorithm detects no triangulation errors, Artec Studio will notify you that it has found no defects. Otherwise, the *Repair* panel will open, displaying the above-mentioned list of defects to be corrected. Next to the names of the defects, a column will appear stating the number of defects of a certain type found in the model. You can select all defects by pressing *View all*. Doing so will display in the model all the defective vertices and triangles using colored points. You can disable display of any particular defect type by removing the icon next to the corresponding name, or disable them all by clicking *View none*. To correct the defects, click *Repair all*. Clicking the *Apply* button accepts the changes.

8.7.2 Small-Object Filter

If you forgot to erase outliers before fusion (see *Outlier Removal*), Artec Studio may solidify and preserve them in the scene as small, distant fragments.

You can effectively remove these remaining outliers by using a filtering algorithm.

To remove these artifacts, select in the *Workspace* panel only the model you are currently editing, then open the *Tools* panel. Click *Apply* next to *Small-object filter* to run the algorithm (see Figure 8.40.). A window containing algorithm settings will appear when you click . You can adjust the following parameters:

mode —the *Leave_biggest_objects* option from the dropdown menu instructs the algorithm to erase all objects except the one with the most polygons; *Filter_by_threshold* erases from the scene all objects whose number of polygons is less than the amount specified in the *threshold* parameter.

threshold —the maximum number of polygons for *Filter_by_threshold*.

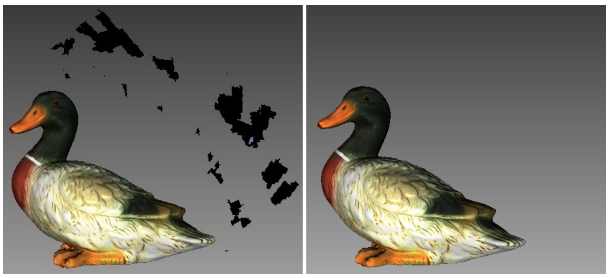


Figure 8.40.: Filtering of scene outliers: before (left) and after (right).

8.7.3 Filling Holes and Smoothing Edges

Sometimes the shape of an object or the scanning conditions prevent you from properly capturing of all parts of the scene. As a result, the fused 3D model will have holes. In such instances, you can use the hole-filling tool to interpolate the surface.

To start analyzing and correcting the model,

1. Select the model and click *Edges* from the side panel. The new panel has two tabs: *Edges* and *Holes*, each of which contains a list of holes detected on the surface. These defects are sorted by their perimeter length.
2. Select a hole, Artec Studio will highlight the corresponding edge in the *3D View* window.

> **Note:** If the *Move camera to selection* option is checked, the model will automatically rotate to display the selected edge. By default, the camera moves smoothly from one edge to another when switching between edges. If the model is large, however, this movement may take too long. To expedite the switch, clear the *Animate camera* checkbox.

To select edges for correction,

- Mark the checkbox next to each one you wish to correct. These edges will be highlighted in red in the *3D View* window (see Figure 8.41.).
- Use the *Select all* and *Deselect all* buttons in the panel to select or clear all selections, respectively.
- You can also select edges right on the model. To do so, rotate the model to make the edge visible in the *3D View* window. Then click `LMB` to select it.

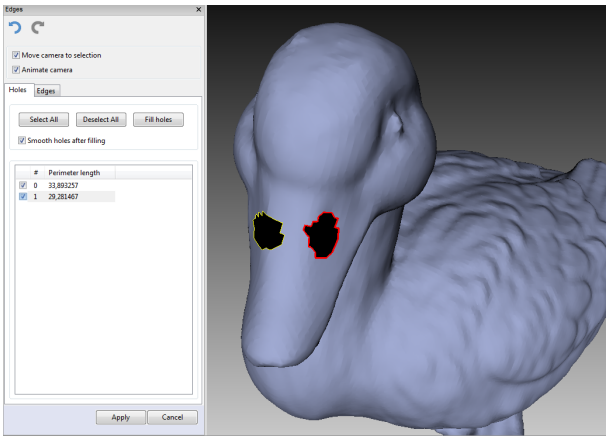


Figure 8.41.: Two holes marked for correction.

Under the *Holes* Tab, you can enable an option that automatically smooths the holes after filling them by checking the *Smooth holes after filling* box (see also *Smoothing*). Under the *Edges* Tab, use the *Strength* slider to control the edge-smoothing intensity. Also, you can use this tab to smooth part of the edge instead of the whole one. To do so, rotate the model to make the edge visible and mark it in the list as "processing required." Next, hold down `LMB` and move the mouse over the edge to drag apart the ends of the profile to the desired position (see Figure 8.43.).

After you have selected all the edges or the holes you want to fix, click *Fill holes* or *Smooth edges*. Artec Studio will repair the model. If the results are satisfactory, click *Apply* to

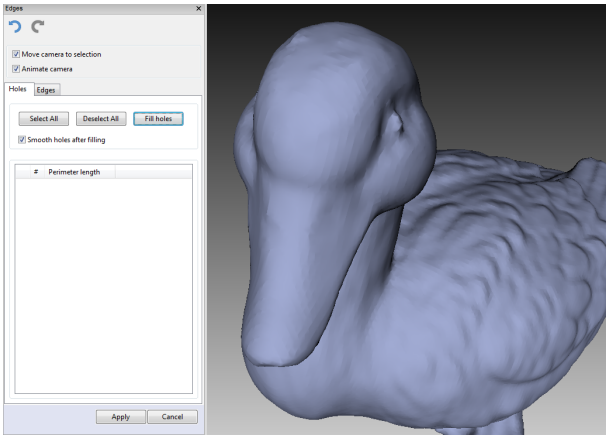


Figure 8.42.: Result from running the *Fill holes* algorithm.

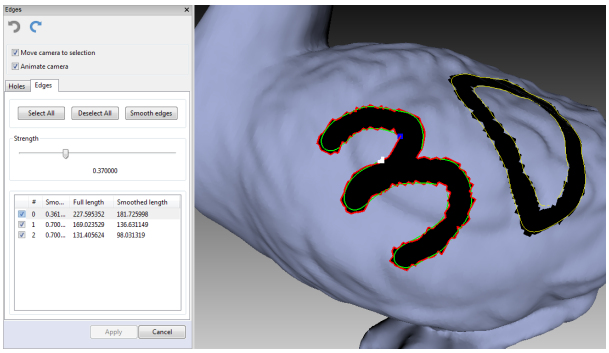


Figure 8.43.: Boundary selection for edge smoothing

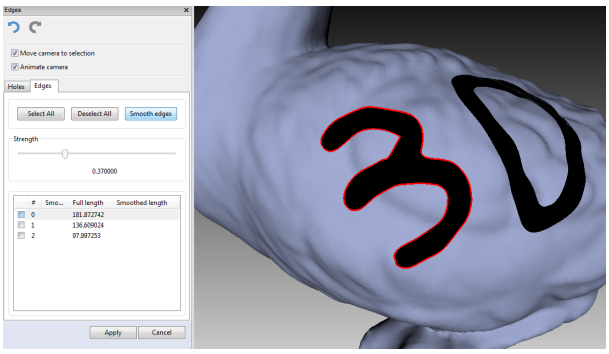


Figure 8.44.: Edge-smoothing algorithm results.

confirm them; otherwise, you can always use the button to cancel any changes. If you try to exit the *Edges* mode without accepting changes, the software will ask you for confirmation.

8.7.4 Automatic Hole Filling

To quickly and automatically fill holes, use the *Hole filling* algorithm in the *Tools* panel. It employs the same edges as the *Edges* tool, processing only those holes with parameters that correspond to the one user-adjustable setting, which you can access through the button:

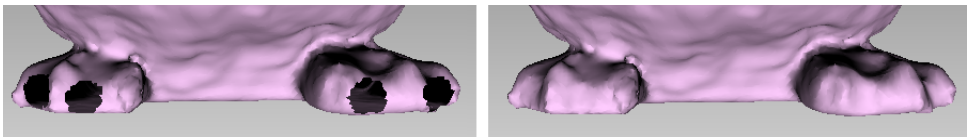


Figure 8.45.: Hole-filling algorithm: original model on left, processed on right.

max_hole_len maximum length of the hole perimeter in millimeters. The algorithm only processes holes with perimeters below this threshold.

8.7.5 Smoothing

The smoothing algorithm evens out noisy areas in the 3D model. Artec Studio provides two such tools: automatic smoothing of the entire model and manual smoothing of specific areas identified using a brush (see *Smoothing Brush*).

To run the automatic smoothing algorithm, open the *Tools* panel and select *Smoothing*. You need only set one parameter:

steps —the number of algorithm iterations to be performed

8.7.6 Mesh Simplification

The mesh produced after fusion may be less than optimal for some applications because it will contain a large number of polygons. This complexity will increase the amount of memory the model occupies, hindering further processing. To optimize the model size while retaining accuracy, use the *Mesh simplification* algorithm.

Select the model and open the *Tools* panel. You can choose from two algorithms.

Conventional Algorithm

Open the dropdown algorithm settings by clicking the button next to *Mesh simplification*. Select the appropriate processing method (determined by the *stop_condition*):

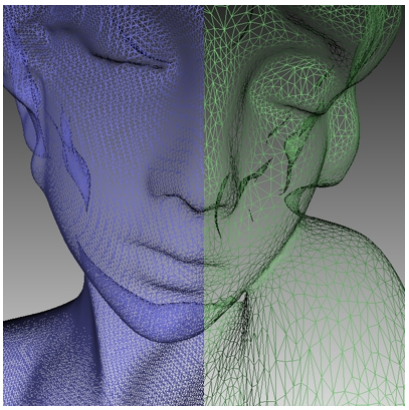


Figure 8.46.: *Mesh simplification:* original mesh on the left, optimized mesh on the right.

Accuracy —optimize model to a predetermined accuracy: the *error* parameter defines the optimized model's maximum allowable deviation (in millimeters) from the original model. When the algorithm reaches this value, the optimization stops.

Remesh —perform simple mesh optimization, removing triangles whose edge lengths are less than the *remesh_edge_thr* value (in millimeters).

Triangle_quantity —simplify the model by targeting the number of triangles specified in the *tri_num* parameter. The algorithm minimizes the resulting model's deviation from the original model, but the final deviation value will remain unknown until processing concludes. Use this method when you know how many triangles the resulting model should have.

Note: To determine the number of triangles, double-click the appropriate model from the list in the *Workspace* panel (see Figure 8.3.).

UV_Triangle_quantity —similar to the *Triangle_quantity* algorithm, but intended for meshes with textures mapped by the *Atlas* method (see *Applying Texture*). This approach not only simplifies the polygon grid, reducing the number of triangles, but it preserves texture.

UV_Vertex_quantity —simplify a textured model by targeting the number of vertices specified in the *vrt_num* parameter.

The three first algorithms in the list above have additional parameters:

keep_boundary —maintain the model boundary. Mesh simplification on the scan edges may affect their geometry. Thus, if the shape of the boundaries is more important than the optimized mesh, select the *On* value. Otherwise, select *Off*, and the algorithm will simplify the boundary mesh.

max_neighb_normals_angle —the angle between the normals of two neighboring faces. You can specify an angle (default value is 120°) to prevent Artec Studio from creating degenerate triangles. If the angle measure in some region exceeds the specified value, the algorithm will leave the mesh unchanged in that region. Note that the default value is appropriate in most circumstances.

Figure 8.47.: Boundary-appearance options: *keep_boundary* enabled (left) and disabled (right).

After adjusting the algorithm settings, click *Apply* to start processing.

Note: Mesh simplification may take a long time when the parameters of the original and optimized models are significantly different (for example, if the deviation value is high in *Accuracy* mode or if the required number of polygons in *Triangle_quantity* mode is much smaller than the number in the original model). For very large 3D models the operation requires extensive memory resources and may fail owing to insufficient RAM. Free the memory by closing unused applications and by optimizing memory usage in Artec Studio, keeping in mind the recommendations in *Memory*, *Command History* and *Selectively Loading Project Data*.

Fast Mesh Simplification

The *Fast mesh simplification* algorithm works faster than the conventional one. To run it, perform these steps:

1. Open the dropdown algorithm settings by clicking the button next to *Fast mesh simplification*.
2. Specify in the *tri_num* text box the desired number of triangles for the resulting model. You can determine how many are in the actual model by double-clicking it in the *Workspace* window.
3. Set the *force_constraints* option:
    - If this option is set to *Off*, the value specified in the *tri_num* text box remains constant.
    - If this option is set to *On* and the algorithm is unable to produce a surface with the specified number of triangles (*tri_num*), Artec Studio will automatically update this value. In other words, improving the quality of the resulting surface is the primary objective.
4. Click *Apply* to run the algorithm.

8.8 Automatic Processing

See also:

Autopilot

Automatic processing is a special mode for the *Tools* panel that saves time and simplifies postprocessing. It allows you to run all postprocessing algorithms from the *Tools* panel (*Rough*, *Fine* and *Global registration*; *Fast*, *Smooth* and *Sharp fusion*; *Small-object filter* or *Outlier removal*; *Hole filling*; *Mesh simplification*; *Remesh*; and *Smoothing*) with a click of just one button.

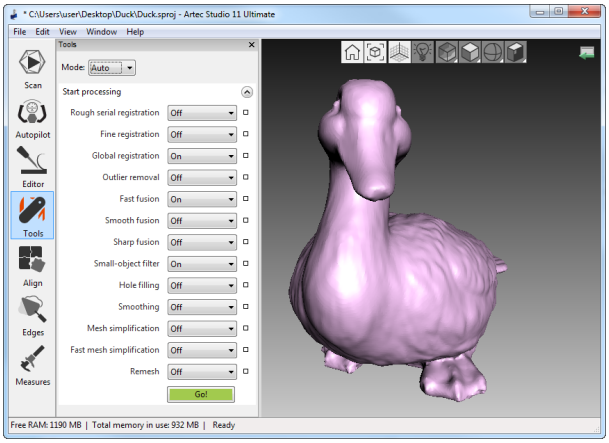


Figure 8.48.: The extended Auto postprocessing menu.

To switch from manual to automatic mode, open the *Tools* panel and choose the *Auto* option from the dropdown list in the left corner. Click the button near *Go!* to view all options available in automatic mode. Note that only *Global registration*, *Fast fusion* and *Small-object filter* are enabled by default. To perform other actions automatically, choose the *On* option in the dropdown list next to the required function, or choose *Off* to exclude a function from automatic processing. Click *Go!* or hit `Ctrl + G` to begin automatic processing.

Each algorithm setting and parameter is based on the values for manual mode. To change these values, switch to *Manual* mode, make the necessary alterations and then run automatic processing—Artec Studio will apply all changes.

Keep in mind that the algorithms run in the order in which they are listed, starting with *Rough serial registration* and ending with *Remesh*. Thus, if you want to run the *Small-object filter* before *Fast fusion* or *Global registration*, for instance, you must do so manually.

Unlike manual processing, automatic processing runs without the need for constant user attention, so it is more convenient when processing large objects: you can configure the settings, start the process and leave it unattended. It can also process objects of any size, reducing the number of mouse clicks to get the result.

8.9 Texturing

Artec scanners are equipped with a color camera, allowing you to capture 3D surfaces with texture and expanding the range of objects available for scanning. Texturing is a process that projects textures from the individual frames onto the fused mesh.

8.9.1 Preliminary Steps

To take advantage of texture, do the following:

1. Make sure the *Don't record texture* checkbox is cleared.
2. Adjust the capture frequency for texture frames (see *Texture-Recording Mode*) if necessary.
3. Avoid turning off the flash bulb.
4. Adjust the texture brightness in *Preview* mode by using the eponymous slider in the *Scan* panel.
5. Scan the object using a tracking algorithm of your choice. Captured frames are marked with the letter "T" in the *Workspace* panel (surface-view mode) (see Figure 8.2., right).
6. Process the data and create a model, consulting the list in the beginning of *Data Processing* or *Autopilot*.
7. Run a mesh-simplification algorithm for the resulting model (see *Mesh Simplification*) to accelerate the texturing process.
8. Use the *Texture* panel to apply the texture to the model.

