Echo™ Software

3D Scan and Edit Software Application

User Guide

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Chapter 1 Scope of this Document

About Mantis Vision Ltd.

Mantis Vision Ltd. brings high definition three-dimensional (**3D**) content to everyday experiences.

The company empower consumers, application developers and industry professionals to instantly capture and share high quality 3D content.

From 3D cameras on mobile devices to professional handheld 3D scanners and engines for OEMs, Mantis Vision's technology easily transforms objects, places and live people into high resolution 3D digital content, in real-time.

Using structured light technology that blends digital and physical realities, the company's vision is to transform the communication medium of tomorrow – where everyone will share 3D selfies, capture 3D volumetric content and document their lives in augmented and virtual reality (**VR**).

About Mantis Vision's Handheld 3D Scanning System

Mantis Vision's Handheld 3D Cameras and their associated Echo™ software application products (referred to, hereinafter, as the System) are components of the Handheld 3D Cameras product line.

Mantis Vision Handheld 3D Cameras are market leading 3D cameras/ scanners for fast scanning of objects and areas from short to far ranges.

Based on a patent algorithm of innovative encoding, the system provides superb quality of data making it the ultimate device for scanning complex scenes within seconds.

The cameras are driven by the Echo™ software – an advanced and easy-to-use integrated software with high-end features such as:

- **Advanced scanning modes** with online real-time preview.
- **Special algorithms** for best performance of data quality vs. distance.
- **Powerful 3D data editing tools**.
- **Post processing tools** to enhance the quality of the scanned images:
  - Noise reduction (Denoise).
  - Meshing model and color projection.

  - Accuracy filtering.
  - Distance filtering.
  - Global registration.
- **Live coverage indication**:
  - Online real-time registration between the scanned frames allowing follow-up on the scanning process.
  - Ability to detect flaws and correct them.
- **Advanced meshing abilities** for professional users with full color projection:
  - Auto set up: high, medium, low.
  - Professional set up: select parameters.
- **Color projection** – Export to all commonly used formats on the market:
  - Point-Cloud format: PTS, E57, XYZ, MPC, MVX.
  - Polygons/mesh: OBJ, MVX, STL, PLY.
- **Optional live preview**:
  - Infra-red (IR) and Color Video streams.
  - Point-Cloud.
  - On-the-fly registration model.
  - Cumulative 3D model.
- **Data quality** for controlling distances and accuracies.
- **Flexible integration** to 3rd-party software applications based on Mantis Vision's Dynamic Link Library (**DLL**) or Software Development Kit (**SDK**).
- **Matching models** from different scans.
- **Multiple interfaces** – tablet/laptop/desktop/Virtual Reality (**VR**).
- **User interface** – touch screen/desktop.

The product provides solutions for large variety of application:

- **Law Enforcement** – forensics and car accident:
  - Crime scene documentation in record speed.
  - Without tampering the evidence on site.
  - Accessibility to concealed places.
  - Ability to observe the most delicate details.
- **Automotive** – Assessment tool for:
  - Crash Analysis in Safety Departments.
  - Quality Assurance/Production line.
- **Heritage**:
  - Excellent mesh and color texture.
  - Scans fast and easily every detail.
  - Scans in any ambient light.

- **Military**:
  - Robust device for field use.
  - Performing in day light and night conditions.
- ***Reverse Engineering*** and Architectural, Engineering and Construction (**EaC**):
  - Integration with leading software companies such as 3D system (Geomatics – design X).
  - Designing an object based on a scanned model.
  - Bridging the gap between As-built and As-planned.
- **Oil and Gas, Maritime and Aerospace**:
  - Periodically inspection of the infrastructure to detect changes.
  - Capturing 3D data on off-shore platforms while in motion.
  - Transportations of heavy devices inside a plant.
- **Gaming and Simulations**:
  - Ergonomic design based on hybrid models – containing static and dynamic data.
  - Human motion capturing (syncing multiple Handheld 3D Camera devices).
  - Full flow to VR.
- **Internal Designers and Architectures**:
  - Visualization tool for renovation.
  - Full flow to VR.
- **Education** – Providing students flexible tool for capturing both static and dynamic for their variable researches.
- **Archeology**:
  - Scanning capability also in complete darkness in places such as caves.
  - Accessibility to difficult locations.

Prospective Audience

This Echo™ User Guide document was developed for professional market end-users of Mantis Vision's Echo™ software and its associated Handheld Cameras.

Document Overview

This document is built out of five (5) major parts:

1. Chapter 1 – Chapter 2 are introductory chapters dedicated to Mantis Vision and its technology, 3D scanning, the Echo™ software as well as details of the structure of this document.

2. Chapter 3 – Chapter 4 deals with the content of the delivered system and its installation, setup and initial activation.
3. Chapter 5 deals with details of the Echo™ User Interface (**UI**).
4. Chapter 6 details the processes of scanning and editing 3D objects and spaces.
5. Appendixes containing complementary data for the system's users.

Conventions Used in this Document

The following typographical conventions are used in this book:

- Normal text is in Calibri Light 12p font.
- **Emphasized text** us in Bold Calibri Light 12p font.
- Names of ***User Interface Elements*** are in Bold-Italic Calibri Light 12p font.
- Links (internal to this document and/or external URLs or mailing addresses) are in underlined Calibri 12p font, blue color.
- `Software Code Samples` are in monospaced Courier New 12p font.
- *`<Variables>`* and *`Values`* (specified values and received results) are in monospaced Italic Courier New 12p font, surrounded with right and left angle bracket.
  - The **[ ]** Square Brackets denote that one or none of the enclosed term(s) may be substituted while the vertical rule | separates between them (OR separator).
- The **{ }** Curled Braces denote that **exactly** one of the enclosed alternatives must be specified while the vertical rule | separates between them (OR separator). For example, {yes | no} means exactly **yes** or **no** must be specified.
- Keyboard accelerator (such as **CTRL-ALT-DEL**), a dash indicates that the keys should be held down simultaneously, whereas a space means that the keys should be pressed sequentially. For example, **CTRL-ESC** indicates that the Ctrl and Esc keys should be held down simultaneously; whereas **CTRL ESC** means that the **CTRL** and **ESC** keys should be pressed sequentially. The keys' name will always be in UPPERCASE letters.
- The symbol ➤ separates menus and their associated commands or indicates a sequence of operations (i.e. keystrokes).

Scope of this Document

- Wherever applicable, **Tips** are provided within the text, to draw attention to some practical aspects of doing things. For example:

TIP:	This icon points out useful information that does not affect the integrity of your system.

- Wherever applicable, **Notes** are provided within the text, to draw attention to specific issues. For example:

NOTE:	This icon points out useful information that does not affect the integrity of your system.

- Wherever applicable, **Warnings** are provided within the text, to draw attention to critical alarms. For example:

WARNING:	This icon alerts you to a situation that could cause a loss of data if a certain action is performed or avoided.

Chapter 2 3D Scanning Technologies

Scanning Technologies for 3D Applications

Three-Dimensional (**3D**) scanners/cameras are devices which analyze real-world objects (or environments) to collect data on their shape and appearance (e.g. color, texture, etc.).

The collected data can be used for:

- Construction of digital 3D models, 3D graphics and 3D CAD.
- Virtual and Augmented Reality (**VR** and **AR**) experience for the entertainment industry and computer games.
- Detailed models of organs in medical applications.
- Highly detailed modeling of chemical compounds.
- Reverse engineering and prototyping.
- Demonstration of proposed buildings and landscapes in architectonic applications.
- Designs of new devices, vehicles and structures for the engineering community.
- 3D geological models for the earth science community.
- Quality control and inspection.
- Digitization of cultural artifacts.
- as well as other applications.

3D scanners perform much like cameras; they have a cone-like FoV (Field of View) and can only collect information about unhidden surfaces.

Cameras record color data of the surfaces within its field of view while 3D scanners collect distance information about surfaces within its field of view.

The image generated by the 3D scanners labels the distance to a surface at each point which enables the identification of 3D position for each point in the image.

In most cases a single scan cannot produce a complete model of the subject. Multiple scans are usually required, from many different directions, to obtain information about all sides of the subject.

3D Scanning Technologies

These scans are brought into a common reference system, a process usually called "alignment" or "registration", and then merged together to create a complete 3D model.

The whole process, from the single range map to the complete model, is known as the 3D scanning pipeline.

There are several technologies for digitally acquiring the shape of a 3D object.

These are divided into two (2) types:

- Contact scanning.
- Non-contact Scanning.

Non-contact solutions are further divided into two (2) main categories:

- Active scanning.
- Passive scanning.

There are several technologies that fall under each of these categories.

Mantis Vision's solutions are classified as Non-Contact Active Scanning category and its Active scanners emit light and detect its reflection passing through cameras to probe an object or environment.

Mantis Vision employs Structured-light 3D scanning technique which projects a pattern of light, formed by a patented filter, on the scanned subject.

A Near-Infra-Red (NIR) Sensor, offset slightly from the pattern projector, examines the shape of the pattern and calculates the distance of every point in the field of view.

The advantage of Structured-light 3D scanners is speed and precision. Compared to scanning one point at a time, Structured Light scanners scan multiple points up to an entire field of view at once.

Scanning an entire field of view in a fraction of a second reduces or eliminates the problem of distortion from motion.

Other Mantis Vision Ltd. systems are also capable of scanning moving objects in real-time.

Mantis Vision's 3D Scanning Technology

Mantis Vision's technology was developed to enable 3D capturing of highly dynamic scenes for high-resolution model creation.

3D shapes and objects are captured during free motion and tolerates operation from moving platforms.

This is achieved by projecting a single coded-light pattern, which contains all the indexing information required by our Structured Light triangulation algorithms.

This way, a complete 3D range-image is captured by a single “camera snapshot”.

Mantis Vision Ltd. developed a unique single pattern codification method allowing the distinct identification of hundreds of times more points than any other method availably in the market today.

Despite the code’s ‘shortness’ (i.e. made of a single pattern only) it incorporates a powerful error detection/correction mechanism.

As a result, the technology provides several unique and highly beneficial attributes:

- High accuracy levels of depth measurements.
- Ability to capture images while in free motion – the camera, the object and the captured environment can both be freely moving.
- Dense sampling at high resolutions of hundreds of thousands of points per single Point-Cloud frame.
- No dependency on color or texture and the ability to project at invisible wavelengths such as Infrared (IR).
- Operation under challenging lighting conditions.
- Ability to acquire challenging targets, such as shiny and largely contrasted surfaces.

How does it Work?

The entire Mantis Vision system include two (2) main components:

- A 3D image acquisition unit – the Handheld 3D Cameras and
- Software application (**Echo™**) to process, manipulate and visualize the 3D data.

The Handheld 3D Camera, which require single-hand operation, consists of dual video camera channels (color and depth) and a light projector, all embedded into a single ergonomic handheld device.

Capturing the 3D environment is like using a regular (2D) video camera.

3D Scanning Technologies

The only difference between a 2D video camera and the Mantis Vision's Handheld 3D Camera is the type of flash light (**Projector**) used.

The system acquires the scene's depth by projecting invisible (Infra-Red) light onto the environment through a mask containing one of Mantis Vision's proprietary patterns.

This projected and distinctly-marked infra-red (**IR**) light reflects from the surface of the scene and captivated by both the color and depth cameras.

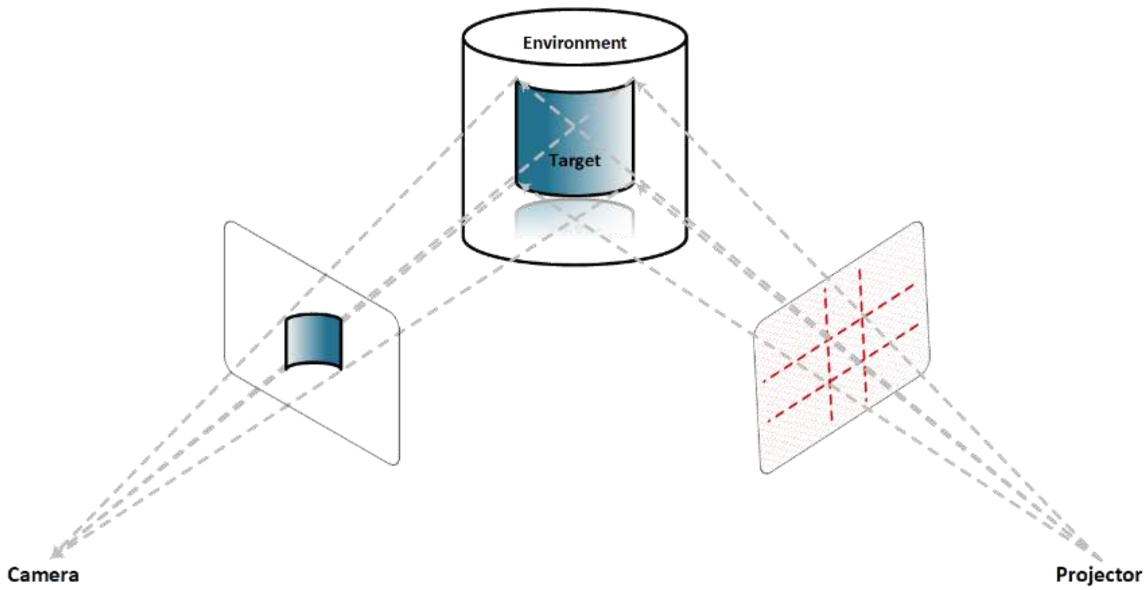


Figure 1 – The Principle of Active Triangulation

Active triangulation is the common method for 3D coordinate data acquisition. The "trick" is the use of stereoscopic parallax to get the information about the third (3^{rd}) dimension.

The color (RGB) video camera channel captures the **Video Frame**s containing the light reflected from the environment including color information with the pattern draped over it.

Each Video Frame can be decoded in real time into a dense colored Point-Cloud of the three-dimensional distance measurements.

The Mantis Vision Handheld 3D Cameras

There are numerous models of Handheld 3D Camera working in conjunction with the Echo™ software, all of which combine two (2) video sensors:

- A **Color (RGB) Camera sensor**, and
- A Near-Infrared (**NIR**) Camera Sensor (the **IR Sensor**).

They also employ a single laser-based NIR light emitter (hereinafter: the **Projector**).

The sensors and projector are mounted on the ends of an anodized aluminum dowel, coated with an ergonomic rubberized hand grip.

The **Projector** emits NIR light (wavelength – 850nm) onto the scene through a slide (mask) containing Mantis Vision's patented single-coded pattern.

The scanned target's area, covered by this single-coded pattern IR light, is captured by the IR Sensor, as **RAW data**, out of which all 3D data will be retrieved/calculated by the Echo™ software's **Decoder Algorithm**.

Figure 2 – The F6 SMART™ Handheld Camera Device

The scanned target's color image captured by the Color (RGB) Camera is meshed with the 3D model, in a later stage of the editing process, to provide the model with the original appearance of the scanned subject.

This data will be edited, on a later stage of the process, in different aspects (these are detailed in later parts of this document), to achieve High Quality (**HQ**) 3D Models of the scanned objects/spaces.

The Echo™ Software

Mantis Vision's Echo™ software optimizes the 3D scanning technology, by offering a full 3D processing pipeline.

This solution addresses depth sensing and processing needs such as auto-calibration, high-quality registration, segmentation, Virtual-Reality/Mixed-Reality (**VR/MR**) shading, and even data compression and streaming.

The result – any user can capture a static or dynamic object, person or scene of choice, in different ambient light conditions and instantly edit, share and stream the real volumetric content to any 2D/3D/MR/VR platform.

The Echo™ software serves three (3) different purposes:

- **Scanning** operation control.
- **Editing** of the scanned projects.
- **Setting-up** and configuring the equipment and software operation.

In other words – the scanning jobs could be done, in the field, with a light-weight laptop (like the recommended Microsoft's Surface™) where the Echo™ software is installed and serves as a control software for the scanning operation, while the editing of the scanned results, up to exporting the outcoming files, in the desired format, can be done on a separated office workstation, where the very same Echo™ software is installed, and serves as an editing station.

The Echo™ software is running on a dedicated workstation. Check Appendix 4 – Technical Specifications in page **288 below** for specifications of suitable computer to serve as a workstation for the Echo™ software.

The Scanned Data Format Evolution

Along the process from scanning the object up to generating the 3D model, the data used goes through an evolution of formats:

- The scanned images come out of the cameras (both the IR Sensor and the Color (RGB) Camera) and being captured and stored in video format.
- During the scan (**Online mode**) and making use of the distances data in the calibration files, these video streams are converted to **Point-Cloud** format (3D vector format with XYZ Cartesian coordinates' values data in addition to possible color-per-point data).

This process utilizes Mantis Vision's proprietary Active Triangulation algorithms and the resulting model is stored in Point-Cloud format.

- The Point-Cloud data goes through, online and/or manually, several registration processes to complete and 'clean' the 3D presentation of the scanned objects, all in the above-mentioned domain of 3D vector format.
- To complete the process and produce a 3D model, the above-mentioned Point-Cloud data goes through another offline process of meshing where every two consecutive points are connected to create vertexes and then to create polygons which covers the entire 3D Point-Cloud model in a skin-like cortex which is then "painted" with the processed color data of the Color (RGB) Camera to create real-life-like model.

Chapter 3 Installation of the Echo™ Software

The method of installing the Echo™ software resembles most other Windows™-based applications' installation processes and is described thoroughly hereinafter.

NOTE: During the process of installing the Echo™ software, the camera **SHOULD NOT** be connected to the workstation!

Content of the USB Disk-on-Key Flash Drive

The Echo™ software is encapsulated in the **USB Flash Drive** (Disk-on-Key) device included in the camera's kit case. The USB flash drive contains:

- The **installation program** – ***setup.exe***.
- ***Prerequisites*** sub-directory containing a few directories and files associated with the installation process.
- **Scanner Explicit Calibration Files**:
  - ***coloring.txt*** – a file containing calibration data for the Color (RGB) Camera.
  - ***rig.txt*** – a file containing calibration data between the IR Sensor and the Color (RGB) Camera.
  - ***config.ecfg*** – a file containing general Echo™ configuration data.

Downloading the Latest Echo™ Software Version

It is suggested to check Mantis Vision's website for availability of a more updated version.

If a more updated version is available – download it, using the above link, onto the workstation for installation instead of the USB-drive included version as follows:

1. Following selection of the above-mentioned link, the **Download Splash Page** opens:

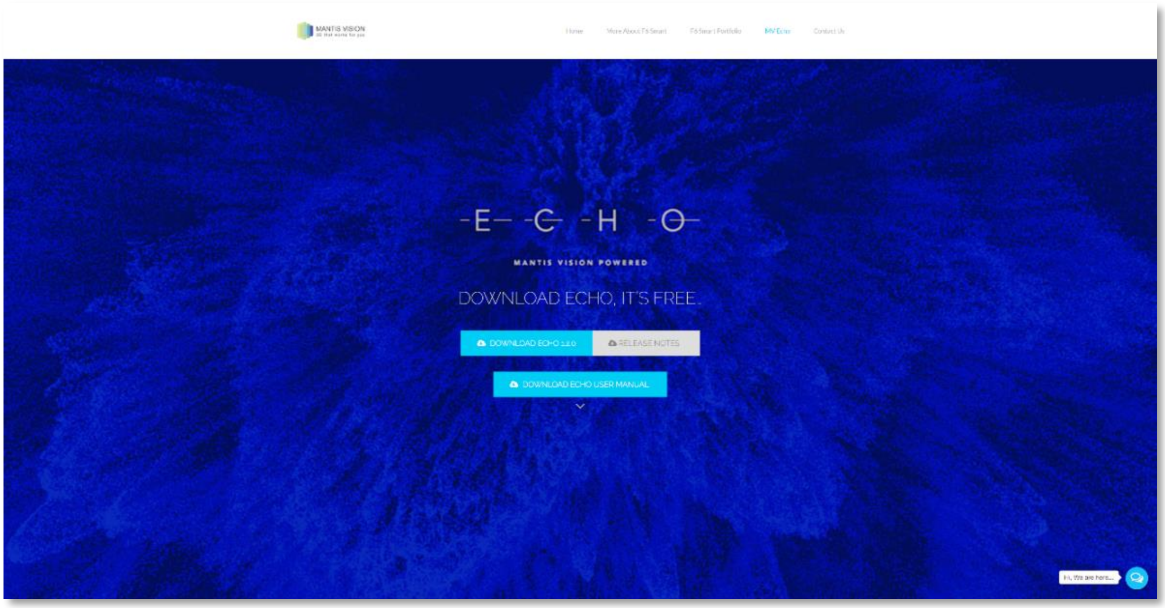


Figure 3 – Echo™ Download Splash Page

This page allows, besides downloading of the Echo™ software, downloading of:

- The Release News document describing changes made to this version.
- The Echo™ User Guide (this document) in PDF format.