8.9.2 Applying Texture

The 3D model obtained after fusion contains no texture information. To apply textures onto a model, open the *Texture* panel and choose a model from the first list (see Figure 8.50.); Artec Studio will apply the textures to this model. Next, select from the second list the scans from which you created the model (these scans have the required textures).

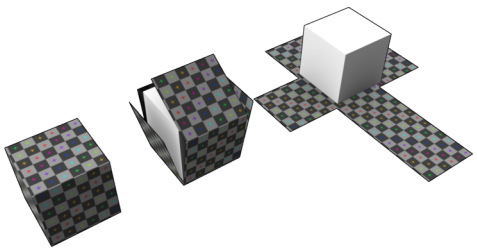


Figure 8.49.: Simplified illustration of texture applying: texture as a single file.

Warning: We recommend that you avoid applying texture to models that have undergone major changes in geometry or orientation. The algorithm will apply the texture incorrectly if you have done any of the following:

- Transform or position the model relative to its source scans
- Nonrigid alignment (see *Nonrigid Alignment*)

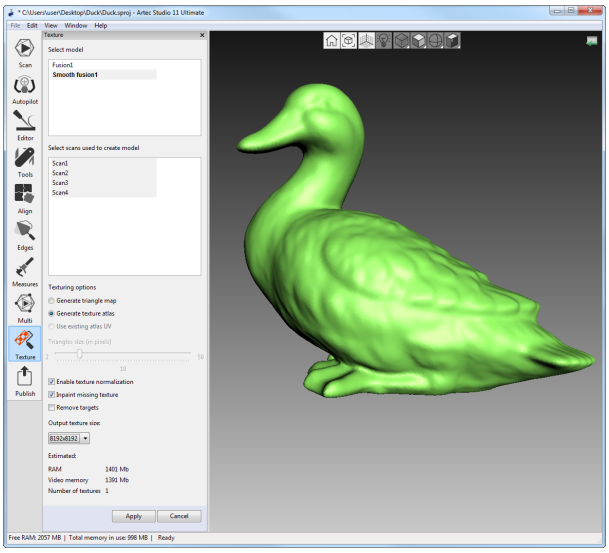


Figure 8.50.: Choosing a texture-application method and adjusting its parameters.

- Erase major parts of the model

Perform these operations only after texturing.

Next, you will need to choose a method for applying textures to the model. Artec Studio offers two methods:

- *Generate triangle map*
- *Generate texture atlas*

Generating Triangle Map

The *Generate triangle map* method transfers all textured triangles to a square texture image (or a series of images). You can adjust the size of the triangles [2] (in pixels) using the *Triangle size* slider (see Figure 8.51., right). To select the resulting texture size, use the dropdown list (maximum texture size depends on the capabilities of your graphics card). After changing the triangle/texture size, the estimated number of textures will appear in the *Estimated* area at the bottom of the panel; the actual number may differ slightly, however.

Generating Texture Atlas

The *Generate texture atlas* method cuts the surface into pieces, then unfolds and nests these pieces flat and fits them into the specified image size (see Figure 8.51. (middle) and Figure 6.12. in *Displaying Boundaries of Texture Atlas*). This method takes longer to run than *Generate triangle map,* but the resulting texture is much more convenient for manual editing.

[2] Triangle size is determined by the number of pixels per side.

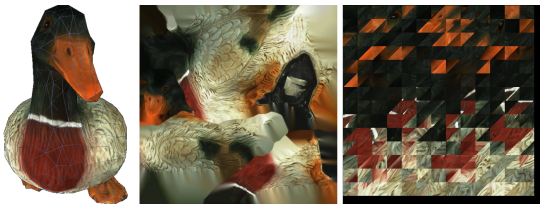


Figure 8.51.: Texture mapping methods: mesh with texture applied (left), texture-atlas sample (middle) and triangle-map sample (right). The latter covers only a portion of the mesh surface (the rest two images not shown).

To modify a texture using an inpainting technique, use one of these two options:

Inpaint missing texture —allows you to apply a texture to regions with no texture information by spreading it from the neighboring regions.

Remove targets —does the same thing, painting out targets by applying surrounding texture information (targets are used to facilitate scanning—see *Target-Assisted Scanning*). This option makes sense if you enabled *remove_targets* before producing this fusion model (see *Fusion*).

Enable texture normalization —this option is selected by default. It aims to compensate for uneven lighting caused by movement of a scanner's flash unit during capture. We recommend leaving this option enabled.

General Information

Finally, select the required *Output texture size* and click *Apply* to start the texture-mapping process.

Important: Texturing with the 16K resolution is only available if your graphics card features at least 3 GB of GPU memory.

To reduce or increase the resolution (*Output texture size*) of the already applied texture, you can re-apply it several times faster by enabling the *Use existing atlas UV* option.

Table 8.4.: Comparison of the texture-applying methods.

Mode	Texture Distortion	Speed	Number of Textures	Texture-Resolution Management
Triangle map	Does not preserve aspect ratio of triangles	Fast	One or more	Adjust triangle size and texture-image resolution
Texture atlas	Preserves aspect ratio of triangles	Slow	Only one	Adjust texture-image resolution

Note that to optimize resource utilization Artec Studio unloads all surfaces from memory, except those needed for texturing, before running the applying procedure. For a more

detailed description of selective project-data loading, see *Selectively Loading Project Data*.

8.9.3 Texture Adjustment

After the texturing is complete, you can adjust the texture on the model (see Figure 8.53.).

Note: You can always return to texture adjustment using the *Adjust texture* command in the *Workspace* panel's context menu.

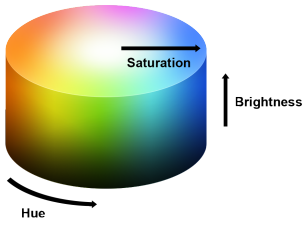


Figure 8.52.: Hue, saturation and brightness representation.

You can adjust the following texture parameters by way of the corresponding sliders (see Figure 8.52. for details):

- Brightness
- Saturation
- Hue
- Contrast
- Gamma correction

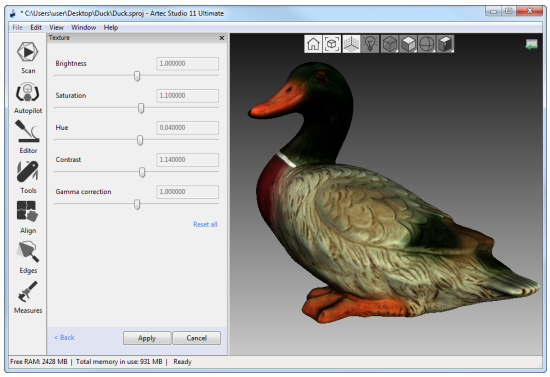


Figure 8.53.: Texture adjustments.

The initial position of the *Hue* slider corresponds to the current texture color. Dragging it left or right corresponds to rotation counterclockwise or clockwise, respectively, on the color wheel.

After making the necessary changes, click *Apply* to transfer the resulting textured model to the *Workspace* panel.

8.10 Texture-Healing Brush: Manual Inpainting

You can manually inpaint missing textures by using the *Texture-healing brush*. This tool is based on the same algorithm as the *Inpaint missing texture* option covered in *Applying Texture*. The inpainting algorithm uses texture information from neighboring regions to fill in areas with missing or incorrect texture. Left image in Figure 8.54. shows a small texture imperfection: a felt-tip pen mark on the figurine. Results of inpainting this region appear in Figure 8.54. (right).

Important: This version of Artec Studio does not support texture restoration on the models textured using *Triangle map* method and in regions of any models that have been corrected using the *Defeature brush*.

Figure 8.54.: Texture-healing brush: before application (left) and after (right).

To launch the tool and inpaint a texture, do the following:

1. Make sure the model that you intend to edit is marked with the icon.
2. Open the *Editor* panel by clicking its icon in the side toolbar.
3. Select the *Texture-healing brush* by clicking the icon.

   Note: Make sure the *Select through* toggle appears as in the *3D View* window.

4. Select a mode: *2D selection* or *3D selection*.
5. Hold down `Ctrl` while using `Scroll wheel` or `[` and `]` keys to adjust the tool size. It should not exceed the size of the region that needs texture correction.
6. Paint over the region of interest using `LMB` while holding down `Ctrl` so that the tool (a circle or a spot) only rolls over the problem area. Try to avoid touching neighboring areas.
7. Click *Apply* to accept the changes or *Cancel* to reject them.

Note: If you paint an area in which the number of polygons exceeds the value specified in the settings dialog (see *Warnings*), a message will appear prompting you to either ignore the value, which means that processing may take longer, or cancel the operation.

CHAPTER 9

Additional Modes

This chapter describes other Artec Studio modes, such as

- Publishing to Viewshape (see *Publishing to the Web*)
- Multicapturing (*Multicapturing*)
- Measurement tools (*Measurement Tools*)

9.1 Publishing to the Web

Having models on a web may simplify the process of collaboration among users. Artec Studio allows you to publish your 3D models on the Web through *viewshape.com*. Viewshape is a service that uses WebGL to render 3D models in a web browser. You can see published models at *viewshape.com* or embedded at other websites, blogs or social networks. Models can be shared privately so that only those who know the unique URL can see, comment on and use them.

Most browsers currently support WebGL. If this feature is disabled or unsupported in a particular browser, *viewshape.com* displays the 3D geometry as a pre-rendered set of images that you can rotate using a mouse. Such images are called spin images.

To publish a model, use the *Publish* panel. It will open only if you have exactly one fusion selected in the *Workspace* window; otherwise, Artec Studio will display an error message. To log into *viewshape.com*, use your *my.artec3d* account. If the process fails, you can access the login window from the link at the top of the panel (see Figure 9.1.).

After you successfully login, you will see the window shown in Figure 9.2.. Follow the steps below to continue uploading:

1. Adjust model's position in the *3D View* window to see how it will appear on the Web.
2. Preview rotation when necessary.
3. Select visibility options (*Public* or *Private*).
4. Choose whether to employ WebGL: use *Show* to display a full-featured 3D model and rotate it freely, or use *Don't show (spin image only)* to display images of the

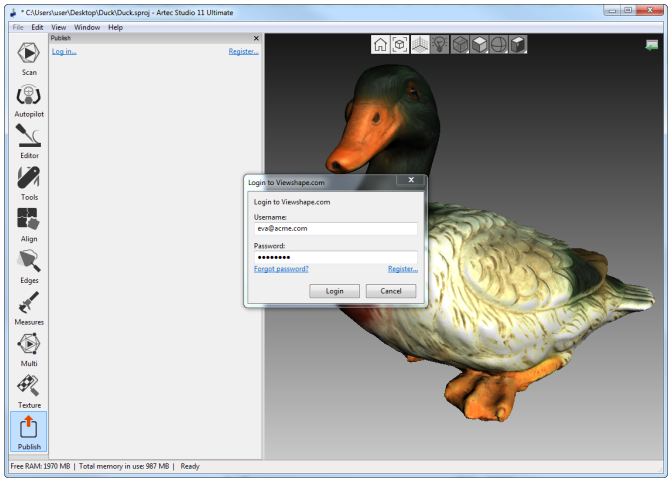


Figure 9.1.: Viewshape.com login window.

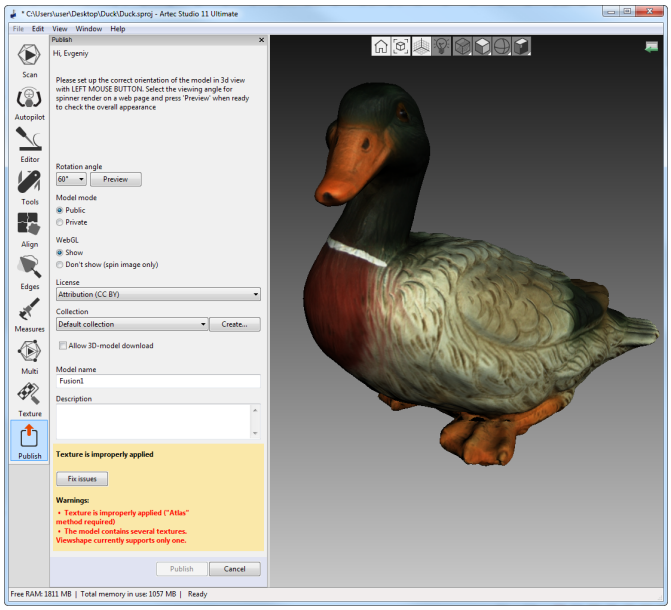


Figure 9.2.: *Publish* panel.

model captured from different angles. You can rotate these images only around the vertical axis.

5. Select a license type for your model.
6. Specify the collection in your gallery to which you want to publish the model, or create a new one.

In addition to the above steps, you must also set the *Model name* and, optionally, the *Model description*. Once you have completed this entire process, click *Publish*; your model will appear on the site.

9.1.1 Model Requirements

WebGL is a progressive API, but it is not very powerful. If your model contains several million polygons and several very high-resolution textures, you will have difficulty rendering it in a browser. Therefore, to produce a model that looks good, you must first optimize it. We recommend the following model parameters:

- Fewer than 300 000 polygons
- Texture size of 1024x1024 pixels (512x512 is better)
- Texture mapped using Atlas method (mandatory)
- Model positioned appropriately to rotate around Y axis

Using `LMB` in the *3D View*, you can rotate the model around its center of mass. Because translation is impossible here, you should rotate the model to the position in which you want it to appear on the web.

If the model parameters fail to satisfy the requirements and recommendations listed above, a yellow notification will appear at the bottom of the window, along with a button that instructs Artec Studio to fix the issue.

9.1.2 Fixing Issues

If your model suffers from one or more issues (as Figure 9.2. shows), click the *Fix issues* button. The software will open the new panel shown in Figure 9.3..

Artec Studio can currently identify two issues: very dense meshes and incorrect texture mapping. If the mesh is too dense, you must first simplify the model. The simplification tool is available in the *Issues found* dialog. If the texture is mapped using the *Generate triangle map* method, you can remap it by clicking *Fix texture*, as Figure 9.3. shows. The *Texture* panel will then open, allowing you to fix it using the *Generate texture atlas* method and the recommended resolution.

Once you have resolved all the issues, click *Back to Publish* to return to the *Publish* panel and resume the publication process.

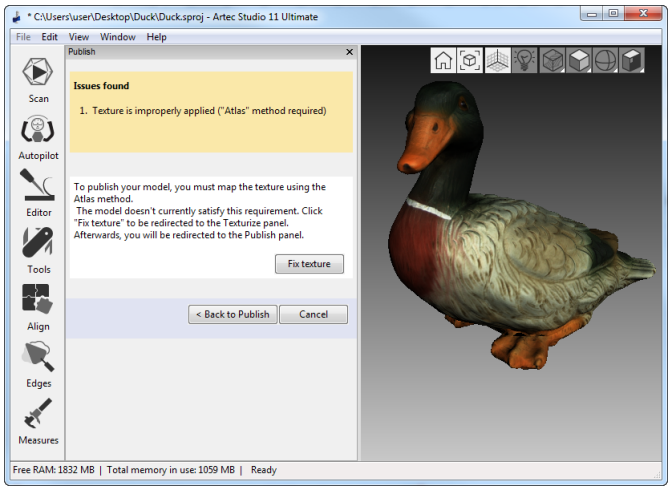


Figure 9.3.: Fixing model issues.