2. Select the ***DOWNLOAD ECHO 2.0.0*** button. A ***Save As*** dialog-box opens:

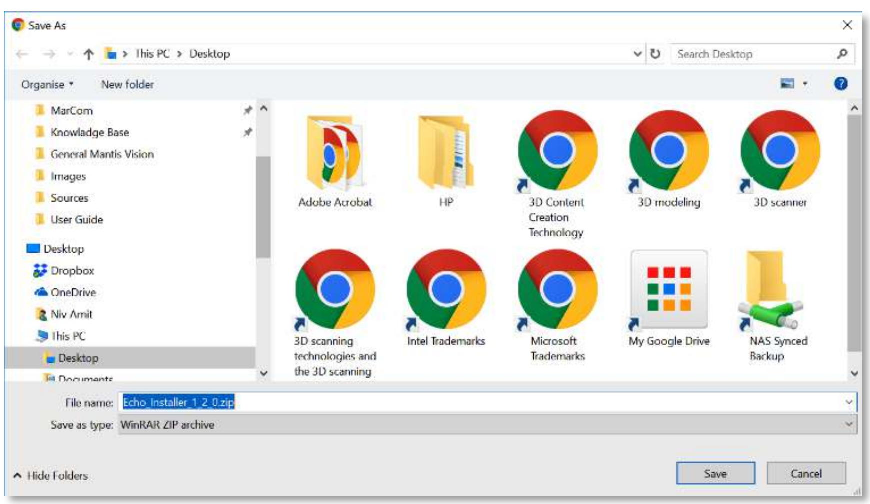


Figure 4 – Save As dialog-box for the Installation ZIP File

3. Browse through this dialog-box to select a storage directory for the installation ZIP file and select the ***Save*** command-button to conclude the download operation.

Installation of the Echo™ Software

4. Utilizing a disk browser program (i.e. ***Microsoft's File Explorer***), go to the above selected repository (where the installation ZIP file was stored) and double-click on the downloaded file's name.
5. The default ZIP application program installed will open.
6. Extract the content of the ZIP file into the same repository directory.
7. The extraction will create a new sub-directory with the Echo™ name and version number.
8. The ***Setup.exe*** installation program discussed in paragraph "Installing the Echo™ Software" below can be found in this new sub-directory.

Installing the Echo™ Software

NOTE:	Prior to the installation of the Echo™ software, verify that the workstation to be used meets the requirements detailed in Table 6 of Appendix 2 in page 234 below) and that the camera is **NOT** connected to the workstation.

1. Double-click on the self-extracting installation file (***Setup.exe***) to trigger the installation process.

   The ***Welcome to the Echo Setup Wizard*** dialog-box opens:

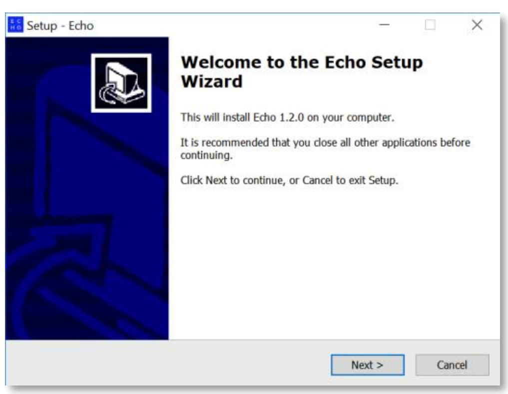


Figure 5 – The Welcome to the Echo Setup Wizard dialog-box

2. The ***Cancel*** command-button allows immediate termination of the installation. To install; select the ***Next >*** command-button. The ***Select Destination Location*** dialog-box opens:

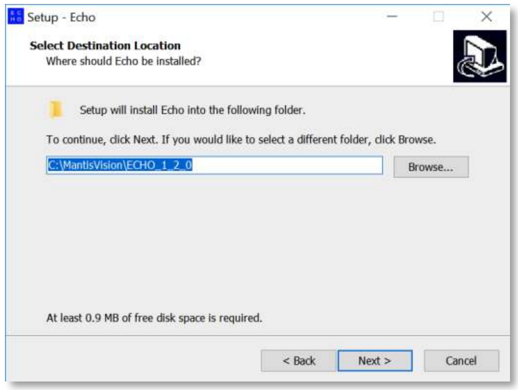


Figure 6 – The Select Destination Location dialog-box

This dialog-box allows manual settings of the folder where the Echo™ software would be installed.

The default location is C:\MantisVision\ECHOxxx where xxx is the software version number.

NOTE: It is recommended to preserve the default location to ease the support tasks of this product.

a. In case a different location is necessary, select the ***Browse…*** command-button. The ***Browse For Folder*** dialog-box opens:

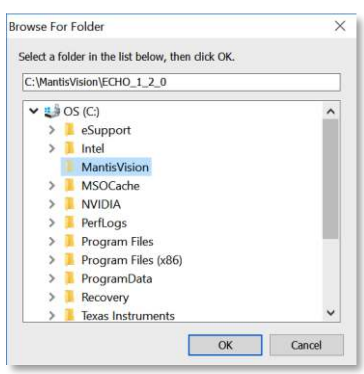


Figure 7 – The Browse For Folder dialog-box

This dialog-box allows manual selection of another folder to install the Echo™ software onto, as well as setting-up a new folder.

Select the ***OK*** command-button as soon as the installation folder is set, or on the ***Cancel*** command-button to cancel the manual selection.

The ***Browse For Folder*** dialog-box closes and the ***Select Destination Location*** dialog-box (see Figure 6 **above**) turns active again with the recently selected installation directory presented in the address bar.

b. In case a step back in the installation process is required, select the ***< Back*** command-button.

c. In case a termination of the installation is required, select the ***Cancel*** command-button.

3. To continue the installation, select the ***Next >*** command-button.

The ***Select Components*** dialog-box opens:

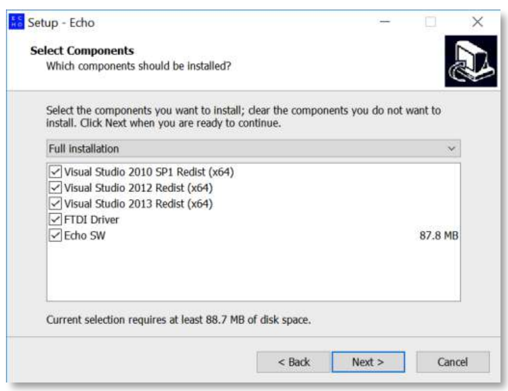


Figure 8 – The Select Components dialog-box

This dialog-box allows selection of which components (out of the options' list) will be installed.

- The ***Echo SW*** and ***FTDI*** (USB communication chip) ***Driver*** are a **MUST** in this installation.
- The rest of the options (all are ***Microsoft™ Visual Studio™ Redistributable Packages*** related) will be installed only if not found on the workstation's hard-disk.

The ***Cancel*** command-button allows immediate termination of the installation process, while the ***< Back*** command-button revokes the previous step in the installation process.

4. To continue the installation, select the ***Next >*** command-button. The ***Select Start Menu Folder*** dialog-box opens:

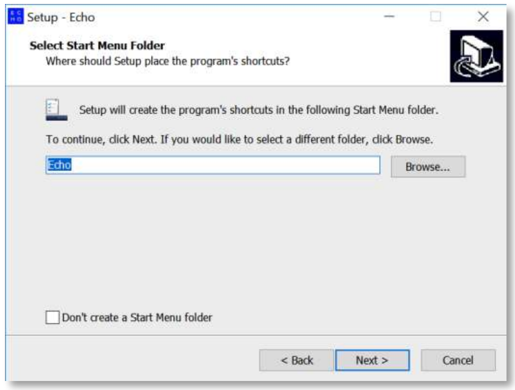


Figure 9 – The Select Start Menu Folder dialog-box

This dialog-box creates the program's shortcuts in Windows's ***Start Menu***.

NOTE: Explanations in this document, from this point onwards, will refer to the **Start Menu's default program name** (*Echo*) and folder.

a. In case a different name (or menu folder name) is required, select the ***Browse…*** command-button to open another ***Browse For Folder*** dialog-box:

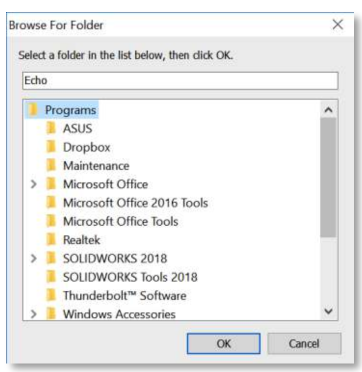


Figure 10 – The Browse For Folder dialog-box

This dialog-box allows manual selection of another name and/or folder for the installation of the Echo™ software, as well as setting-up a new name/folder.

Select the ***OK*** command-button as soon as the installation name/folder is set, or on the ***Cancel*** command-button to cancel the manual selection.

The ***Browse For Folder*** dialog-box closes and the ***Select Start Menu Folder*** dialog-box (see Figure 9 above) turns active again with the recently selected installation name and folder presented in the address bar.

b. The ***Select Start Menu Folder*** dialog-box also allows complete elimination of the Echo™ Strat Menu Folder by marking the ***Don't create a Start Menu Folder*** check-box at the bottom-left side of the dialog-box.

c. In case a step back in the installation process is required, select the ***< Back*** command-button.

d. In case a termination of the installation process is required, select the ***Cancel*** command-button.

5. To continue the installation, select the ***Next >*** command-button.

The ***Select Additional Tasks*** dialog-box opens:

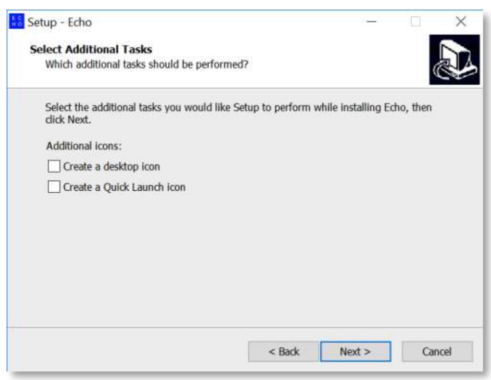


Figure 11 – The Select Additional Tasks dialog-box

This dialog-box allows creation of a **Desktop Icon** and a **Quick Launch Icon** (in the Task Bar, at the bottom of the screen, between the Windows™ Start Button and the active programs), by marking the relevant check-box in the dialog-box.

Same as in previous dialog-boxes; the ***< Back*** command-button is used to invoke the previous dialog-box while the ***Cancel*** command-button is used to terminate the installation process.

6. To continue the installation, select the ***Next >*** command-button.

The ***Ready to Install*** dialog-box opens:

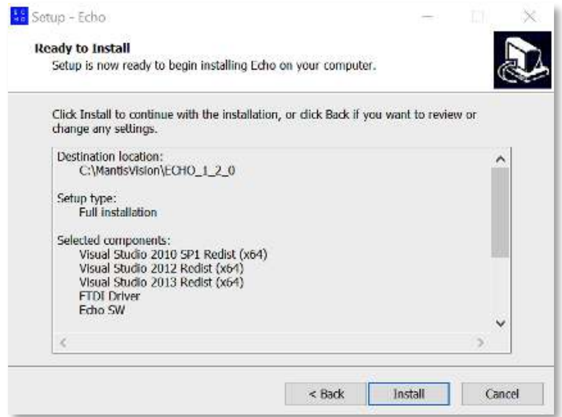


Figure 12 – The Ready to Install dialog-box

This dialog-box details all previously provided installation parameters/components for verification purpose.

As in previous dialog-boxes; the ***< Back*** command-button is used to invoke a previous dialog-box while the ***Cancel*** command-button is used to terminate the installation process.

7. To continue the installation, select the ***Install*** command-button.

The ***Installing*** dialog-box opens:

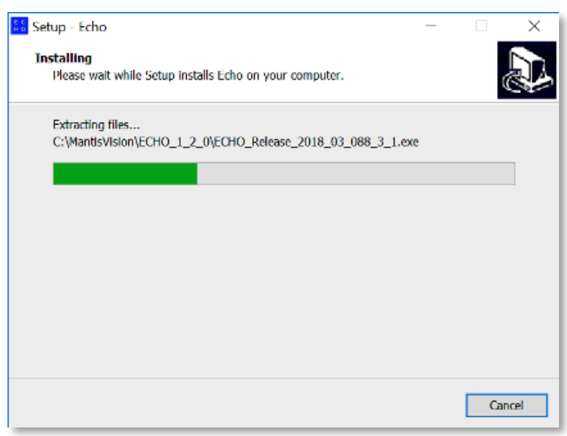


Figure 13 – The Installing dialog-box

This dialog-box informs about the installation progress by presenting a Progress meter.

There is an option, during this step of the installation, to terminate the process by selecting the ***Cancel*** command-button.

If the FTDI Driver option was marked in the ***Select Components*** dialog-box (see Figure 8 **above**), the ***FTDI CDM Drivers*** dialog-box will open during this installation progress presentation (see Figure 14 **below**).

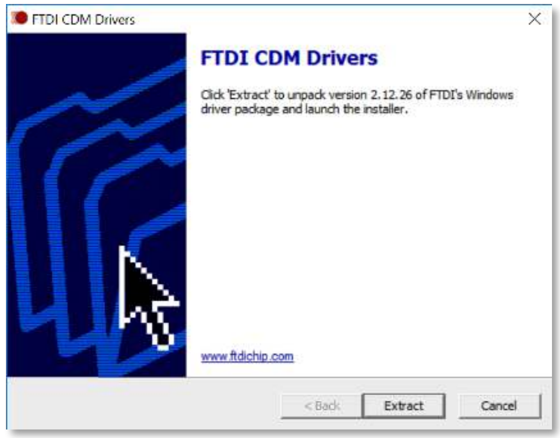


Figure 14 – FTDI CDM Drivers dialog-box

The ***Cancel*** command-button terminates the FTDI Drivers' installation process while the ***Extract*** command-button allows extraction of the FDTI Drivers' file required for the installation.

The ***Extracting Files*** dialog-box opens to present, by means of a Progress meter, the progress of the extraction procedure.

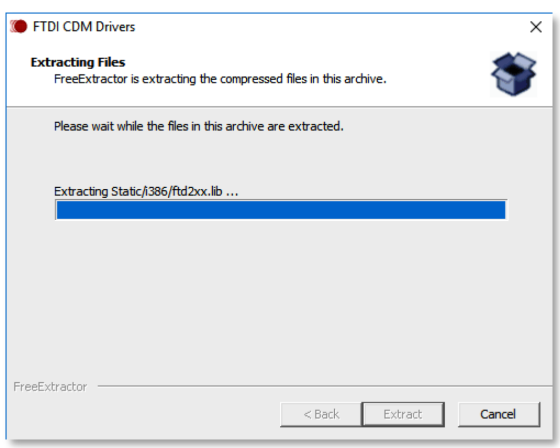


Figure 15 – The "Extracting Files" dialog-box

As soon as the FTDI Drivers' installation files are extracted and installed, the ***Welcome to the Device Driver Installation Wizard*** dialog-box opens (see Figure 16 **below**).

This dialog-box allows the installation of the recently extracted FTDI Device Drivers.

Selecting the ***Cancel*** command-button terminates the installation of the FTDI Device Drivers while selecting the ***Next >*** command-button allows the installation and thus promotes the process to the next step of installing the Echo™ software.

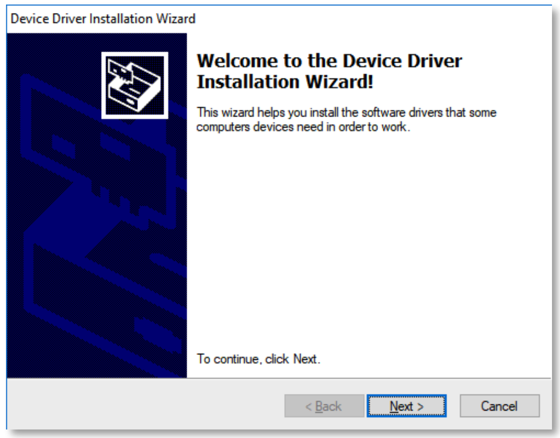


Figure 16 – The Welcome to the Device Driver Installation Wizard dialog-box

8. Once the installation of the FTDI Drivers is complete, and with accordance to FTDI's Terms and Conditions, the drivers' ***License Agreement*** dialog-box opens:

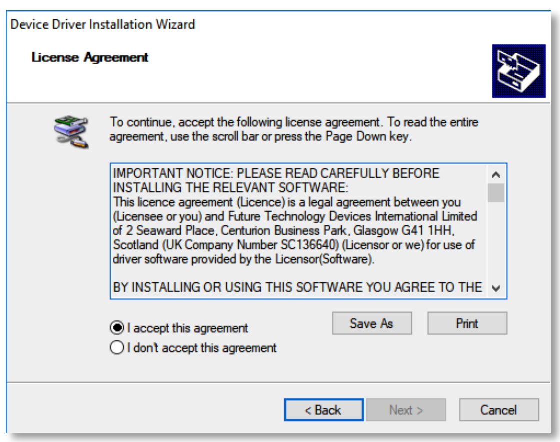


Figure 17 – The License Agreement dialog-box

In this dialog-box:

- FTDI's License Agreement for the Device Drivers may be saved to a local storage by selecting the ***Save As*** command-button or printed by selecting the ***Print*** command-button.

A copy of this License Agreement is attached to this document in Appendix 9 in page **304 below**.

- There is a need to mark the ⊙ ***I accept this agreement*** (or ⊙ ***I don't accept this agreement***) radio-button.

  Marking the ⊙ ***I don't accept this agreement*** button will cancel and terminate the installation process.

- As soon as one of the above radio-buttons is marked, all three (3) command-buttons at the bottom of the dialog-box turn active and allow:
  - Invocation of the previous dialog-box, by selecting the ***< Back*** command-button.
  - Move to next step of the installation process, by selecting the ***Next >*** command-button.
  - Terminating and cancellation of the installation, by selecting the ***Cancel*** command-button.

9. Once the ***Next >*** command-button is selected, the ***Completing the Device Driver Installation Wizard*** dialog-box opens:

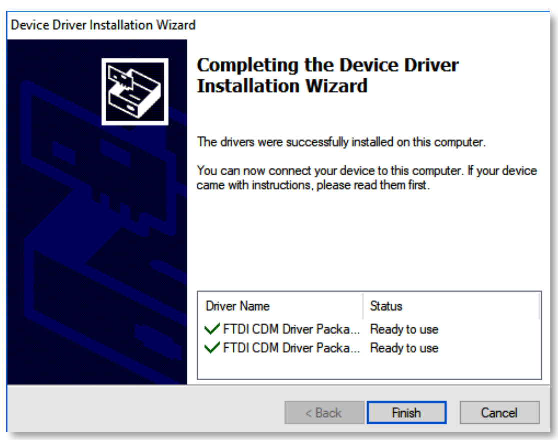


Figure 18 –The Completing the Device Driver Installation Wizard dialog-box

This dialog-box is provided for verification purposes only.

Selection of the ***Cancel*** command-button terminates the installation of the FTDI Device Driver.

Selection of the ***Finish*** command-button concludes the execution of the extraction procedure as well as the installation procedure of the FTDI Device Drivers.