9.2 Multicapturing

Artec Studio enables synchronized scanning with multiple scanners. This mode is helpful when capturing a large object from several angles using more than one scanner simultaneously. Multicapturing with several scanners implies that the system knows their position in advance. This condition simplifies and accelerates data processing considerably. For this reason you must calibrate the relative positions of the scanners before capturing. The resulting calibration data, which includes scanner IDs and their spatial orientations, is referred to as a *bundle*.

You can bundle Artec 3D scanners, third-party 3D sensors or any combination thereof. The only restriction is that the bundle should include no more than one *Microsoft Kinect v2* or *Intel RealSense* (*F200* or *R200*) device.

Note: Also note that adding a third-party 3D sensor to a bundle is only possible in Artec Studio Ultimate.

Use the following procedure to prepare the devices and the environment to simultaneously capture 3D reality:

1. Calibrate the relative position of each device (i.e., create a bundle)
2. Use the *Multi* panel to capture scans

To create a bundle, perform the following steps:

1. Capture the test object using all bundled scanners (see object requirements in *Bundle Creation*)
2. Manually align the resulting scans using the *Align* tool to compute the relative position of all scanners
3. Create the bundle using the *Create bundle* panel

Note: Once you have created the bundle, you can no longer move the scanners relative to one another. If even one device has changed position, you must recreate the bundle!

9.2.1 Bundle Creation

Perform the following steps before creating a scanner bundle:

1. Select device positions. The scanners' combined field of view should cover the required area.
2. Fix the scanners in the chosen positions. If you plan to use hardware synchronization (see *EVA Scanners: Hardware Synchronization*), attach the scanners to the tripods by securing them with thumbscrews while allowing the wires to hang freely.
3. Select and set up the calibration object. Any object with a geometry-rich surface is a candidate. Avoid selecting objects with simple geometries for calibration (e.g., planes, spheres or cylinders). You may use several objects as a composition when creating a bundle. We recommend object installation at the distance corresponding to the middle of the operating range for the corresponding device type.

You can perform the scan using the *Capture* or *Multi* panel. The latter option is more convenient, as it allows you to capture the video data stream simultaneously from several scanners. For details regarding this mode, see *Performing Multicapture*.

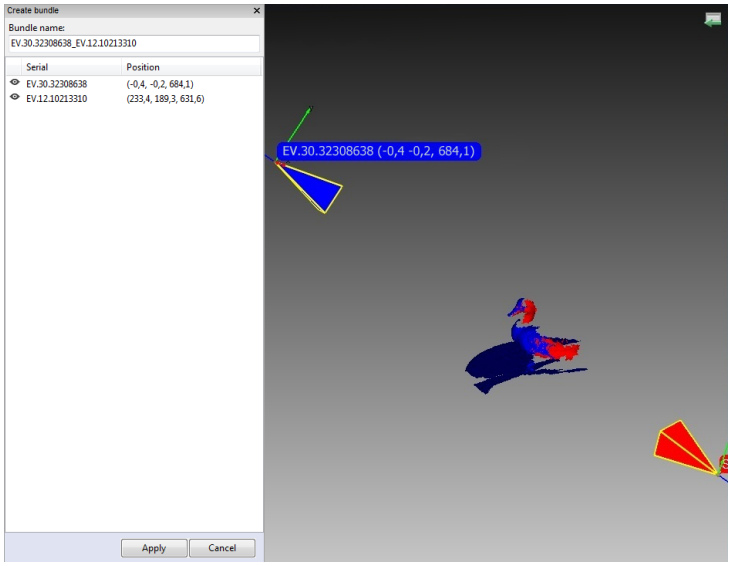


Figure 9.4.: Bundle-creation window.

If you install the scanners at small angles relative to each other (i.e., you can see the same object area simultaneously through different scanners), you need not rotate the object. In this case, you can take calibration scans either sequentially or concurrently.

Note: In case of sequential scanning, make sure the object is fixed safely and remains motionless during the scan.

If you set up the scanners at a large angle and their fields of view have no overlap, use the *Multi* panel to start the capture sequence and then turn (move) the object to enable all scanners to capture the same parts.

Note: It is important that all scanners capture a large portion of the object or scene (but not necessarily the same portion) in each frame, because the position of all subsequent frames—as well as the scanners themselves—will be determined by their predecessors. Also, the relative positions of the scans will determine the intercalibration of the devices.

If the cameras are far from each other and the object was moving, then you should register the scans using the *Fine registration* and *Global registration* algorithms. This requirement, however, isn't applicable for 3D sensors: running *Global registration* may spoil the scans owing to low quality of the geometry obtained from the sensors.

4. Next, proceed to the *Align* panel and align the captured scans as *Scan Alignment* describes. At that point, everything will be ready for bundle creation.
5. From the menu, select *File* → *Create bundle*. A warning message will appear if you forget to align the scans. Otherwise, the bundle-creation panel will appear (see Figure 9.4.). The *3D View* window will show the selected scans, the position and viewing direction of the scanners (by means of an appropriately colored pyramid), the device ID, and the scanner coordinates. It will display a list of connected devices and corresponding information.
6. Add a device to the bundle or remove one by inverting the image in the leftmost column of the list. The order of devices in a bundle refers to the scan order in the *Workspace* panel.
7. A bundle name will appear in the field at the top of the bundle-creation panel. By default it contains the serial number of the bundled scanner. Before creating the bundle, you can easily change this name by typing in the corresponding field. Click *Apply* at the bottom of the panel to create and install the bundle.

9.2.2 Performing Multicapture

Multi mode allows you to capture 3D-data streams simultaneously from several devices. Selecting this mode activates the corresponding panel (see Figure 9.5.) and lets you choose the device configuration: either use one of the existing bundles or specify the scanner list manually.

Note: In multicapture mode the system possesses information about the relative scanner positions. Therefore, scans captured by bundled scanners differ from manual scans in that

the matching frames from different scanners are already in the same coordinate system.

Warning: You cannot use a bundle if the number of devices it includes is greater than the number of processor cores in your PC (i.e., a quad-core PC enables up to four scanners in a bundle).

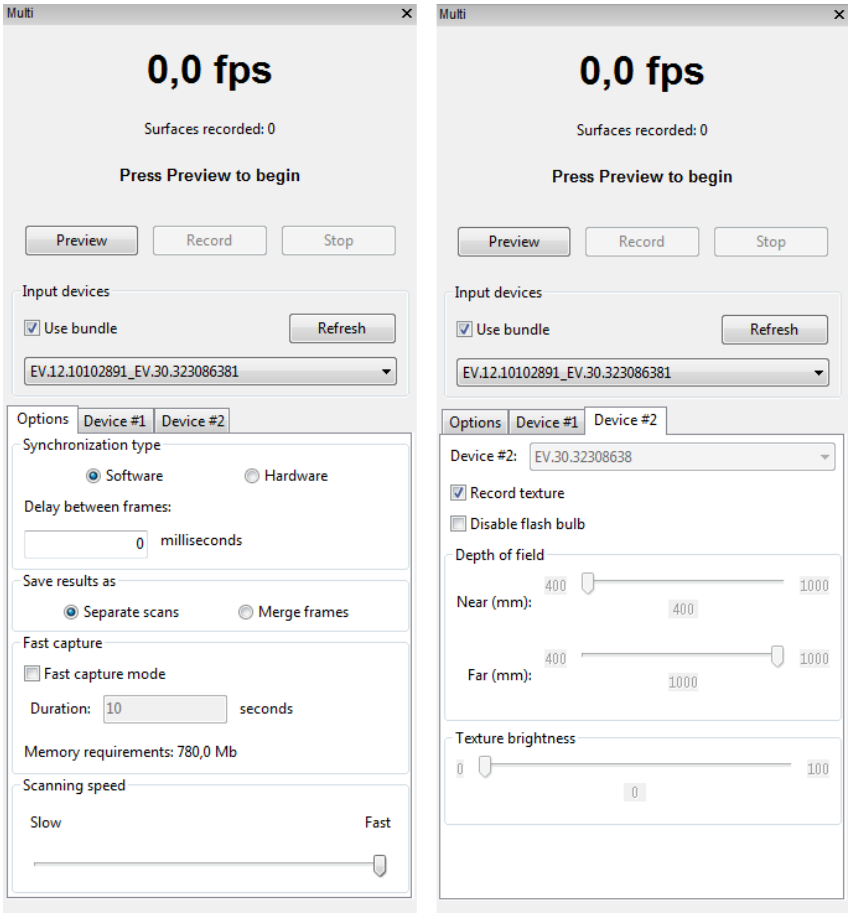


Figure 9.5.: Multicapture panel: *Options* tab on left, *Device* tab on right.

1. Select the *Use bundle* checkbox. A dropdown list of all installed bundles will appear in the panel. Active bundles are highlighted in black, inactive bundles in gray. Artec Studio considers the bundle active if all bundled devices are installed and connected to the PC.
2. Select *Synchronization type* from the *Options* tab in the *Multicapture* panel.
   - In *Software* mode, scanners are synchronized via USB, *Windows* and Artec Studio, and the slave-scanner actuation time always varies (~10 milliseconds) owing to the numerous links in the chain.
   - In *Hardware* mode, scanners are synchronized via cables (see *EVA Scanners: Hardware Synchronization* for details). Hardware synchronization provides high precision and repeatability for slave-scanner actuation time (about 1 millisec-

ond with a precision of less than 10 microseconds, thanks to microelectronic processes).

Note: We recommend hardware synchronization in most circumstances; when capturing moving objects, it is mandatory.

3. Click *Preview* to start capture.

Tweaking Multicapture Options

You can store multicapture data either as separate scans (use the *Separate scans* radio button) or as a single scan in which every frame represents an aligned union of corresponding frames from all bundled devices (use the *Merge frames* radio button).

If you need to capture frames with a certain delay between the scanners, enter the delay value in the *Delay between frames* field. Unlike the *Scan* mode, the *Multicapture* mode captures each frame independently without attempting to align each subsequent frame with the previous one, so it makes sense.

Sometimes, limiting the cameras' field of view is necessary (e.g., to cut off extraneous distant objects). Two sliders in the *Depth of field* area set the near and far scanning boundaries. The application sets work-area boundaries for each device independently in the device tabs (see Figure 9.5., right). By default, the minimum and maximum boundary values for the corresponding device type are set to the recommended range; we encourage you to avoid changing them. However, if you're using Artec L scanners or 3D sensors, it may become necessary. To change these values manually, mark the *Override default depth range* checkbox in the *Scan* tab of the *Settings* dialog and enter the appropriate values in the fields below.

Note: For most scanner types, redefining the recommended depth range may reduce accuracy.

If capture speed is crucial, enable *Fast capture mode* by checking the corresponding box and entering the desired capture duration in seconds. In this mode, Artec Studio wastes no processor time on building and rendering surfaces; instead, it stores raw data in memory and processes frames after completing the capture sequence. When you change the duration of the fast capture period, the application will automatically recalculate and display the required amount of memory. Artec Studio saves multicapture parameters when you exit the application and reapplies them the next time you start it.

9.3 Measurement Tools

Artec Studio offers a number of measurement and commenting tools, including

- Linear measure

- Geodesic measure
- Sections (cross-sections)
- Surface-distance maps
- Annotations

The corresponding buttons reside in the upper part of the *Measures* panel (see Figure 9.6.).

1. Choose a measurement tool, the application displays a list of scans you can work with
2. Select the checkbox of each desired scan. The scans will appear in the *3D View* window.
3. Click *Next*. The selected measurement-tool window will open.

The coverage below takes a closer look at the different measurement tools and their features.

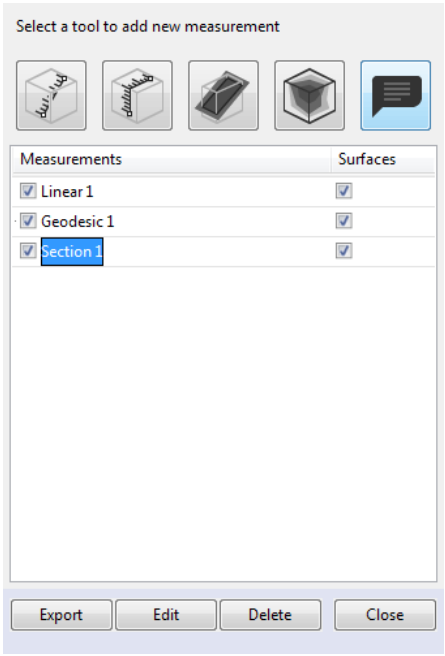


Figure 9.6.: *Measures* panel.

Hint: If your *Measurement* panel lists the previously created items, you can open one of them by double-clicking that item or clicking the *Edit* button.

9.3.1 Linear Distance

The linear-measurement tool (see Figure 9.7.) allows you to measure distances between selected points and to measure the total length for a string of multiple points. Click the

 button and select the scan to switch to the *Linear* window. You can enter a name for the new measurement by typing it in the *Name* field in the upper part of the window. The application creates new measurements with default names `Linear 1`, `Linear 2` and so on.

To measure distances between points,

- Use `LMB` to sequentially select the points on the model in the *3D View* window. The application will add these points to the current point list, which will also display linear dimensions and point coordinates.
- When you roll the cursor over any one of these points in the *3D View* window, the point will be highlighted in red; you can then drag it to another location using `LMB`. When you release the mouse button, the point will fix to its new location.

> **Warning:** You can't set a point outside the object's surface; in this situation, if you release the mouse button, the point will return to its original position.

The total number of points and total length of the measurements appear in the *Measures* panel.

Table 9.1.: Basic operations in the linear and geodesic measurement modes.

Purpose	Control Name
Hide scans in the *3D View*	*Hide source data* checkbox
Display order numbers of points	*Show numbers* checkbox
Display dimension results in the *3D View*	*Show labels* checkbox
Specify the label and line color	*Color* button
Start a new measurement chain on the same objects (clear *3D View* of all points and empty point list)	*Make another* button
Export measurements in a `CSV` or `XML` file	*Export* button
Return to the original *Measures* tab	*Measurements* link in the upper part of the panel

After you click *Apply*, the application will return to the original *Measures* panel and will display a list of all saved measurements along with editing and deletion options.

9.3.2 Geodesic Distance

Geodesic distance is defined as the length of the shortest path over a surface between several given points. Click the  button in the *Measures* panel and select a scan to start using the tool.

Note: Only scans containing one surface will appear in the selection panel for the

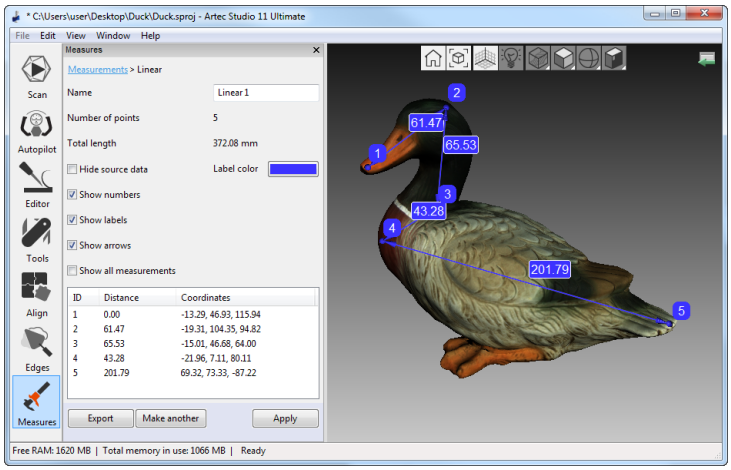


Figure 9.7.: Linear measurement.

geodesic measurement tool.

Working with geodesic measurements is similar to working with linear measurements (see Figure 9.8.). Calculation of the shortest path is a time-consuming process that is accompanied by a progress-bar window. Also keep in mind that the shortest path between different surfaces or disconnected parts of the same surface is not defined. Therefore, the program will display an error if you select points on parts of a surface that are not connected to each other.

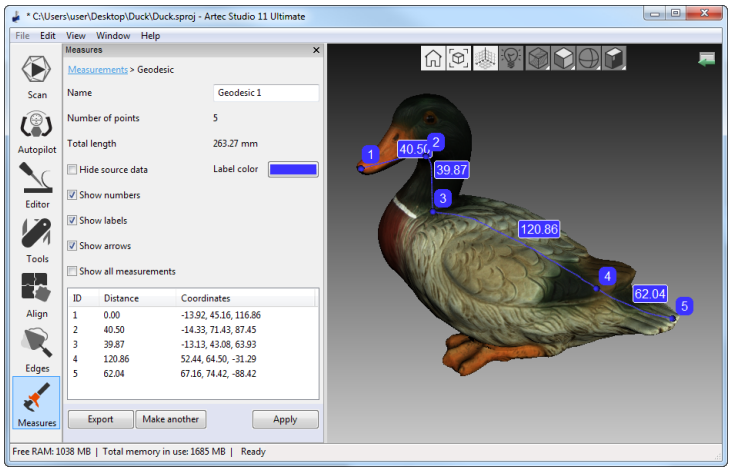


Figure 9.8.: Geodesic-distance measurement.

Note: The geodesic algorithm is complex, and computations for a large number of vertices may take a long time. Therefore, if you choose the first point on a surface containing more than 150000 points total, the software will warn you that it may be a lengthy operation. You can either use the mesh-optimization algorithm beforehand (see *Mesh Simplification*) or delete the parts of the surface that you don't need.

The left panel in this mode is similar to the one for linear-measurement mode (see *Linear*

Distance).

9.3.3 Using Sections to Measure Area and Volume

To create a section of the object (see Figure 9.9.), click the  button in the *Measurements* panel and select one or more scans. After clicking *Next*, you can change the section name in the *Name* field. By default, the application creates new sections with names `Section 1`, `Section 2` and so on.

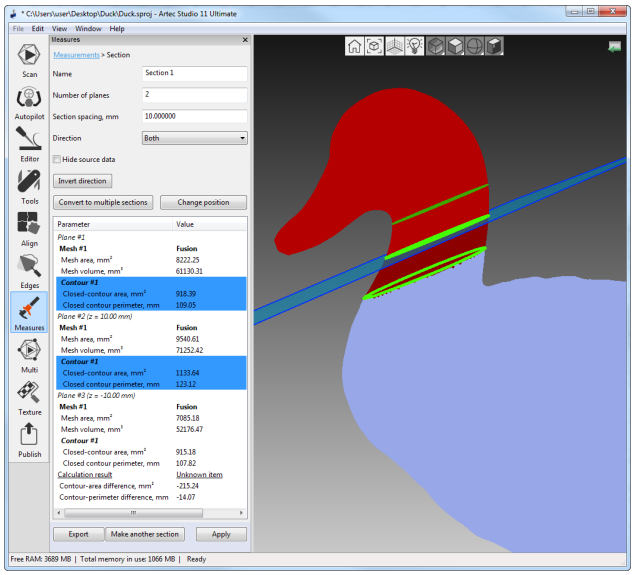


Figure 9.9.: Using sections.

Now you can define the section:

1. Use `LMB` to mark points on one or more surfaces:
   (a) Mark only one point to specify a plane in parallel with one of the coordinate planes (XOY, YOZ, XOZ).
   (b) Mark three points to specify the plane that passes through them exactly.
   (c) Mark more than three points to specify the plane that passing through their center of mass.
2. Redefine your point selections, if necessary, before you use *Create section*; to do so, click the *Clear points* button.
3. Click *Create section*. If necessary, redefine the plane. Click the *Change position* button and choose a tool: *Translate*, *Rotate* or *Scale*. You can either specify numerical values (in the global coordinate system) in the text fields or drag the controls (see Figure 8.6., Figure 8.7. and Figure 8.8.) in the *3D View* windows. For instance, by enlarging the *Scale* for the plane defined in Step 1.2, this plane would then cross the whole surface. Confirm your changes by clicking *Apply*.

4. Create a series of sections, if desired. To do so, specify the quantity of planes you want to create by entering the value in *Number of planes* and define the spacing in the *Section spacing, mm* field. Then select from the *Direction* list one of three directions (*Positive*, *Negative* or *Both*) in which to create the new planes.
5. Save your changes by clicking *Apply*, or click *Measurements* in the upper part of the panel. To save the changes and begin creating the next plane, click *Make another section*.

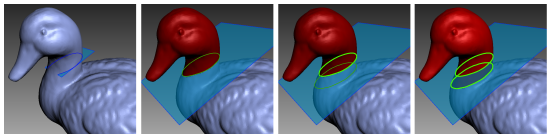


Figure 9.10.: View of contours (from left to right): open contour (1), closed contour (2), contour selected (3), pair of contours selected (4).

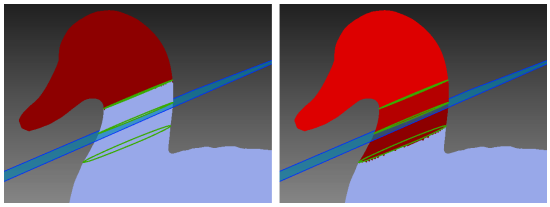


Figure 9.11.: View of meshes: one mesh selected on left and several on right.

Once you have created the section, the *Section* panel will display its geometrical information. This information includes perimeter and area for closed contours as well as area and volume for meshes. If the section object consists of several planes, the data is grouped by plane. Besides displaying geometrical values, Artec Studio will show a list of meshes and contours that allows you to highlight them in the *3D View* window using different colors:

Blue (see image 1 in Figure 9.10.) if the contour is open.

Green (plain) (see image 2 in Figure 9.10.) if the contour is closed.

Green (highlighted) (see image 3 in Figure 9.10.) applies to the currently selected contour or the polygons under (above) the selected plane. To toggle between polygons, click the *Invert direction* button.

Pair of green highlighted contours (see image 4 in Figure 9.10.) highlights both contours in the list if you selected a pair using `Ctrl`. Simultaneously, Artec Studio calculates the differences between the areas and perimeters of these contours.

Several shades of red denote polygons belonging to one mesh (dark red in left image in Figure 9.11.) or to several meshes (from brighter red to the brightest red in right image in Figure 9.11.). When you have selected a pair of meshes, the application also calculates the difference between volumes and areas and displays the results in the lower part of the *Section* panel.

If you want to separate a set of sections into individual ones, click *Convert to multiple sections*. The software will notify you that the operation was successful, and the new objects will appear in the *Measurements* list.

Exporting Sections

You can export sections in the following formats: `CSV` , `XML` or `DXF` .

- To export each section individually, enter the *Section* panel and click *Export*
- To export several objects at a time, access the original *Measures* panel, select the checkbox next to desired sections and then click *Export*.

9.3.4 Surface-Distance Maps

You may often find it necessary to compare two models and assess the deviation of their forms. For instance, quality control may require comparison of the original model with the scanned one. You can handle these tasks by using *Surface-distance map*.

Note: Artec Studio can only compare models or scans containing a single surface.

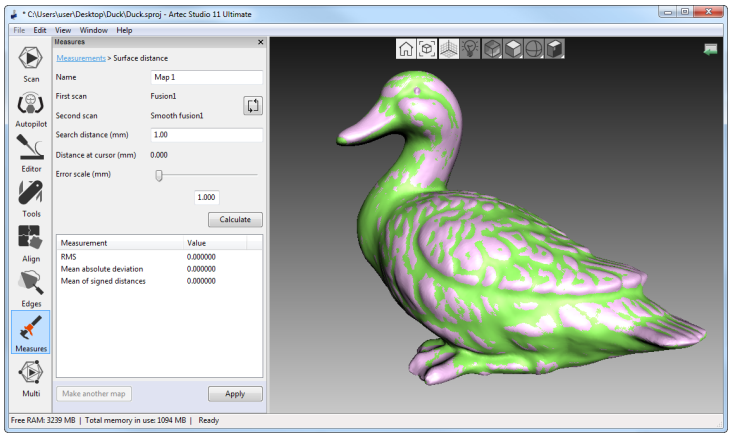


Figure 9.12.: Specifying parameters for surface-distance map calculation.

Use this tool as follows:

1. Click the  button from the *Measures* panel.
2. Select two models for comparison and click *Next*.
3. If necessary, specify the name of the distance map in the *Name* field of the *Measures* panel (see Figure 9.12.). By default the application creates new distance maps under the names `Map 1` , `Map 2` and so on.

Note: The direction along the normals of the first scan is considered positive; the opposite direction is considered negative. The button swaps scans.

4. Specify the *Search distance (mm)* value, a maximum range in millimeters for calculating distances between surfaces. You can adjust the actual range subject to this maximum after the calculation finishes.
5. Click *Calculate*. Once the process is complete, the distance map will appear in the *3D View* window and the calculation results in the *Measures* panel (see Figure 9.13.).

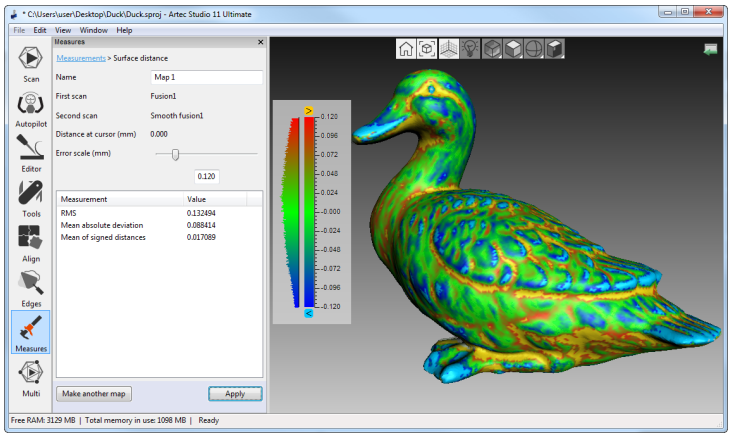


Figure 9.13.: Surface-distance map calculated for two models.

You can analyze the calculation results and the distance map:

- On the basis of the *Search distance* value you entered, Artec Studio calculates the following:
  - *RMS* (root mean square)—the square root of the arithmetic mean of the squared distances
  - *Mean absolute deviation*
  - *Mean of signed distances*
- A distance map is a colored rendering on the particular surface regions. You can read the corresponding distance values and their distribution from the graduated scale and histogram that appear adjacent to the model. The map color changes from blue, which corresponds to a negative distance, to red, which corresponds to a positive distance.
  - Green means the distance between surfaces in this region is close to zero.
  - Gray highlights any surfaces with distances that exceed the specified *Search distance*.
  - Orange and bright blue correspond respectively to distances that are slightly above and below the limiting values of the scale.
- The graduated scale ranges from the positive value to the negative value of the *Error scale*. You can adjust this range using the *Error scale (mm)* slider or text box. Its maximum value cannot exceed the *Search distance*.
- If you move the mouse cursor to a particular point on the map, the exact distance will appear nearby and in the *Distance at cursor* field in the left panel.

To save the current distance map and quit this mode, click *Apply*. To save the current map and create another one, click *Make another map*.

Note: Surface-distance maps are supported by annotations. You can use any saved distance map in *Annotation* mode (see *Annotations*).

9.3.5 Annotations

Annotations tools allow you to mark noteworthy surfaces and surface-distance maps. The annotation can include one or more labels, which look like rectangular tags with connecting lines pointing to the corresponding surface elements (see Figure 9.14.).

To create an annotation,

1. Click the  button in the *Measures* panel, then select one or more scans and click *Next*.
   (a) If you want to annotate a previously obtained surface-distance map, select it from the *Distance map* list.
2. Specify the *Annotation name* in the upper part of the panel, or simply proceed with your annotation using the default name.
3. Click `LMB` on the surface's target point in the *3D View* window; the label will appear with a blinking text cursor in the *Annotation text* field of the *Measures* panel.

   Note: Artec Studio doesn't enable you to redefine a label's target point. If you inaccurately specify a point on the surface, add a new one (repeat Step 3) and delete the old one (consult the instructions below).

4. Type any desired text for your annotation; this text will appear in both the corresponding field in the panel and the label in the *3D View* window.
5. Repeat Steps 3 and 4 to create a new label. In addition to tagging the surface, each new label will appear in the annotation list of the *Measures* panel (see Figure 9.14.). You can show or hide labels in the list or change their colors by clicking `RMB` and selecting the appropriate option from the menu. Alternatively, toggle the selection flag or click the square button to show/hide labels or change their colors, respectively.

You can adjust the label position (meaning the rectangular tag, not the target point!) by holding `LMB` in the *3D View* window while moving the mouse cursor. To delete unnecessary labels, use any of the following approaches:

- Select the label in the *3D View* window; its border color will become red (see selected label in Figure 9.14.). Hit the `Del` key.

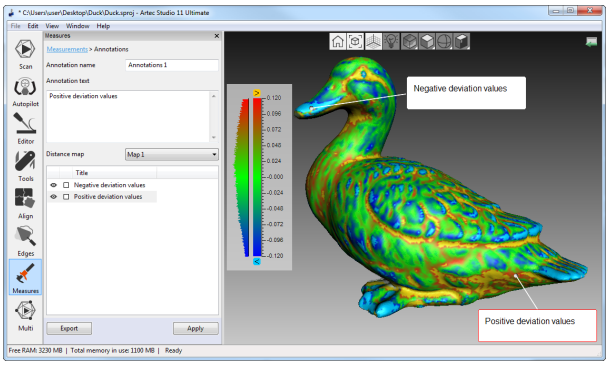


Figure 9.14.: Annotation of a model layered with a surface-distance map.

- Select the label from the list, then either hit `Del` , or click `RMB` and choose *Delete* from the menu.

To export annotations (more precisely, label coordinates and titles) to a `CSV` or `XML` file, click *Export* in either the *Annotations* or original *Measures* panel. By default, the file name will be the same as the annotation name. Accept it or type in another name of your choice. To complete the annotation, click *Apply* in the bottom of the *Measures* panel or click *Measurements* in the upper part.

CHAPTER 10

Settings

This chapter describes Artec Studio settings that you can change through the *Settings* dialog. To display this dialog, select *Settings...* from the *File* menu or hit the `F10` key.

The user-adjustable settings are divided into categories under separate tabs. These categories include the following:

- General
- Performance
- Scan
- UI
- Miscellaneous

10.1 General

The *General* tab contains basic Artec Studio settings and includes the following options (see Figure 10.1.):

- *Project-storage folder*
- *Autosave* options
- *Import/export* options
- *Default import units* and *Default export units*
- *View control* settings

10.1.1 Project-Storage Path

You can set the default folder in which Artec Studio will save projects by typing in the path, or select it from the dialog by clicking *Browse...*.