Progress of this process is reported utilizing a dialog-box with a progress meter:

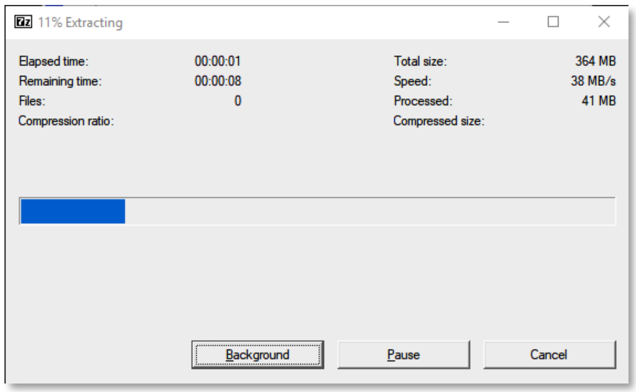


Figure 19 – Progress meter of the FTDI Drivers' Extraction and Installation

This dialog-box also allows:

- Execution of the extraction procedure and installation of the FTDI Device Drivers in the background by selecting the ***Background*** command-button.
- Halting the progress of the extraction procedure and installation of the FTDI Device Drivers by selecting the ***Pause*** command-button.
- Terminating the extraction procedure and installation of the FTDI Device Drivers by selecting the ***Cancel*** command-button.

10. If no action is taken (none of the command-buttons mentioned above was selected) throughout the previous installation step (9), the procedure of installing the Echo™ software ends up with the following ***Completing the Echo Setup Wizard*** dialog-box:

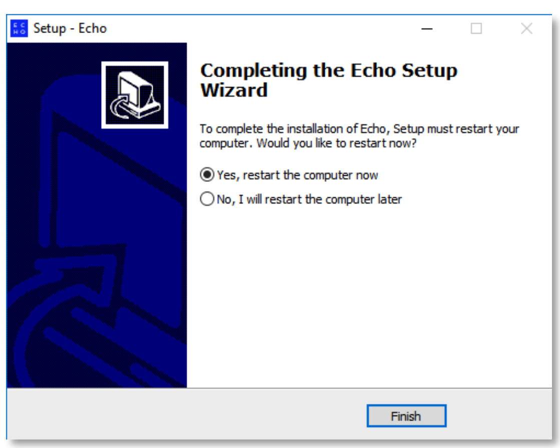


Figure 20 – The Completing the Echo Setup Wizard dialog-box

Installation of the Echo™ Software

To conclude the installation of the Echo™ software, the workstation **MUST** be restarted.

The decision whether to perform it straightaway or delay it for a later stage is left for the installer by letting him mark one (1) of the two (2) following radio-buttons:

- ⦿ ***Yes, restart the computer now***, or
- ⦿ ***No, I will restart the computer later***.

Followed by a selecting the ***Finish*** command-button.

Uninstalling the Echo™ Software

The procedure to uninstall the Echo™ software is performed in a similar way to the uninstall of any other Windows™ application program:

1. Selecting the ***Control Panel*** menu option from Windows' Main Menu.
2. From the ***All Control Panel Items*** Window that opens, selecting the ***Programs and Features*** option.
3. Search for the Echo™ xxx (where xxx is the version number) line-item in the ***Programs and Features*** window that opens and select it by right-clicking on it with the mouse.
4. A roll-down menu opens.

Selecting the ***Uninstall*** option and follow the uninstall procedure's instructions provided therein.

WARNING:	If the scanning data files' repository was set within the ***MantisVision*** directory (see paragraph "Setting the Database Repository" in page **37 below**), uninstalling the Echo™ software application will **also delete the Projects' data files!** Make sure these data files are backed-up **PRIOR** to the execution of an uninstall procedure.

Updating/Upgrading the Echo™ Software

WARNING:	Since complete removal of the Echo™ software application also deletes the Projects' data files, update/upgrade of new versions need to be done as explained in page 25. Each new version is to be installed under a separate directory, each carrying the software version number.

Based on the assumption that settings of the **Database Repository**, as well as the **Calibration Files' Repository**, were executed, in the preceding installation steps, as described in paragraph "Setting the Database Repository" (see page **37 below**), the procedure of updating/upgrading the Echo™ software is done in a similar way to the initial installation of the Echo™ software (described in Chapter 3 – Installation of the Echo™ Software in page **22 above**), except that:

- There is no need to re-install the camera's ***FTDI CDM Device Drivers*** (see page **26 above**).
- There is no need to re-install the ***Visual Studio™ Redistributable Packages*** (see page **26 above**).
- The ***Destination Location*** (see page **25 above**) will be different since the software version number, which is part of the installation directory's name, is different to the previously installed Echo™ software version.

Data Compatibility Issues

Update (or upgrade) of the Echo™ software might involve changes in the data (files and records) structure and content.

To avoid compatibility issues in such cases, it is recommended to:

1. Export the required ***Projects*** into a temporary repository.

   The exported ***Projects*** should carry different file names (the ***.db*** extension is automatically set by the Echo™ software), from the previous version (prior to the installation of the new one), and

2. Import it back into the new version following its installation.

Installation of the Echo™ Software

See section “The Import Project Command-Button” in page 59 below for information on importing ***Projects***, and to section “The Export Project Menu Option” in page 51 below for information on exporting ***Projects***.

Chapter 4 Initial Setup of the System

Following the installation (or update/upgrade) of the Echo™ software, there are three (3) more setup activities to perform to make the system a complete and integrated working system ready for work.

These initial setup activities are:

1. Setting the Database Repository – for storage of the scanned and edited data files and database.
2. Connecting the Camera to the Workstation – required for the next step of uploading the camera's calibration files onto the camera.
3. Uploading the Camera's Calibration Files – to match the camera's characteristics with the Echo™ software.

Detailed of these initial setup activities are as follows:

Setting the Database Repository

Upon initial activation of the Echo™ software, the following ***First Start*** message-box opens to indicate that **Database Repository** (directory to store recorded takes) was not yet set for action:

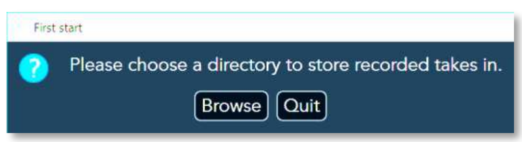


Figure 21 – The First Start message-box

If setting of the Database Repository is to be put-off for a later stage, select the ***Quit*** command-button.

To set the Database Repository, select the ***Browse*** command-button.

The ***Select Folder*** dialog-box opens (see Figure 22 – The Select Folder dialog-box **below**) to allow designation of an existing directory (e.g. ***C:\MantisVision\Database***) to be used as the Repository, or, creation of a new directory for storage as follows:

1. Right-clicking over an empty space on the right window of the ***Select Folder*** dialog-box.

2. Select the ***New*** option from the drop-down menu that opens.
3. Select the ***Folder*** option from the drop-down sub-menu that opens.
4. Type-in the new folder's name and select the ***Select Folder*** command-button.

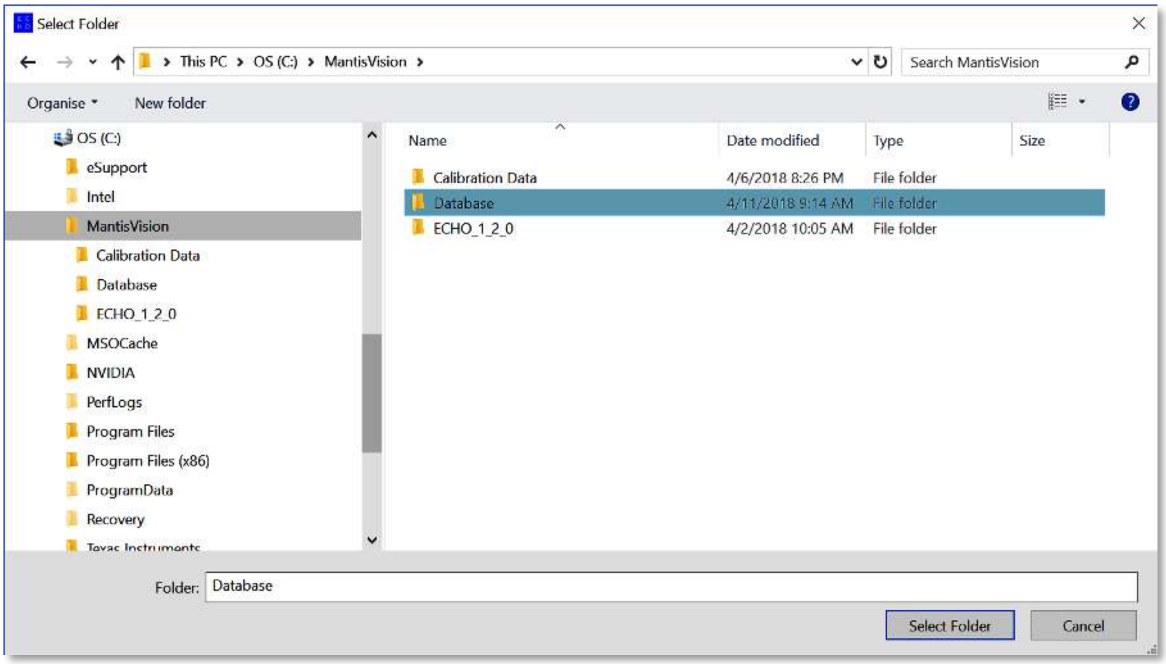


Figure 22 – The Select Folder dialog-box

TIP:

Use (or create) a Repository folder within the Echo™ installation directory (*C:\MantisVision*) but **NOT** under any specific version included therein.

The reason is that a repository/directory which is a sub-directory to an installation directory might be deleted during removals or upgrades of software versions.

In the example (see Figure 22 **above**), the repository was set to a newly created directory called "***Database***".

The new Repository folder will be created and registered in the system as the **Default Repository** for **ALL** scanning projects.

NOTE: Setting the **Default Repository** (or changing to another one) may also be done manually, at a later stage, utilizing the Echo™ **Main Menu**'s ***Settings*** option. See section "The Settings Menu Option" in page **168 below**.
The **Projects**' files will not be stored right under the Repository, but, under an additional sub-directory named ***/Takes*** which is automatically created by the Echo™ software upon creation of the first **Project**. See Figure 23 **below**.