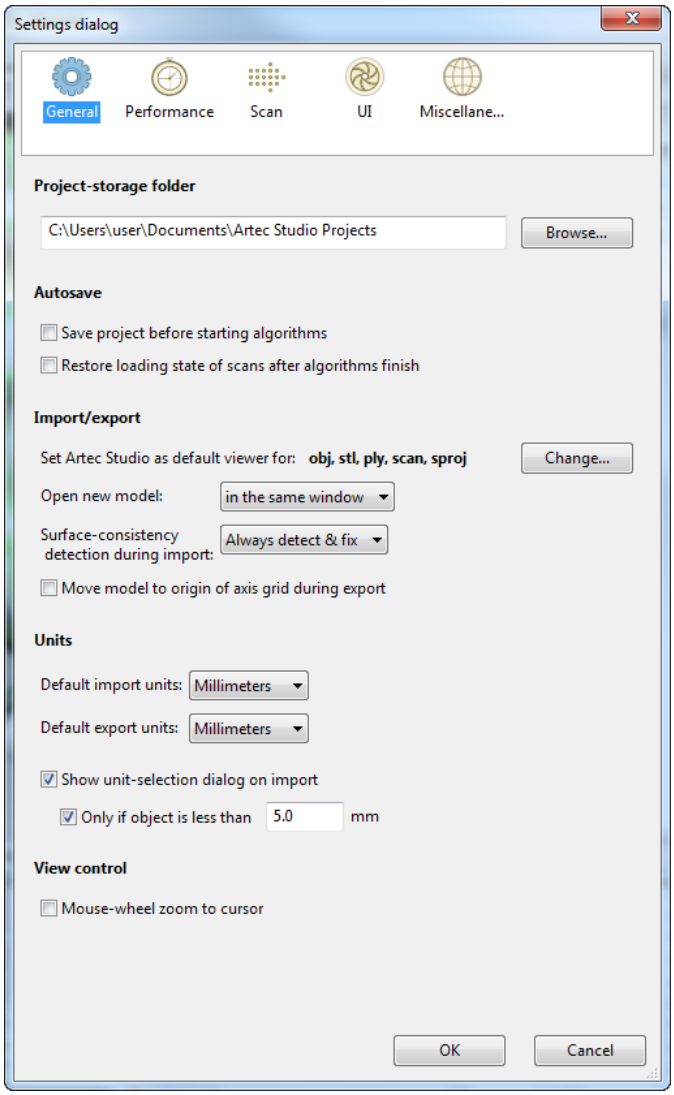


Figure 10.1.: *General* settings page.

10.1.2 Autosave Options

When the *Save project before starting algorithms* option is enabled, the application will always save your project before running any processing routines. The *Restore loading state of scans after algorithms finish* checkbox allows you to control loading of selected scans once the algorithm is complete. Artec Studio always loads selected scans into memory before launching an algorithm; if a scan is not loaded at this point, the application will automatically save it to the hard drive after the algorithm finishes, freeing up memory. For more information about autosaving projects, see *Autosaving a Project*.

10.1.3 Registering Artec Studio as Default Viewer

Artec Studio supports various file formats. To make it the default application for supported formats, click *Change...* and select the formats you want the application to open by default (see Figure 10.2.):

***.sproj** —project files for Artec Studio

***.scan** —single-scan export/import format

***.ply** —format for saving polygonal models obtained using 3D scanners

***.stl** —3D-model export format for fast-prototyping equipment

***.wrl** —virtual-reality files in VRML 1.0 and VRML 2.0 format

***.obj** —texturized 3D models; Wavefront OBJ format

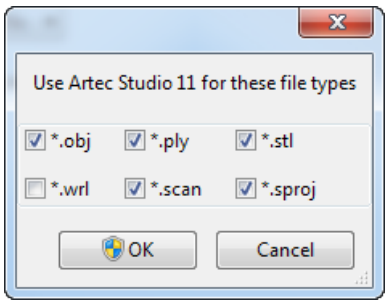


Figure 10.2.: Making Artec Studio the default application for various file types.

For more information on importing and exporting files, see *Exporting Models and Scans* and *Importing Models and Scans*.

10.1.4 Opening Files

Artec Studio can serve as the default viewer for `SPROJ`, `SCAN`, `PLY`, `STL`, `OBJ` and `VRML` (`*.wrm`) formats. To open each subsequent file in a new application window, select *Open new model in a new window*. If the *Open new model in the same window* option is selected, Artec Studio will use existing windows to display subsequent files.

10.1.5 Surface-Consistency Detection During Import

The *Surface-consistency detection during import* option instructs Artec Studio to examine imported files for defects. Select one of the following parameters:

Do not detect —disable automatic surface-consistency detection

Detect & ask —enable automatic surface-consistency detection; Artec Studio will prompt you to start defect correction

Always detect & fix —enable automatic surface-consistency detection and correction

10.1.6 Model Placement

When exporting, the application can automatically center scans and models on the origin of the axis grid. To enable this option, select the *Move model to origin of the axis grid during export* checkbox. If the checkbox is cleared, the application will save the model's current placement on the axis grid when exporting surfaces.

10.1.7 Units

In Artec Studio, all software operations use millimeters as the default measurement unit. If you need to import or export a model in other units, change the settings under *Units*. The software applies these settings only when importing or exporting a model.

Selecting the *Show unit-selection dialog on import* option enables you to choose on import which measurement unit was used to create the scan (see Figure 10.3.). Artec Studio supports units of millimeters, centimeters, inches and meters. If in most cases you import data in a particular measurement unit, but you might occasionally import models created using another unit, you should enable the *Only if object is less than __ mm* option and enter the threshold value. In this case, the unit-selection dialog will only appear if the model dimensions are below the threshold value.

The *Default import units* and *Default export units* dropdown lists determine the default measurement units for importing and exporting models.

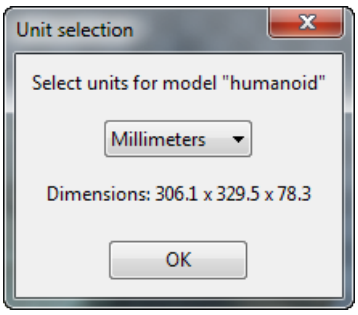


Figure 10.3.: Unit-selection window.

10.1.8 View-Control Settings

Artec Studio allows you to use `Scroll wheel` to zoom in on the model in the *3D View* window. You can take advantage of this capability in two ways:

Clear the Mouse-wheel zoom to cursor checkbox to enable zooming to the center of the screen. In this case, you must keep the target area in the screen center and readjust its position from time to time.

Select the Mouse-wheel zoom to cursor checkbox to enable interactive zooming to the mouse-cursor position. In this mode, you need only keep the cursor on the target area while spinning `Scroll wheel` forward and backward.

10.2 Performance

The following parameters are user adjustable by way of the *Performance* tab (see Figure 10.4.): multithreading, memory usage, command-history storage, compression levels for stored data, texture-recording mode and *Real-time fusion* settings.

10.2.1 Multithreading

On computers that feature multicore processors, Artec Studio uses all cores by default. If you would like to limit the number of cores the application employs, clear the *Use all available processor cores* checkbox and enter the number of concurrent threads manually.

10.2.2 Memory

Under *Memory*, the *Settings* dialog shows RAM availability. If the current amount is insufficient, you can try to increase it by clicking the *Compact memory* button. Artec Studio will clear the command history and attempt to optimize memory allocation. Clicking *Compact memory* won't permanently delete the history, but simply unload it from memory. The *Undo* command will reload it. For more information about saving projects, see *History of Project Changes*.

Note: You cannot unload the command history from memory if you haven't saved the project. Save the project and try again.

10.2.3 Command History

Under the *Command history* section you can limit the amount of history Artec Studio will save. By default, the maximum values are set as a certain number of commands and size on disk (in MB). If necessary, you can clear the *Max history length* checkbox. Doing so means the program will save all history for each project from the beginning. You can

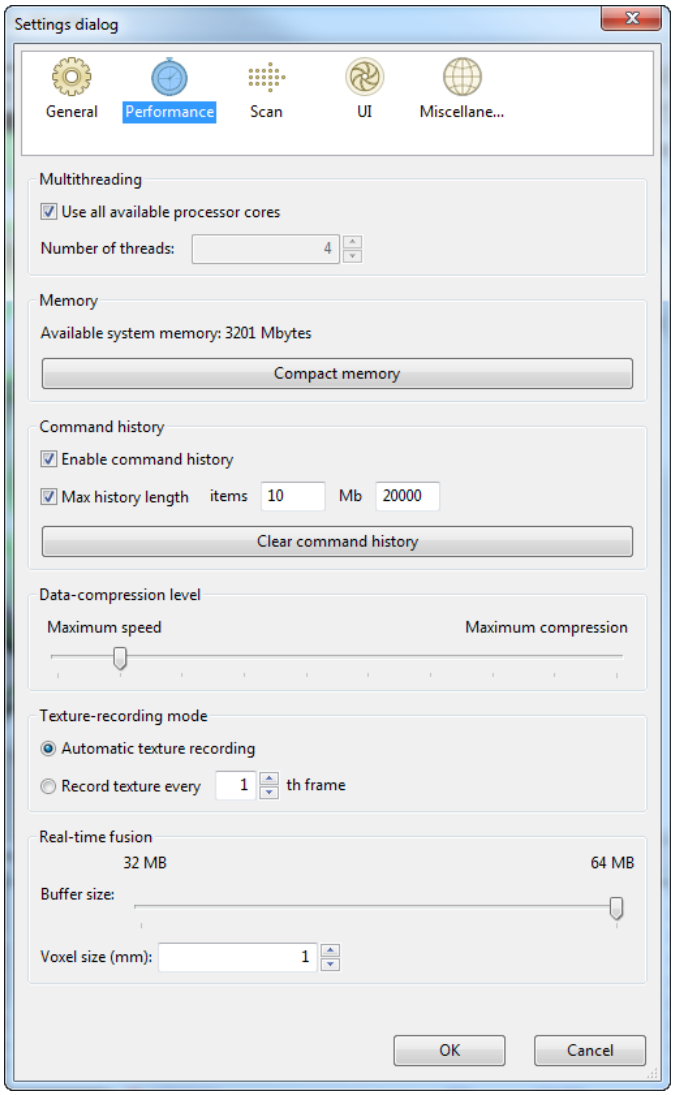


Figure 10.4.: Performance-tab options.

clear the project history by clicking the *Clear command history* button; the application will prompt you to confirm this action.

Note: Once you clear the history, you cannot return to an earlier project version.

10.2.4 Data-Compression Level

The slider under *Data-compression level* allows you to change the amount of file compression when saving data. Higher compression saves disk space, but loading and saving these scans takes longer. These settings apply to both projects and `SCAN` files.

10.2.5 Texture-Recording Mode

By default (*Automatic texture recording* enabled), Artec Studio doesn't capture texture for every frame. You can, however, manually specify the frequency for capturing texture frames by using the *Record texture every __th frame* spinner.

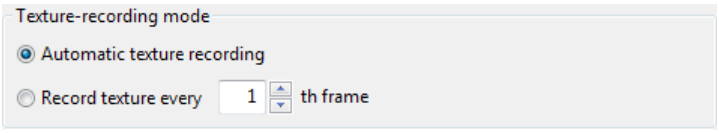


Figure 10.5.: Spinner for adjusting capture frequency of texture frames.

10.2.6 Real-Time Fusion Settings

Real-time fusion offers two optional settings (see *Scanning With Real-Time Fusion*):

Voxel size (mm) The fusion resolution. It affects the algorithm's performance and quality. The lower the value, the sharper the shape of the model. Note that specifying low values may produce noisy surfaces.

Buffer size Amount of GPU memory employed to reconstruct a Real-time fusion object in the scene. The default value depends on the computer's available GPU memory. Note that Artec Studio may fail to correctly determine the upper limit if your computer has an Intel HD Graphics card. The more memory you have, the larger the scene you can scan in Real-time fusion mode. The slider doesn't define the total finite memory size, however; the algorithm employs system memory (RAM) when GPU memory is consumed.

Note: Avoid altering the *Buffer size* unless you have started noticing artefacts while scanning.

Table 10.1.: Default values of *Voxel size*.

	Artec EVA	Artec Spider	Third-Party 3D Sensors
Voxel size (mm)	1	0.3	3

10.3 Scan

The *Scan* tab allows you to edit the parameters that the application uses both while scanning and while postprocessing the results (see Figure 10.6.).

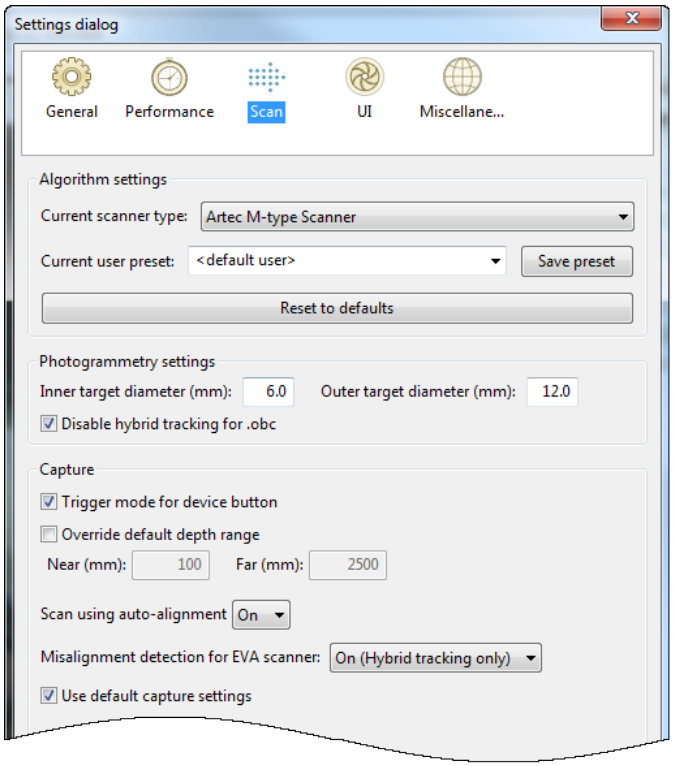


Figure 10.6.: Scan-settings tab.

10.3.1 Algorithm Settings

Artec Studio automatically selects and displays settings for each scanner type in the *Current scanner type* dropdown. If it fails to correctly identify your scanner type, select the appropriate scanner manually. While using the application, you may need to change algorithm settings manually. To reset all settings to their default values, click *Reset to defaults*.

Current user preset allows you to save the current parameter values in the *Tools* panel. By selecting a saved preset, you can change all settings at once. Note that this option applies only to the selected device type.

10.3.2 Photogrammetry Settings

Photogrammetry settings allow you to define the target size. *Inner target diameter (mm)* corresponds to the diameter of the white circle in the middle of the target; *Outer target diameter (mm)* corresponds to the outer diameter of the target's black ring. The most popular targets have diameters of `6` mm and `12` mm; the values `5` mm and `10` mm correspond to the *Scan Reference* target. See *Target-Assisted Scanning* for details.

The *Disable hybrid tracking for .obc* checkbox ensures that tracking is purely based on targets. Select the checkbox if you don't want the texture and geometry features to assist target scanning (*Using Photogrammetry Solution (Scan Reference)*).

10.3.3 Capture

The *Capture* section covers settings related to the trigger button for the Artec MHT scanner, as well as the scanning-depth range and individual frames acquired during the scan.

The first option is the *Trigger mode for device button* checkbox, which changes the button behavior on the Artec MH and Artec MHT scanners. For details regarding these buttons, see *Scanner Buttons and Capture Modes*.

The scanner has a defined depth range. If it's too close to the object, it may fail to capture all or part of the object. On the other hand, if the scanner is too far away, various types of 3D "noise" will appear in the scene, complicating the postprocessing effort and affecting the final results. Therefore, you should position the scanner as close as possible to the object without crossing the cutoff plane. Default settings for each 3D scanner contain minimum and maximum limits within which you can position the cutoff planes. The scanner model determines these values. If you are using an Artec L scanner or 3D-sensor and high accuracy is of lesser importance, however, you can adjust the depth boundaries manually, allowing you to scan closer to or further from the object than the recommended distances indicate. To this end, mark the *Override default depth range* checkbox and enter new range values.

> **Warning:** Redefining the depth range may reduce accuracy.

Scan Using Auto-Alignment

The *Scan using auto-alignment* option is enabled by default and is covered in the *Resuming Scan After Lost Tracking* and *Continue Scanning From Scans Selected in Workspace* sections. The application's behavior varies depending on this option's value, as Table 10.2. shows.

Table 10.2.: Application behavior with option enabled and disabled.