Hierarchical Structure of the Database Repository

Following the setup of the Database Repository as recommended, the hierarchy tree of the whole Echo™ installation on the workstation's hard-disk would look like:

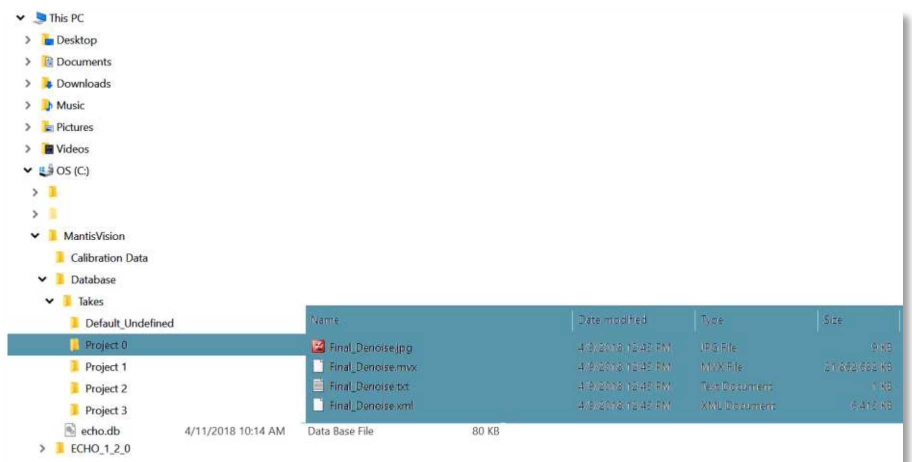


Figure 23 – Hierarchical Structure of the Database Repository

Connecting the Camera to the Workstation

NOTE: This phase in the setup procedure need to be done while the workstation is powered **ON**.

TIP: Electrical connection of the camera to the workstation is required for the next steps.

1. Connect the Communication Cable supplied with the camera kit, between the camera and the workstation.

Initial Activation of the Camera

2. Turn the camera's power **ON** by briefly pressing down the **Power/Scan Button** until:
   - The **Red LED indicator** turns constantly ON, and,
   - The workstation sounds a typical Windows' notification beep sound.

   Based on the USB standard, the workstation will automatically identify the newly connected camera and embed it into the workstation's supported/connected devices' list in the workstation's ***Device Manager***.

3. Verify the connection between the camera and the workstation utilizes Window's Device Manager mechanism.

Uploading the Camera's Calibration Files

To complete the installation and setup of the camera for operation, one more step is mandatory – the upload of the camera's explicit calibration files. These are provided, from the manufacturing line, explicitly for **EACH** camera device, following an optical calibration procedure.

These calibration files are included in the USB Disk-on-Key Flash Drive supplied with the camera kit.

The calibration files are:

- The "***rig.txt***" – Calibration data between the ***Projector*** and the ***IR Sensor***.
- The "***coloring.txt***" – Calibration data between the ***IR Sensor*** and the ***Color (RGB) Camera***, and,
- The "***config.ecfg***" – General system calibration data.

These files will later be stored in the initial (***Raw***) scan files and the data included in them will be used in the conversion process from the ***IR Sensor*** video data to the 3D Point-Cloud format.

Calibration Files' Repository

Same as with the Database Repository, there is a need to setup a repository for the calibration files. Same rules apply for this case – select (or create) a repository location within the Echo™ installation directory (*C:\MantisVision*) but **NOT** under any of the different Echo™ software versions included therein (as these might be deleted during removals or upgrades of installations).

NOTE: Since more than one camera can be assigned to a single workstation, there might be more than one repository.

Uploading the Files

The process of uploading these calibration files is done as follows:

1. Launch the Echo™ software by selecting its desktop icon (or Windows' Main Menu's option) to invoke the Echo™ **Main Screen**.
2. Set the Echo™ software to **Scan Mode** by selecting the ***Scan*** command-button in the **Main Menu** bar:

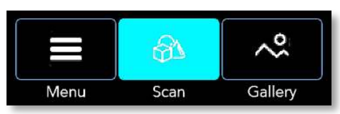


Figure 24 – Scan Mode command-button in the Echo™ Main Menu bar

Since the calibration files are not yet uploaded, a ***Recording Initialization Failed*** message-box opens:

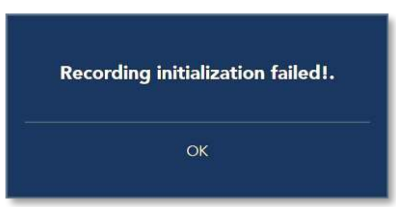


Figure 25 – The Recording Initialization Failed! message-box

Select the *OK* command-button to accept and close this message-box.

3. Select the ***Settings*** command-button at the bottom-left corner of the screen:

Figure 26 – the Settings command-button

4. The ***Settings*** toolbar opens next to the Settings command-button:

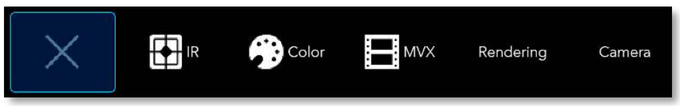


Figure 27 – Main Screen – Scan View –The Settings toolbar

5. Select the ***Camera*** command-button of the Settings toolbar.

   The ***Cameras*** dialog-box opens:

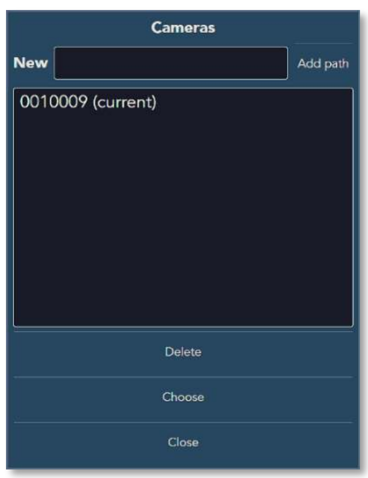


Figure 28 – Settings toolbar – The Cameras dialog-box

The ***Cameras*** dialog-box is constructed of three (3) parts:

- A ***New*** bar with its associated ***Add path*** command-button, at the top.
- Center window listing all cameras assigned/pre-installed to the workstation.
- Three (3) command-buttons – ***Delete***, ***Choose*** and ***Close***.

NOTE:	The following steps refer to the initial uploading of the calibration files only. Other parts of this dialog-box are detailed in paragraph "Main Screen – Scan View Mode – The Settings Toolbar" in page 152 below.

6. Type into the ***New*** bar a sub-directory name for storage of the calibration files of the new camera.

NOTE:	The new sub-directory's name should be the camera's unique Serial Number (S/N). This serial number can be found on the barcode label attached to the bottom end of the camera's body.

7. Select the ***Add path*** command-button.

   The newly created sub-directory is added to the center window which lists all cameras assigned to the workstation.

8. Copy-paste the three (3) calibration files from the USB Flash Drive onto this sub-directory.
9. Select the newly added camera name and then select the ***Choose*** command-button to set it as the system's default/active camera.

The ***Cameras*** dialog-box will close and the system has its camera's calibration files uploaded and set for operation.

With this last step of the initial setup, the system is completely installed, set up and initialized, and ready for work. Other setups will also be required for a fine-tuned camera. These will be detailed throughout the process of scanning in the following chapters.

Chapter 5 User Interface (UI) of the Echo™ Software

Synopsis of the Echo™ Main Screen

Double-clicking on the Echo™ icon residing on the workstation's desktop (or its Quick Launch Bar, pending parameters selected during installation; see page 28 above), launches the Echo™ software application.

The Echo™ is always set to motion with a **Splash Screen** presented in Figure 29 below:

Figure 29 – The Echo™ Splash Screen

The **Splash Screen** will automatically be replaced by the **Echo™ Main Screen** which will open, by default, in the **Gallery View Mode** (see paragraph "Gallery View Mode" in page 54 below).

As mentioned before, the Echo™ software was developed to serve three (3) purposes:

- **Scan** Control,
- **Editing** of the scanned projects up to a complete 3D model, and
- **Setting up** and configuring the equipment and the software operation.

The **Echo™ Main Screen** is the foundation for these three purposes – scanning, editing and settings for the system.

Navigation of the system between these three purposes is made by selecting one of the three (3) **Main Menu** bar command-buttons (see Figure 30 **below**):

- The ***Main Menu*** command-button; for **settings**,
- The ***Scan*** command-button; for **scanning**, and
- The ***Gallery*** command-button; for **editing**.

This chapter of the User Guide document describes the components of the **Echo™ Main Screen**, down to their details, as a prologue for their practical use in actual scanning, editing and setting functions which will be referred to in later chapters of this User Guide.

The Main Bar

On the top-left corner of the **Echo™ Main Screen** resides the **Main Bar** for sustained navigation (common to and active) through all of Echo™ functions and screens:

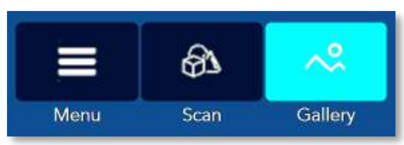


Figure 30 – The Main Menu bar

NOTE: By default, Echo™ is launched in **Gallery View** mode of operation.

The **Main Bar** represents the three (3) functions of the Echo™ software:

- **Scanning** operation control, in **Scan View mode**, activated by the ***Scan*** command-button.
- **Editing** of the scanned projects, in **Gallery View mode**, activated by the ***Gallery*** command-button.
- **Setting-up** and configuring the equipment and software operation, activated by the ***Menu*** command-button.

The Change Item Drop-Down Menu

To alter (Open, Rename, Delete, Move, etc.) an existing **Project**, data file of the **Project** or database record of the **Project**; there is a drop-down menu, common to all pages of the **Gallery View** mode called ***Change Item***.

Activation of this menu is done by right-clicking the mouse over the thumbnail image of the data file (or database records) to be altered.