Scan Using Auto-Alignment	*On*	*Off*
Tracking Mode	Geometry + Texture	Geometry or Geometry + Texture
Audio Notification?	Yes (see *Audio Notification*)	Yes
Message in *3D View*	Searching for position: Point 3D Scanner at the object to continue	Tracking lost: Repeat scan using slower motions or additional features
Instructions	Direct the scanner at any already captured region with sufficient texture, maintaining the original scanner orientation relative to the object	Direct the scanner at the last captured region
Data Recording	Handled in a newly created scan	Handled in the same scan

10.3.4 Misalignment Detection

In some cases, Artec Studio may incorrectly determine relative frame positions, resulting in misalignment. When this error occurs, you must restart the scanning session and remove the misaligned scans. Alternatively, you can attempt to fix the misalignment by breaking the scan into several segments. Further information about addressing this problem by dividing scans is available in *Separating Scans*. To prevent possible misalignment and improve your scanning experience, Artec Studio features a *Misalignment detection for EVA scanner* setting that functions during the scanning process. However, if you have difficulty maintaining the tracking when scanning particular objects, you can disable this setting.

Options are as follows:

On (Hybrid tracking only) —default value, option works for *Geometry + Texture tracking* mode

On —option works for all tracking modes, including *Geometry*

Off —option is turned off for all trackers.

Default Capture Settings

Artec Studio allows you to change the characteristics of single-frame surfaces as the scanner captures them. To change the default parameters, clear the *Use default capture settings* checkbox and change the settings manually in the displayed window. The options below are user adjustable:

Important: We recommend using default settings. Poorly chosen settings may reduce data quality.

Triangles step —point density for a frame mesh

Minimum object size —smallest object scanned, by number of polygons

Length filter threshold —triangle-filtration threshold by edge length (maximum possible size in mm)

Interpolate —use interpolation for parts of surface that are missing data

Max interpolated length —maximum size of areas to be interpolated (in mm)

Max angle —triangle-filtration threshold by maximum angle (in degrees) between the triangle's normal and the camera's sight vector

Geometry registration threshold —the higher the threshold, the stricter the quality requirements for the geometry being scanned. Therefore, determining the proper geometry in the scene is more difficult in such cases. Subsequently, Artec Studio runs geometry registration less frequently, making way for texture registration. Works with *Geometry + Texture tracking* only, values are between 0 and 1.

10.4 UI

The *UI* page allows you to edit user-interface settings (see Figure 10.7.) and covers the following categories:

- Audio notification
- Workspace colors
- Warnings
- Surfaces that Artec Studio displays during a scan

10.4.1 Audio Notification

Sometimes, automatic alignment in real time is impossible during the scanning process, and the program is unable to align the previous frame with the current one (see *Resuming Scan After Lost Tracking*). When this situation occurs, Artec Studio issues an audio warning that stops once you reposition the scanner and the software again finds its location in 3D. To enable or disable this feature, use the *Enable audio warnings in scan mode* checkbox. A standard "beep-sound" is the application's default sound. You can choose any `WAV` file as the warning sound. To this end, click the ... and specify a file path.

Note: You will only receive audio warnings during a scan if your computer is equipped with a sound card and speakers.

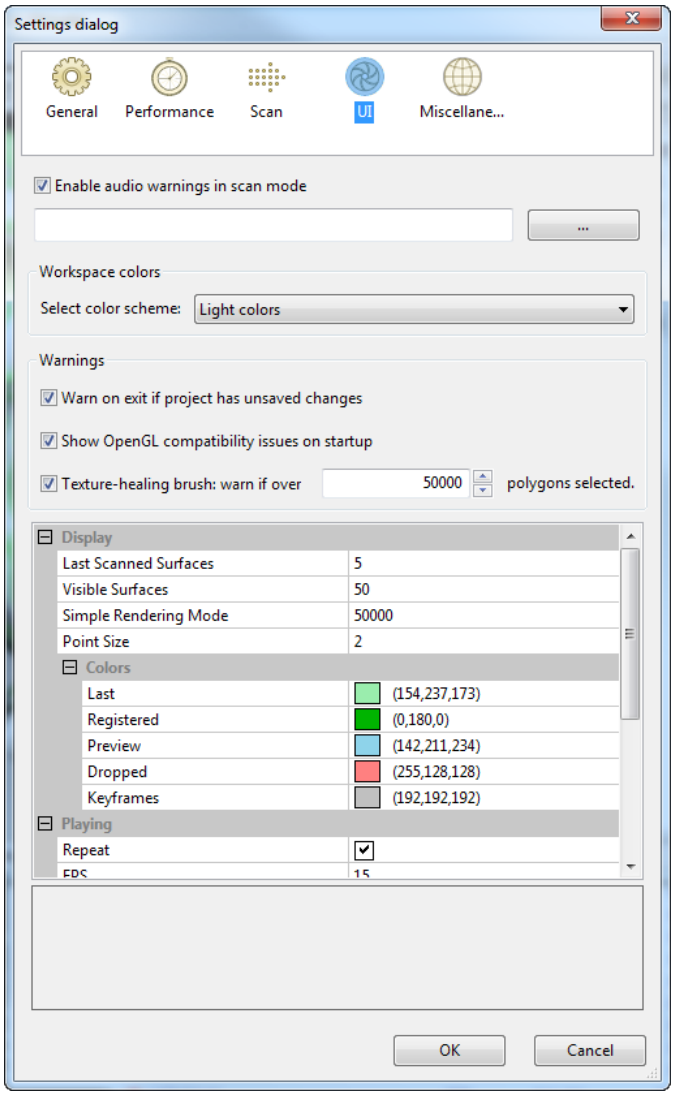


Figure 10.7.: Interface-settings tab.

10.4.2 Workspace Colors

Artec Studio automatically chooses display colors for newly created scans. You can select any of the standard palettes:

- Full palette
- Light colors
- Web-safe colors
- Random colors
- Monochrome

10.4.3 Warnings

The *Warnings* options allow you to toggle certain notifications. They include the following:

Warn on exit if project has unsaved changes. If this option is enabled, Artec Studio will warn you that you will lose unsaved data if you close the application without saving your work.

Show OpenGL compatibility issues on startup. Artec Studio requires *OpenGL* version 2.0 and some *OpenGL* extensions to function properly; your PC may or may not currently support these capabilities. Selecting this option activates a display window on startup containing information regarding possible missing extensions.

Texture-healing brush: warn if over __ polygons selected. This checkbox instructs the application to display a warning if you exceed the maximum number of polygons to be inpainted at one time. This limit reduces the potential for the computer to hang up. Specify a suitable value for your system, or clear this checkbox if you require no warnings of this kind.

10.4.4 Displaying in 3D View Window

You can change the way you see surfaces and points during the scanning process, adjust their colors as well as the background color, and specify the mode for frame playback. To these ends, use the settings below:

Display

Last scanned surfaces —number of visible surfaces most recently captured that will appear in *3D View* during scan

Visible surfaces —total number of visible surfaces displayed during scan (equal to the number of most recently scanned surfaces plus the number of key frames to display)

Simple rendering mode threshold —maximum number of vertices in the viewport beyond which Artec Studio will switch to simple rendering mode during 3D navigation

Point size —number of pixels for rendering each point when using the *Points* or the *Points and solid* rendering mode

Colors

Last —color of last scanned surfaces

Registered —color of correctly aligned surfaces

Preview —color of surfaces in preview mode

Dropped —color of unaligned (and thus dropped) surfaces

Key frames —color of key frames (surfaces)

Playback

See also:

Selecting Data

Repeat —continuously loop the frame sequence in the surface-view mode of the *Workspace* panel

FPS —speed (in frames per second) at which frames appear during playback

Background

See also:

Figure 10.8.

Color —background color

Dropped color —background color when misalignment occurs while scanning

Texture —display patterned (chessboard pattern) or plain background

Gradient —gradient or monochrome background color

Welcome Screen

Don't show —disable the welcome screen

Autopilot

Don't show greeting screen —disable the *Autopilot* screen showing the steps to pass in this mode

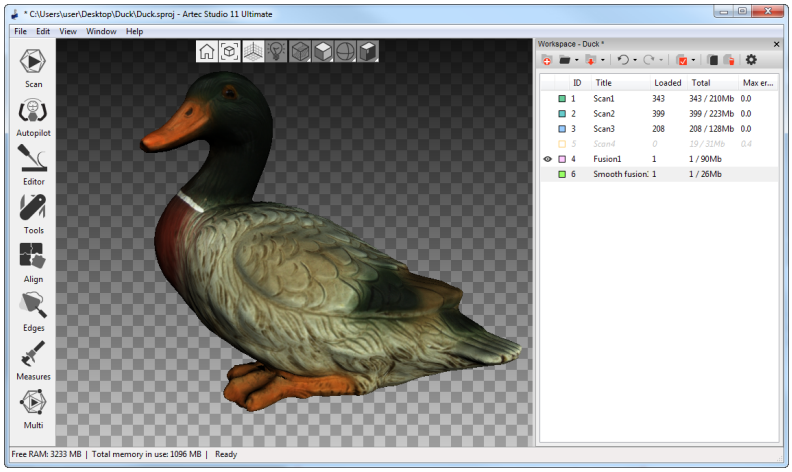


Figure 10.8.: Example of altered background.

10.5 Miscellaneous

10.5.1 Usage Information

You can help us improve the quality and performance of Artec Studio by allowing us to collect and send usage information to Artec Group. This information will not be used to identify you, and it excludes your project data, 3D surfaces, textures and any other data that you obtain and process using Artec Studio. By default, the *Collect and send anonymous usage data to Artec* checkbox is selected. We recommend leaving this checkbox marked so we can better improve the application.

When installing Artec Studio, you can decide whether you want it to collect and send usage data. The same checkbox described above also appears in the final installation dialog (see Figure 4.13.).

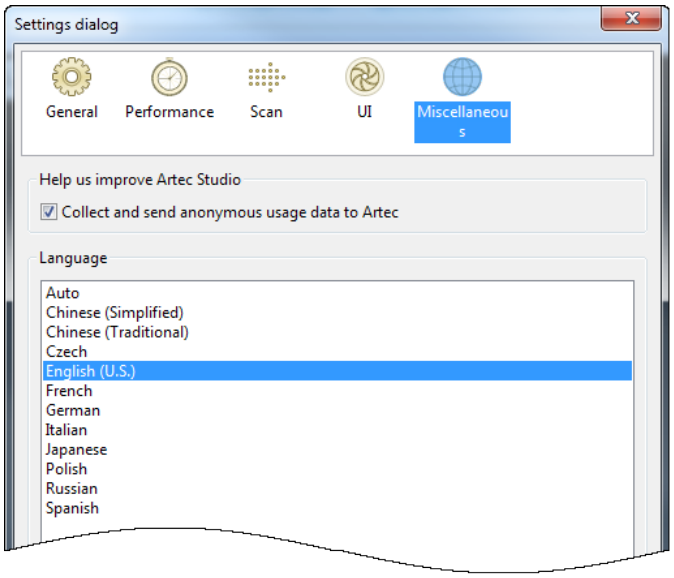


Figure 10.9.: Miscellaneous-settings tab.

10.5.2 Language

The Artec Studio interface supports several languages:

- *Auto*—automatic language selection on the basis of system settings
- *Chinese (Simplified)*
- *Chinese (Traditional)*
- *Czech*
- *English (U.S.)*
- *French*
- *German*
- *Italian*
- *Japanese*
- *Polish*
- *Russian*
- *Spanish*

To switch between languages, choose the one you want and click *OK*. The program will then prompt you to restart. If you agree, the application will restart automatically using the newly selected interface language. If you choose not to restart, the changes will take effect the next time you start the application.

Note: To change the language, Artec Studio must restart.

CHAPTER 11

Scanner Calibration and Correction

The Diagnostic Tool is a special utility that enables you to calibrate Artec 3D scanners and correct an existing calibration. In general, calibration is the process of checking and adjusting a scanner's measurements by comparing them with the standard (etalon) values. Every Artec scanner is delivered pre-calibrated.

In some cases, owing to careless handling or transportation (jolts, accidental drops or some other reason), the scanner may fail to capture surfaces properly. The scanned surfaces may only be partially reconstructed or may contain holes (for example, the results of bad reconstruction are noticeable on the blue surface in Figure 11.5.). You can resolve these issues by correcting or calibrating the scanner.

Depending on the scanner model, the Diagnostic Tool can operate in one of the three working modes:

- Correction for Artec MHT, Artec MH, Artec L and Artec EVA scanners
- Correction for Artec Spider scanner
- Calibration of Artec Spider scanner

Note: Calibration is available only for Artec Spider scanners.

11.1 Suggestions for Use

Correction differs from calibration in that it preserves the current calibration: it only changes the correction ratio so as to enable good reconstruction. Application of this process does not guarantee that captured geometric shapes and linear measurements will be accurate.

Table 11.1.: Correction versus calibration.

Mode	Characteristics	Speed	For Spider?	For EVA, L, MHT?
Correction	Inexact	Fast	Yes	Yes
Calibration	Exact [1]	Prep required	Yes	No

11.2 Launching Diagnostic Tool

To launch the Diagnostic Tool, first ensure that the scanner you intend to diagnose appears in Artec Installation Center as either *Rented* or *Activated*. You can launch the tool either through the *Start* menu by clicking *Start* → *All Programs* → *Artec Group* → *Artec Studio* → *Diagnostic Tool* or in Artec Studio by selecting the *Run Diagnostic Tool* command from the *File* menu.

If you have several scanners connected, select the appropriate one from the dropdown list.

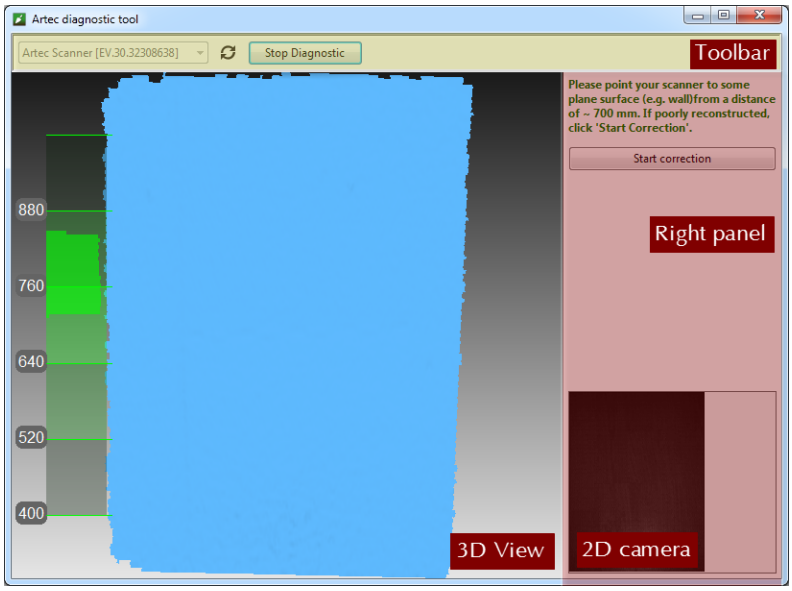


Figure 11.1.: Diagnostic Tool window.

The utility window contains three sections: the *3D View* panel, the right panel and the toolbar (see Figure 11.1.).

[1] Restores the device to its original factory settings.

11.3 Scanner Correction

11.3.1 Correcting Calibration Data for EVA, MHT, MH and L Scanners

The Artec EVA, Artec MHT, Artec MH and Artec L scanners only allow you to correct the current calibration settings.

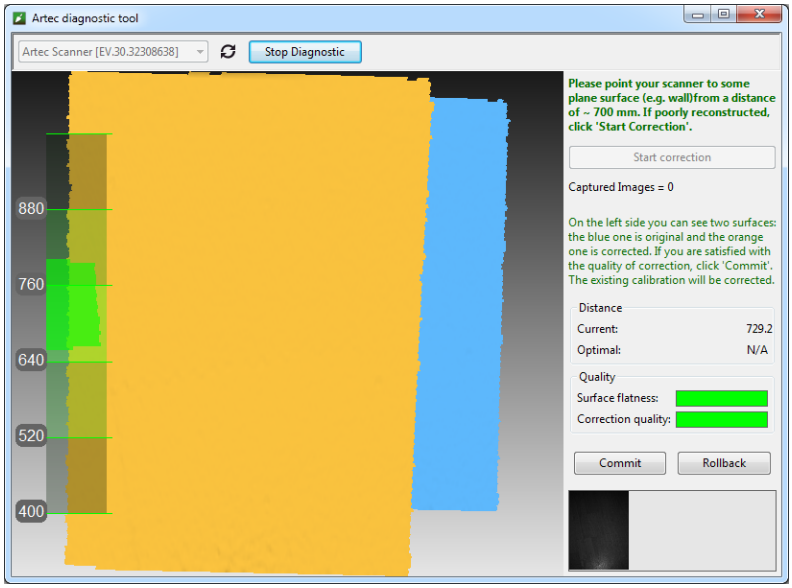


Figure 11.2.: Artec EVA correction results.

1. Launch the Diagnostic Tool as *Launching Diagnostic Tool* describes.
2. Select the scanner you want to diagnose.
3. Click *Start diagnostic* or press the ▶ button. The scanner will start the preview, a range meter will appear in the *3D View* window and another panel will appear on the right showing a 2D camera preview.
4. Direct the scanner at the right angle to a flat, light (but not shiny) monochrome surface (e.g., a wall or floor) from a distance of 650–700 mm for an Artec MHT, Artec MH or Artec EVA scanner or a distance of 850–900 mm for an Artec L scanner. The tool will render the surface in blue in the *3D View* window.

   Note: If the rendered surface is not flat and contains holes, the correction is worth performing.

5. Click *Start correction* or press the ▶ button on the scanner. In addition to the blue surface, a yellow surface will appear in the *3D View* window. Blue corresponds to the surface captured using the original calibration data; yellow corresponds to the surface captured using corrected calibration data.

6. Two indicators in the right panel can help you assess the surface quality (green stands for good results, yellow for satisfactory and red for unsatisfactory). If the corrected (yellow) surface has no holes and is sufficiently flat, and if the correction results meet your expectations, click *Commit* or press the ▶ button on the scanner. Otherwise, click *Rollback* or press ■ on the scanner.

11.3.2 Correcting Calibration Data for Spider

Correction for Artec Spider differs slightly from correction for Artec MHT and Artec EVA scanners.

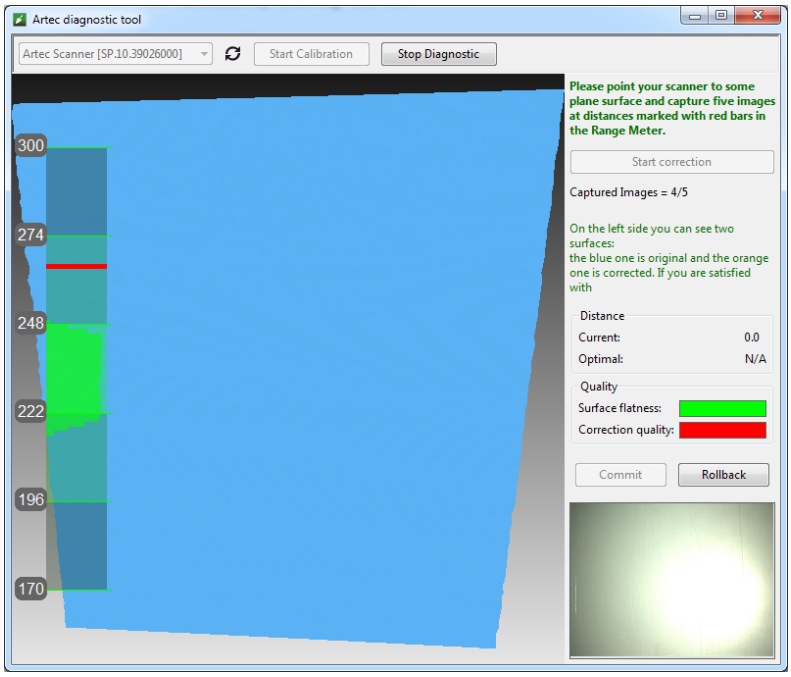


Figure 11.3.: Artec Spider correction process.

1. Launch the Diagnostic Tool as *Launching Diagnostic Tool* describes.
2. Select Artec Spider from the dropdown list.
3. Click *Start diagnostic* or press the ▶ button; the scanner will start the preview, a range meter will appear in the *3D View* window and another panel will appear on the right showing a 2D camera preview.
4. Direct the scanner at the right angle to a flat light monochrome surface (e.g., a wall) from a distance of 190–270 mm. The tool will render the surface in blue in the *3D View* window.

Note: If the surface, when captured from a distance within the suggested range, fails to render as flat or contains holes, correction is worth performing.

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5. Place the scanner on a desk or attach it to a tripod, keeping a distance of about 190 mm from the flat surface (see the range meter in the *3D View* window).
6. Click *Start correction* or press the ▶ button on the scanner. A red mark will appear on the range meter.
7. Move the scanner smoothly toward the flat surface such that the histogram peak coincides with the red mark on the range meter (see Figure 11.4.).
8. Look for a new red mark to appear higher on the range meter. Smoothly move the scanner away from the flat surface to approach the red mark.
9. Repeat Step 8 three more times. Once you finish, the calculation will start. A yellow plane that corresponds to the surface you captured using the corrected calibration settings will then appear in the *3D View* window (see Figure 11.5.).
10. If the yellow surface has no holes and is sufficiently flat, and if the correction results meet your expectations, click *Commit* or press the ▶ button on the scanner. Otherwise, repeat Steps 7–9, click *Rollback* or press ■ on the scanner. Two indicators on the right panel can help you assess the surface quality (green stands for good results, yellow for satisfactory and red for unsatisfactory).

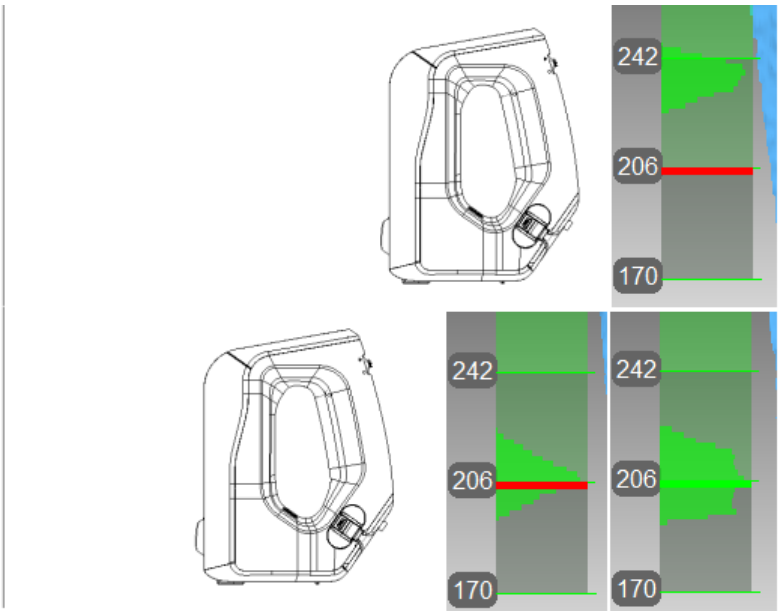

Figure 11.4.: Artec Spider scanner's position and corresponding distance on the range meter.

Approaching the read mark (at the top), reaching the required distance (at the bottom).

11.4 Spider Calibration

To carry out the calibration, you will need the following additional equipment: a calibration rig, a scanner stand and a pattern. Assembly instructions for the scanner stand and calibration rig appear in *Assembling the Scanner Stand* and *Assembling the Calibration Rig*, respectively.

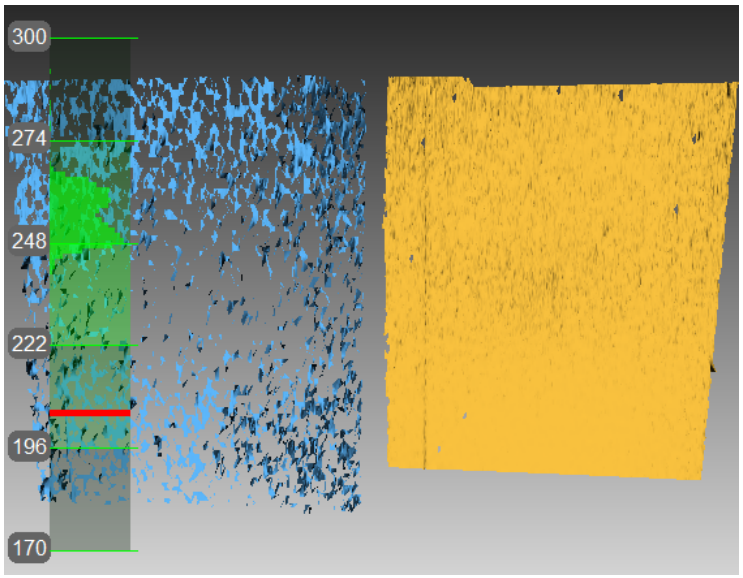

Figure 11.5.: Artec Spider correction results.

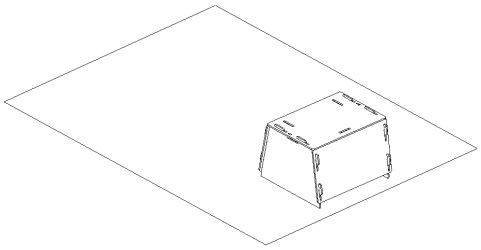

Figure 11.6.: Scanner stand resting on a pattern.

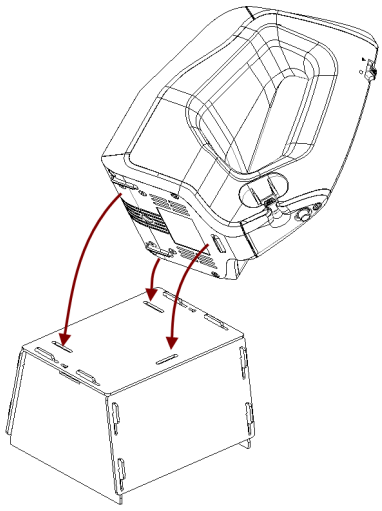

Figure 11.7.: Placing Artec Spider on the stand

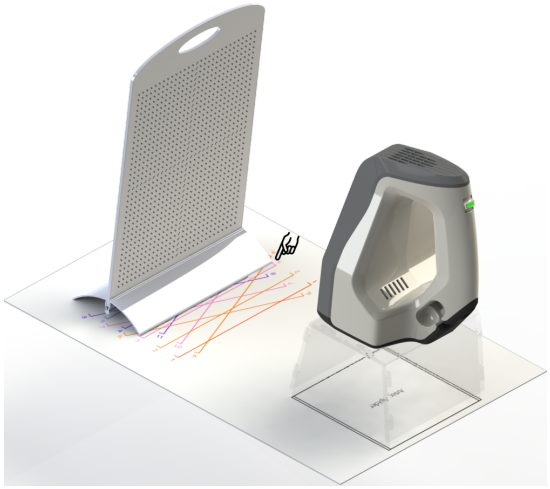

Figure 11.8.: Calibration rig, pattern and scanner stand with Artec Spider.

1. Unfold the pattern and place it on a desk or any hard, planar surface.
2. Align the scanner stand with the rectangle marked on the pattern, paying close attention to the orientation of the slots in the stand cover (see Figure 11.6.).
3. Place the scanner on the scanner stand, making sure that you insert the three scanner stems in the three slots of the stand cover (see Figure 11.7.).
4. Set the calibration rig on the pattern, turning its marker side toward the scanner as Figure 11.8. shows.
5. Launch the Diagnostic Tool as *Launching Diagnostic Tool* describes.

> **Note:** You should conduct the calibration only after the scanner has warmed to the optimal temperature.

6. Click *Start calibration*. A dialog box will open (see Figure 11.9.); enter the serial number of your calibration rig (it appears on the board). If the scanner temperature is outside the optimal range—for example, you just connected the device to a power outlet—the tool will notify you of this condition (see Figure 11.10.). We advise against clicking *Skip* and instead recommend waiting for the Artec Spider to reach its optimal temperature.
7. Place the rig in its initial position such that the front edge of its base coincides with the color line numbered 1 on the pattern. As you do so, also keep an eye on the *3D View* window for a red plane (current position) and a green plane (target position)—see Figure 11.11.. Once the red plane coincides with the green one, stop moving the rig and wait for the scanner to capture the plane.
8. Wait for the tool to instruct you to move the rig to the next position on the pattern; the number for that position will appear on the screen. Move the rig and again wait for the scanner to capture the plane.
9. Repeat the preceding step for the remaining positions sequentially. Depending on the version of your calibration kit, the pattern will have 11 to 15 positions.

10. Once you have captured the last position and the calculations have concluded, a message will appear prompting you to either overwrite the existing calibration or keep the current one. Before you decide, direct the scanner at a flat, nonglossy surface (e.g., a piece of paper) from a distance of about 200 mm. Assess the quality of the reconstructed surface and check for any holes.
11. Click *Yes, apply the calibration* if no holes appear on the surface and you are satisfied with the reconstruction results. To reject the new calibration, click *No, keep the old one* (see Figure 11.12.).

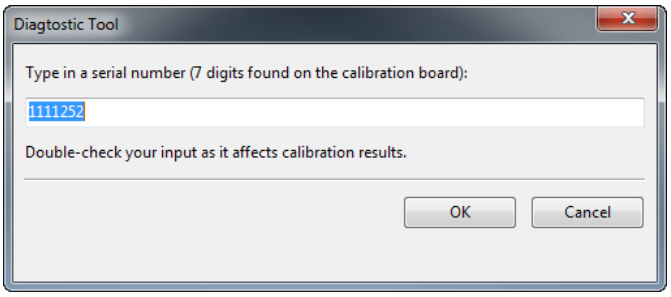

Figure 11.9.: Entering serial number of calibration board.

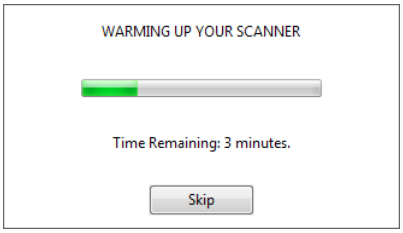

Figure 11.10.: Warming up the scanner.

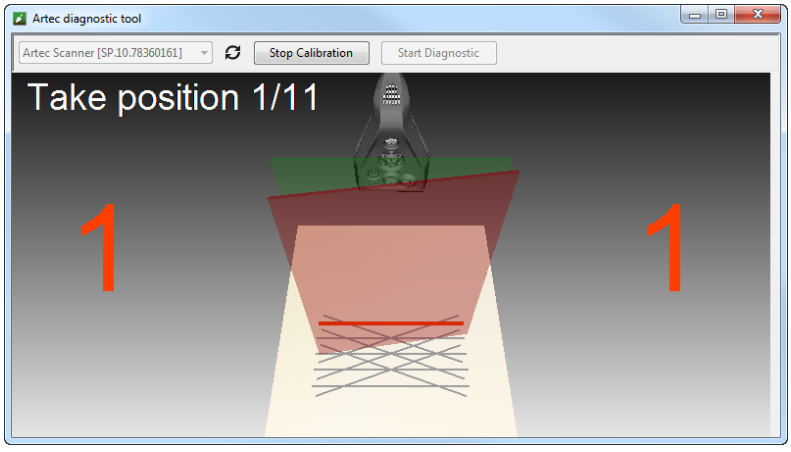

Figure 11.11.: Moving calibration rig to position number 1.