The ***Change Item*** drop-down menu opens:

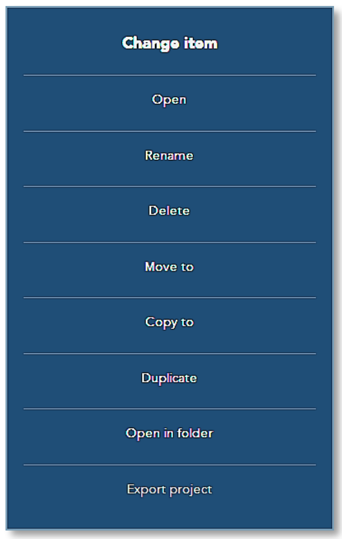


Figure 31 – Gallery View Mode – Change Item drop-down menu

NOTE: This ***Change Item*** drop-down menu is common to the:

- ***Projects*** window,
- ***Raws*** window (second page of the **Gallery View** mode),
- ***Editable*** window (second page), and
- ***Spawn*** window (second page).

Some of these options are not active at all times pending the content of the specific window this menu was triggered from.

The menu includes eight (8) options:

The Open Menu Option

The ***Open*** menu option is used:

- In **Gallery View mode – First Page** – to open the **Projects** (changing display from **First** to **Second** page),
- In **Gallery View mode – Second Page** – to open (changing display from **Second Page** to **Edit Page**) the **Raws** *.MVX* files, the **Editable** database records and the **Spawns** database records, for viewing and editing purposes in **Gallery View mode – Edit Page**.

NOTE:	The ***Open*** menu option is functionally equal to a mouse-click on the thumbnail.

Once selected, this menu option opens the progress meter (see Figure 32 **below**) which informs about the progress of aggregating the data and opening the requested file/database records. Pending parameters like: size, type and complexity of the item to be opened, this action might take some time to complete.

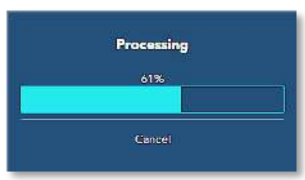


Figure 32 – Gallery View Mode – Open Process progress meter

NOTE:	Opening a data file (or database record) is also possible by selecting its thumbnail image in **Gallery View** mode's first or second page.

The Rename Menu Option

The ***Rename*** menu option allows altering the names of the **Project**'s ***Raw*** files and/or its affiliated database records in ***Editables*** and/or ***Spawns***.

Figure 33 – Gallery View Mode – Enter a Name dialog-box

Once selected (in the ***Change Item*** drop-down menu), the ***Enter a name*** dialog-box opens with the file/record name presented in the ***Name*** bar, allowing over-writing it. Once done, select the ***OK*** command-button to accept and store the new name, or, the ***Cancel*** command-button to reject it.

NOTE: It is recommended to use plain English names to ease file management and maintain the system uniformity.

The Delete Menu Option

The ***Delete*** menu option allows erasure of the **Project**'s ***Raw*** files and/or its affiliated database records in ***Editable*** and/or ***Spawn*** windows. Select the ***Delete*** menu option and a confirmation drop-down menu ***Really Delete?*** opens:

Figure 34 – Gallery View Mode – Delete Confirmation drop-down menu

Select the ***Yes*** menu option to confirm erasure of the file/record, or, the ***No*** menu option – to cancel the delete operation.

The Move to Menu Option

The ***Move to*** menu option is used for moving **Project**'s ***Raws***, ***Editable*** and ***Spawns*** files and database records from one **Project** to another.

NOTE:	The ***Move to*** operation is equal to Microsoft® Windows' cut-paste operation. The ***Move to*** operation does not leave a copy at the primary location.

Select the ***Move to*** menu option and the ***Where do you want to move this take?*** window opens:

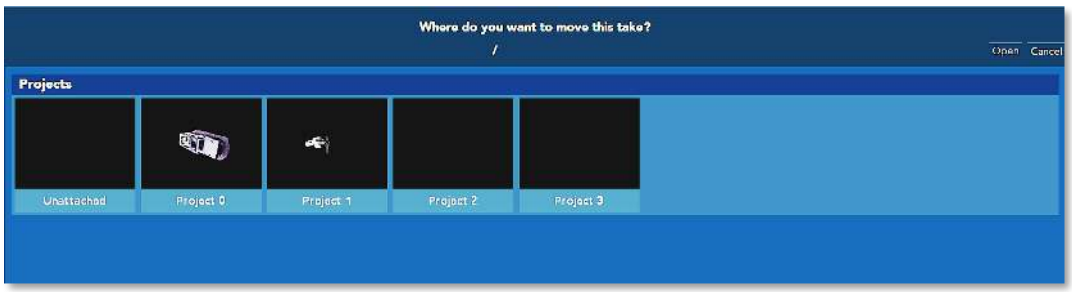


Figure 35 – Gallery View Mode – Where do you want to move this take window

This window replicates the ***Projects*** window of **Gallery View mode – First Page** and enables designation of the **Project** where the moved item needs to be moved into.

At the top-right side of this window, there are two command-buttons:

- The ***Open*** command-button – which is inactive (dimmed-out).
- The ***Cancel*** command-button – which allows cancelation of the ***Move to*** operation.

The Copy to Menu Option

The ***Copy to*** menu option is used for copying **Project**'s ***Raws***, ***Editable*** and ***Spawns*** files and database records from one **Project** to another.

NOTE:	The ***Copy to*** operation is equal to Microsoft® Windows' copy-paste operation. The ***Copy to*** operation leaves a copy at the primary location.

Select the ***Copy to*** menu option and the ***Where do you want to copy this take?*** window opens.

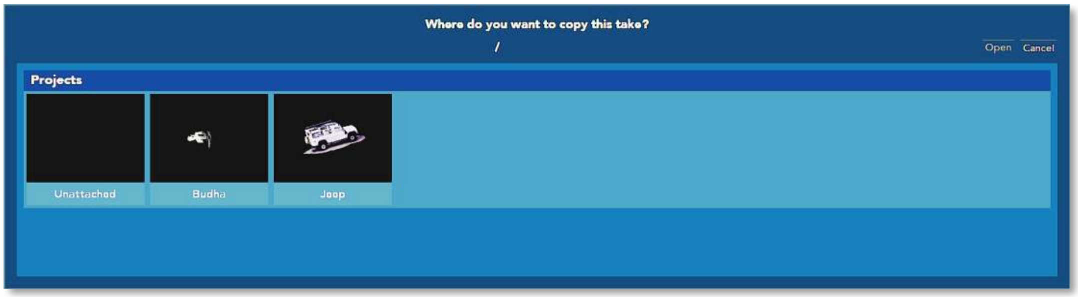


Figure 36 – Gallery View Mode – Where do you want to copy this take window

This window replicates the ***Projects*** window of **Gallery View mode – First Page** and enables designation of the **Project** where the copied item needs to be copied into.

At the top-right side of this window, there are two command-buttons:

- The ***Open*** command-button – which is inactive (dimmed-out).
- The ***Cancel*** command-button – which allows cancelation of the ***Move to*** operation.

The Duplicate Menu Option

The ***Duplicate*** menu option is used for replicating **Project**'s ***Raws***, ***Editable*** and ***Spawns*** files and database records within a **Project**.

NOTE: The ***Duplicate*** operation leaves both copies (original and duplicated) at the primary location.
The duplicated copy will carry the same name with added trailing text of: ***Copy_of_***.

Select the ***Duplicate*** menu option and the window in use (where the original file/records reside) opens:

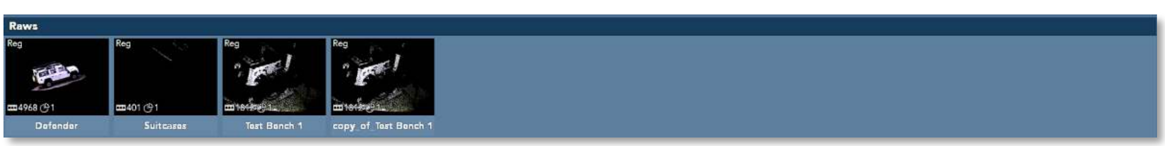


Figure 37 – Gallery View Mode – Raws window with a Duplicated Copy

The replicated file will appear shortly after, in the same window, with added trailing text of *Copy_of_*{*original name*}.

The Open in Folder Menu Option

The **Open in Folder** menu option allows browsing the hard disk directories where the **Raws'** *.MVX* files resides. This operation will come in handy where there is a need to copy the original *.MVX* file(s) from a specific hard disk directory into an external storage device, i.e. in such cases where the scan job is done on one laptop computer but need to be processed on another one.

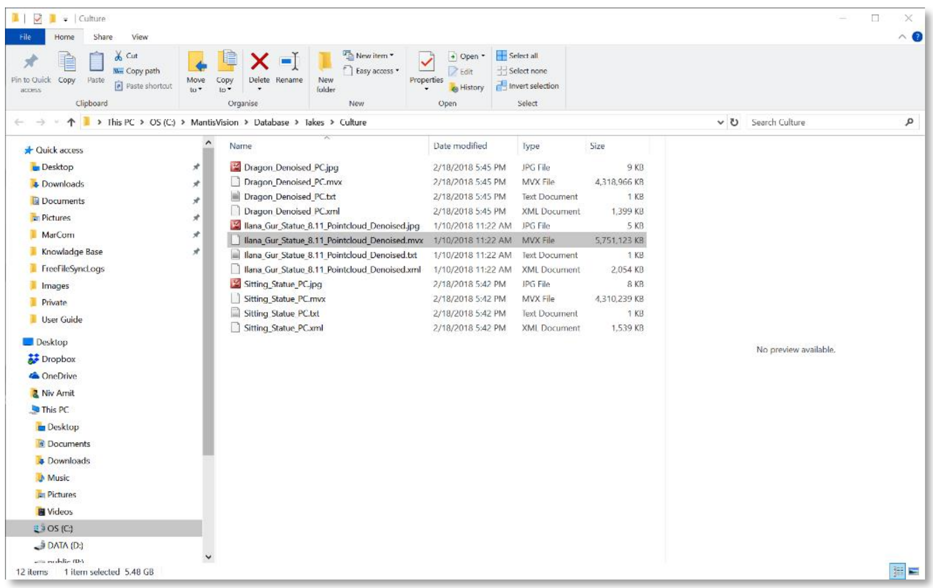


Figure 38 – Gallery View Mode – Open in Folder Search dialog-box

NOTE: The ***Open in Folder*** menu option is active for **Raws** files ONLY since all other types (***Editables*** and ***Spawns***) are not actual files, but database records.