11.5 Notes Regarding Scanner-Calibration Files

Calibration and correction results reside in files that you can access as follows. Their location is

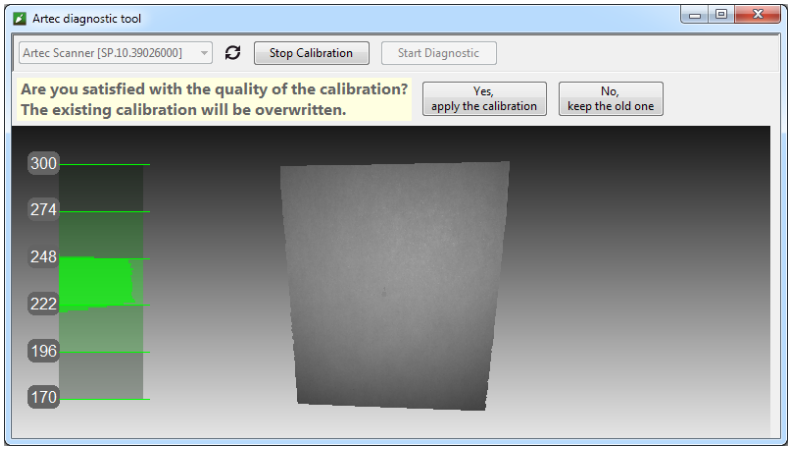

Figure 11.12.: Assessing calibration results.

`C:\Users\%name%\AppData\Roaming\Artec\Artec Installation Center\Devices\SP.00.00000000.`

Here, `%name%` is the current user folder and `SP.00.00000000` is the folder corresponding to the scanner serial number. Note the following information regarding calibration and correction.

- Once you apply correction results, the software will create an `ACD` file.
- Once you apply calibration results, the software will create `ACD` and `CORR` files.
- All newly created files have names of the form `YYYYMMDD_HHMMSS`, with the characters corresponding to the date and time of the file's creation.
- Original `ADD` and `CORR` file names are based on the scanner serial number and have the form `SP.00.00000000`.

Note: You can restore the initial calibration by removing the `ACD` and `CORR` files whose names have the form `20131121_101010`.

Note: If you use the scanner on several computers, you need not recalibrate it on every one. Simply copying the `ACD` and `CORR` files to the above-mentioned folder on each computer may be sufficient.

11.6 Assembling the Scanner Stand

The scanner stand comes unassembled with Artec Spider and consists of five parts (see Figure 11.13.): two side walls, one front and one back wall (these parts are identical, however), and a cover. Before beginning assembly, lay them all out as Figure 11.13. shows. Then follow these steps:

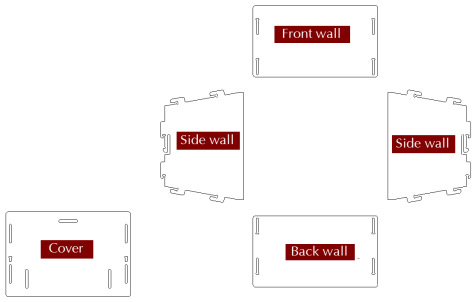

Figure 11.13.: Parts of the scanner stand.

1. Raise the two side walls to the upright position, as Figure 11.14. shows. Noting carefully the orientation of the T-shaped slot, install the front wall to the side walls using the two pairs of hooks. Press the front wall and slide it down against the stop. Make sure the three walls are properly aligned with each other.
2. Install the back wall in the same way (see Figure 11.15.).
3. Paying attention to orientation of the slots, install the cover using the upper hooks of the side walls (see Figure 11.16.).
4. Press your thumbs against the T-shaped holes on the cover and shift it toward the back wall until you hear a click (see Figure 11.17.).

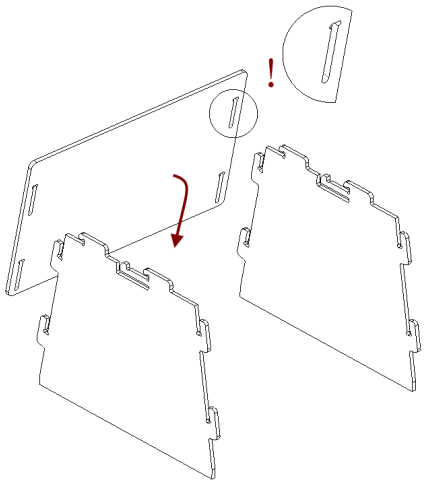

Figure 11.14.: Assembling the front wall.

The scanner stand is now ready to use.

Note: To disassemble the stand, release the detents in the cover's T-shaped slots (see Figure 11.13.) using a thin object like a ballpoint pen. Repeat the assembly steps in reverse order (from Figure 11.17. to Figure 11.14.), moving the parts in the opposite directions.

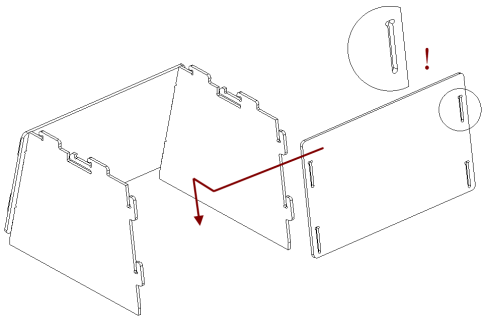

Figure 11.15.: Assembling the back wall.

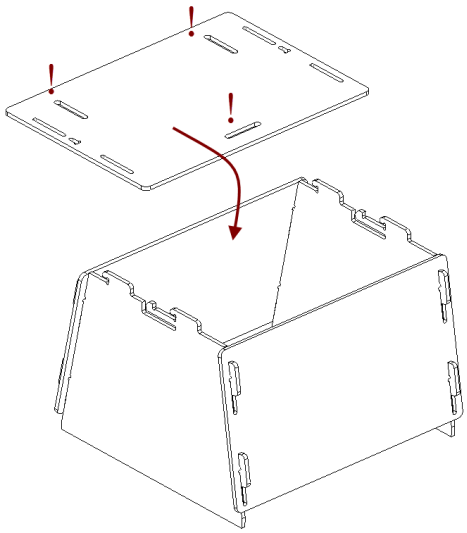

Figure 11.16.: Mounting the cover.

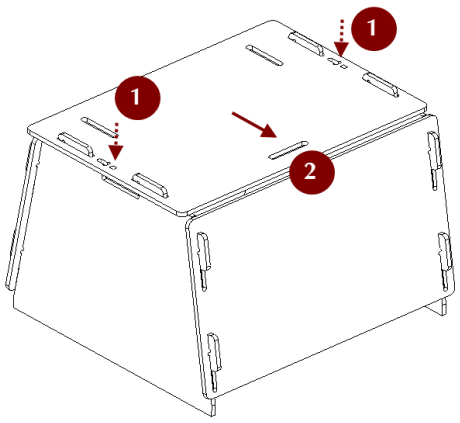

Figure 11.17.: Latching the cover.

11.7 Assembling the Calibration Rig

The calibration rig comes only with Artec Spider and consists of the base and the board. To assemble the rig, follow these instructions:

1. Press the hinge of the base against your forefingers.
2. Unfold the bent leaves of the base, pressing on their edges with your thumbs.
3. Insert the board into the slot, as Figure 11.18. shows.

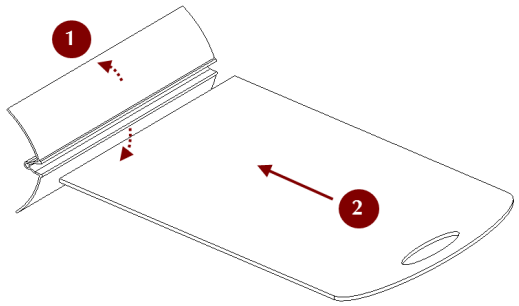

Figure 11.18.: Assembling the rig.

CHAPTER 12

Appendices

12.1 Hot Keys

Table 12.1.: Hot key combinations.

Hot Key	Function	Where to Press
`1` or `Ctrl+Shift+1`	Switch viewpoint to front	*3D View* window
`Ctrl+1`	Switch viewpoint to back	*3D View* window
`3` or `Ctrl+Shift+3`	Switch viewpoint to left	*3D View* window
`Ctrl+3`	Switch viewpoint to right	*3D View* window
`7` or `Ctrl+Shift+7`	Switch viewpoint to top	*3D View* window
`Ctrl+7`	Switch viewpoint to bottom	*3D View* window
`5` (numpad) or `Ctrl+5`	Toggle between perspective and orthogonal views	*3D View* window
`F7`	Start scanning (activate *Preview* mode)	Anywhere exc. modal dialog
`Space`	Toggle between *Preview* and *Record* modes	*Scan* panel
`F8`	Open *Multicapture* panel	Anywhere exc. modal dialog
`F9`	Open *Autopilot*	Anywhere exc. modal dialog
`Ctrl+G`	Start automatic processing (don't confuse with *Autopilot*)	Anywhere exc. modal dialog
`F10`	Call *Settings* dialog	Anywhere exc. modal dialog
`F11`	Show/hide *Workspace* panel	Anywhere exc. modal dialog
`Ctrl+Alt+L`	Show/hide *Log* window	Anywhere exc. modal dialog
`Ctrl+Shift+S`	Save screenshot	Anywhere
`Ctrl+N`	Create new project	Anywhere exc. modal dialog

Continued on next page

Table 12.1 -- continued from previous page

Hot Key	Function	Where to Press
Ctrl+S	Save project	Anywhere exc. modal dialog
Ctrl+O	Open existing project	Anywhere exc. modal dialog
Ctrl+Shift+O	Open existing project with scans unloaded (to save memory)	Anywhere exc. modal dialog
Ctrl+I	Import 3D files	Anywhere exc. modal dialog
Ctrl+Alt+H	Clear command history	Anywhere exc. modal dialog
N	Display/hide normals	Anywhere
B	Display/hide boundaries	Anywhere
F1	Open web manual	Anywhere
Ctrl+F1	Open local User Guide file	Anywhere
Ctrl+T	Open *Tools* panel	Anywhere exc. modal dialog
Ctrl+L	Open *Align* panel	Anywhere exc. modal dialog
1	Display aligned scans/models	*Align* panel
2	Display unaligned scans/models	*Align* panel
3	Display all scans selected for alignment	*Align* panel
Shift	Manually align scans	*Align* panel
Space and Backspace	Switch between point sets/pairs	*Align* panel → points
Space	Confirm creation of point set	*Align* panel → *Complex*
Ctrl+B	Open *Edges* panel	Anywhere exc. modal dialog
Ctrl+R	Open *Repair* panel	Anywhere exc. modal dialog
Ctrl+M	Open *Measures* panel	Anywhere exc. modal dialog
Ctrl+U	Open *Texture* panel	Anywhere exc. modal dialog
Ctrl+E	Open *Editor* panel	Anywhere exc. modal dialog
P	Start *Positioning* tool	*Editor* panel
T	Start *Transformation* tool	*Editor* panel
T	Enable *Translate* transformation	*Editor* → *Transformation*
R	Enable *Rotate* transformation	*Editor* → *Transformation*
S	Enable *Scale* transformation	*Editor* → *Transformation*
X	Translate (rotate/scale) the model along (around/in direction of) X axis	*Editor* → *Transformation* → any mode → *3D View*
Y	Translate (rotate/scale) the model along (around/in direction of) Y axis	*Editor* → *Transformation* → any mode → *3D View*

Continued on next page

Table 12.1 -- continued from previous page

Hot Key	Function	Where to Press
Z	Translate (rotate/scale) the model along (around/in direction of) Z axis	*Editor* → *Transformation* → any mode → *3D View*
S	Start *Smoothing brush*	*Editor* panel
E	Start *Eraser* tool	*Editor* panel
Ctrl+Shift+Scroll Wheel	Move cutoff plane	*Editor* panel → cutoff-plane selection
D	Start *Defeature brush*	*Editor* panel
Ctrl+[and Ctrl+] or Scroll Wheel	Change tool size	*Editor* panel → any tool
Ctrl+Alt+LMB	Invert selection of 3D regions	*Editor* panel → any tool → *3D View*
Ctrl+Alt+LMB	Select one scan and deselect the rest	*Workspace* panel
Ctrl+LMB	Select one scan and deselect the rest	*Workspace* panel, first column
Shift+Alt+LMB	Select/deselect scan	*Workspace* panel
Ctrl+A	Select all scans/models or frames	*Workspace* panel
Ctrl+D	Deselect all scans/models	*Workspace* panel
Ctrl+Alt+A	Invert selection of scans/models	*Workspace* panel
F2	Rename scan/model	*Workspace* panel
Ctrl+P	Start/stop playback scan frames	*Workspace* panel
Del	Delete selected frames/scans	*Workspace* panel (including surface list)

12.2 Third-Party 3D Sensors

Figure 12.1.: Microsoft Kinect v1

Figure 12.2.: Microsoft Kinect v2

Figure 12.3.: Asus Xtion (Primesense Carmine)

Figure 12.4.: Intel RealSense 3D camera by Creative (F200)

Figure 12.5.: Laptop featuring Intel RealSense 3D camera

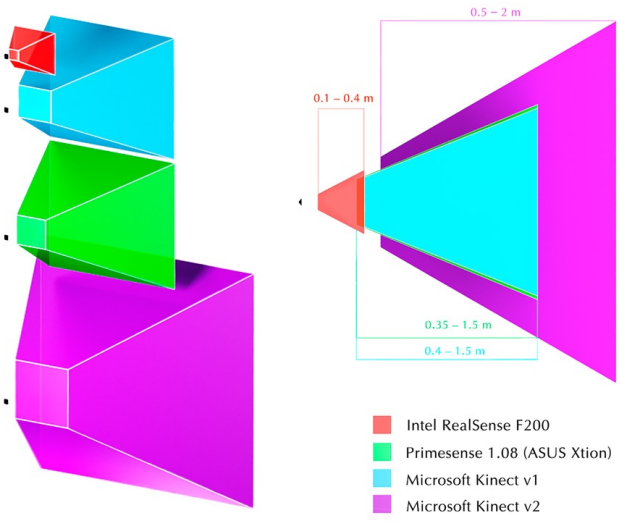

Figure 12.6.: Operating ranges and fields of view for third-party 3D sensors.

Accuracy, 114
accuracy (general term), **14**
Autopilot, **14**

buffer size, 147
bundle, **14**
By_radius, 109

CAD model, **15**

error, 114

Fill_holes, 109
Filter_by_threshold, 111
fine registration, **15**
force_constraints, 116
frames, **15**

Geometry
    for Fine registration, 91
    for Global registration, 105
global registration, **15**

iterations, 105

keep_boundary, 115
key frames, **15**

Leave_biggest_objects, 111
loop_closure, 91

Manually, 109
max_hole_len, 114
max_hole_radius, 109
max_neighb_normals_angle, 115
mesh, **15**
minimal_distance, 105
mode, 111
model, **15**

near and far cutting planes, **15**

project, **15**

radius, 109
refine_serial, 91
registration_algorithm
    for Fine registration, 91
    for Global registration, 105
Remesh, 114
remesh_edge_thr, 114
remove_targets, 109
resolution
    for Fusion, 109
    for Outlier removal, 107
resolution (general term), **15**
rough registration, **15**

scan, **15**
std_dev_mul_threshold, 107
steps, 114
stop_condition value, 114

targets, **15**
Texture_and_Geometry
    for Fine registration, 91
    for Global registration, 105
threshold, 111
tracking, **15**
tri_num
    for Fast mesh simplification, 116

for Mesh simplification, 114
Triangle_quantity, 114

UV_Triangle_quantity, 114
UV_Vertex_quantity, 114

voxel size, 147
vrt_num, 114

Watertight, 109