The Export Project Menu Option

The ***Export Project*** menu option is active in **Gallery View mode – First Page** only and used for exporting complete **Projects** out of the Echo™ system.

Select this menu option and the ***Save As*** dialog-box opens:

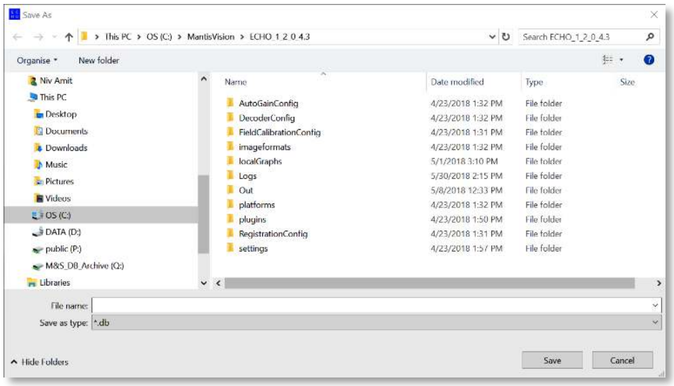


Figure 39 – Gallery View Mode – Save As dialog-box for Export Project

A name for the export file should be given in the ***File name:*** row (the extension is set to ***.db*** by default) then select the ***Save*** command-button is required to execute the export operation. A ***Cancel*** command-button is also available for termination of the process.

Once a **Project** is selected and the ***Export Project*** menu option is selected also, the Echo™ software encapsulates ALL available files and database records relating to this project and pack it in a database format file.

This file can be copied/moved to any desired location where it would be imported (utilizing the ***Import Project*** command-button of the **View Control toolbar**, see section "The Import Project Command-Button" in page **59 below** for details).

As part of the importation process, this database file will be processed to recreate the original files/records it was built from.

Synopsis of the Gallery View Mode

The **Gallery View** mode, activated by the **Gallery** command-button of the **Main Menu** bar, supports one of the three (3) main purposes of the Echo™ software by presenting the scanned projects, for processing (editing) purposes, in a hierarchical fashion where:

1. The ***Actions*** window is in fact, a command-button initiating new **Projects**.
2. **Jobs** are detailed in ***Projects***' window.

   Under each of these **Projects** there will be, in **Main Screen's – Second Page**, one or more of the following:

- **Raw Data Files** – originally scanned raw data files (Point-Clouds, IR and color RGB videos, etc.), in Mantis Vision's *.MVX* file format, **untouched**, and/or
- **Editable Database Records** – Modified replications of the above files, in records of SQLite™ file format, created following ANY processing act (Online Registration, HQ Registration, Edit and Merge, Global Registration as well as export/import operations), and/or
- **Spawn Database Records** – Modified replications of the above **Editable** files, in same SQLite™ file format, which are created following Denoise and Meshing processes.

These are all represented in Window's File Explorer style – either as thumbnails or in a file-list format as detailed in Figure 40 **below** and Figure 42 **below**.

Data Evolution in the System

The **Gallery View mode** reflects the evolution which the scanned data is going through along the process, from scanning and up to a complete 3D model including all the in-between steps.

The object scanned is captured, in **video streams format** by the IR Sensor and the Color (RGB) Camera. These video streams are stored, as layers, in video format, within the *.MVX* files and presented in the ***Raws*** window (see section "The Projects' Raws " in page 75 below).

The IR Sensor's video stream is processed, **online** (in parallel with the scan operation), by the decoder part of the Echo™ software.

The algorithm attempts to find corresponding points between the pattern (symbols) projected by the Projector, and the IR Sensor captured videos, to extract out of them the 3D Point-Cloud.

The result of this step is in **Point-Cloud format** where the projected symbols are identified, their location in space is calculated (the **Triangulation** process) to generate their XYZ location values in addition to color value of every point taken from the RGB video data.

This process is performed on each **Video Frame** of the original ***IR*** video stream and creates equivalent **Point-Cloud Frames**.

These points are referred to as **Vertexes**.

The Point-Cloud Frames are continuously searched for overlapping geometries and if such geometries are found, the Point-Cloud is being built sequentially; frame-by-frame consecutively.

This process is referred to as **Registration**.

Consecutive Point-Cloud Frames form **Segments** and if the scan is performed in optimal conditions, the whole scanned image will be converted into a **single Segment**.

Special algorithms also attempt to calculate and correct the resulting Point-Cloud data to correct 'broken' Segments (**Stitching**), minimize errors and improve the quality of the resulting Point-Cloud.

This online post-processing is performed to create an instant on-screen image allowing the users to assess their quality of work, as well as for immediate improvement of the scanning results.

The resulting **Point-Cloud** data, which include XYZ dimension values in addition to color data, is also stored as a layer in the *.MVX* (*Raw*) file.

This Point-Cloud data will go, on a later stage of the process, through different manual processes of editing including: registration, stitching, removal of redundant segments, merging segments, alignment of segments, denoising and smoothing, etc., while still in Point-Cloud format.

All these processes will be recorded as database records within the ***echo.db*** file residing under the repository's main directory.

The original *.MVX* file (the **Raws**) will always remain the **initial reference** and hence – **intact**.

Finally, the Point-Cloud data will go (if so required) onto meshing process (also referred to as **Surfacing**) where the points will be connected to create polygons.

These polygons will 'cover' the Point-Cloud model and receive a **Texture** (skin-like) of color.

The color data is derived/calculated from the above-mentioned RGB color values included in the Point-Cloud data, to create the final 3D model.

Gallery View Mode – First Page

The **Gallery View** mode's first page include:

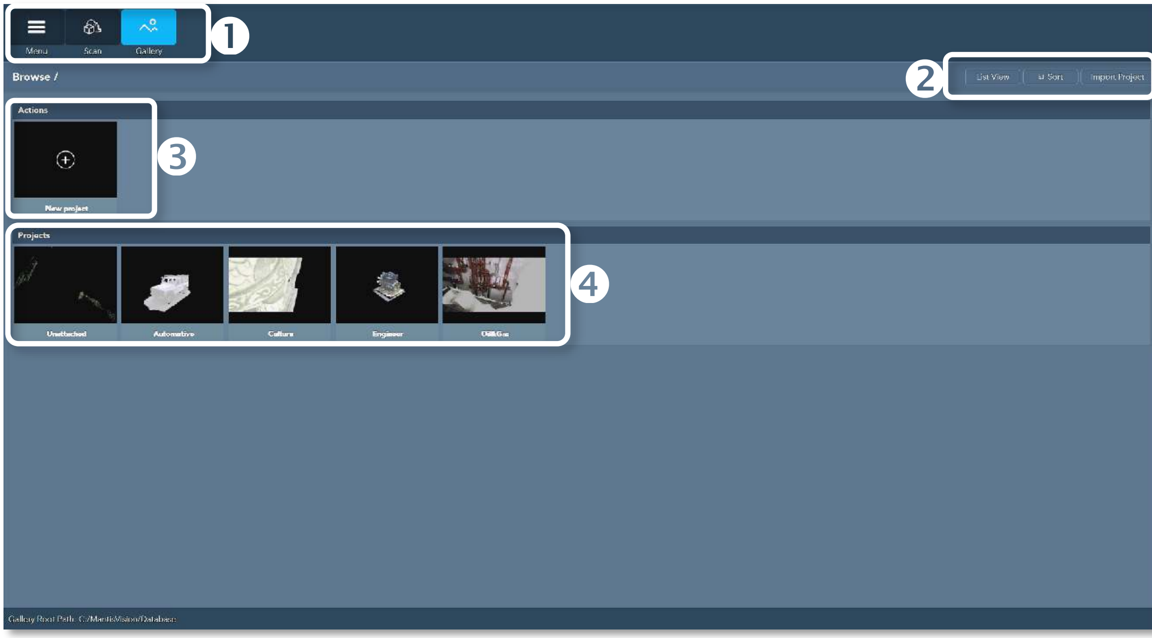


Figure 40 – Gallery View Mode – First Page

❶ The above-mentioned **Main Menu** bar (see paragraph “The Main Bar” in page 45 above) controlling the navigation between the three (3) main functions of the Echo™ software.

❷ The ***View Control*** toolbar which controls the views of the Main Screen – Gallery View Mode, on the top-right end of the screen.

❸ The ***Actions*** command-button which initiates new projects to be processed by the Echo™ software.

❹ The ***Projects*** window which details each of the projects generated by the above-mentioned ***Actions*** command-button.

The bottom-left side of the screen informs about the repository’s directory where the presented ***Project***s are taken from (see paragraph “Setting the Database Repository” in page 37 above).

The View Control Toolbar

The ***View Control*** toolbar is presented on the top-right side of the screen.

It is a command-buttons’ toolbar controlling the way ***Gallery View*** mode is presented to the users.

Figure 41 – Gallery View Mode – First Page – View Control toolbar

There are three (3) command-buttons included in this View Control toolbar:

- *List View* command-button,
- *Sort* command-button, and
- *Import Project* command-button.

Details of these command-buttons are given below:

The List View Command-Button

The *List View* command-button switches the display in *Gallery View* mode between the default thumbnail display and the classic file-list display.

In classic file-list display the files are arranged and presented and may be sorted based on their most important attributes.

The attributes presented are:

- *Name* – Name of the Project/file/record.
- *Type* – Type of the *Project*/file/record (at this point in time only *Project* type is presented).
- *Timestamp* – Encoded time stamp representing the date and time of creation of the *Project*/file/record.
- *Date* – Same as *Timestamp* and representing the date and time of creation of the *Project*/file/record, but not encoded.
- *Child Count* – Counter of the Files and Records (total of *Raws*, *Editables* and *Spawns* displayed in Gallery View mode – Second Page) created along the process of editing this *Project*.

In the default Gallery View mode, the button's name is *List View* and the display is in thumbnail style (see Figure 40 in page 55 above).

When switched to *List View* mode, the button's name changes to *Icon View* and the display is in Window's File Explorer style (file list with details, see Figure 42 below).

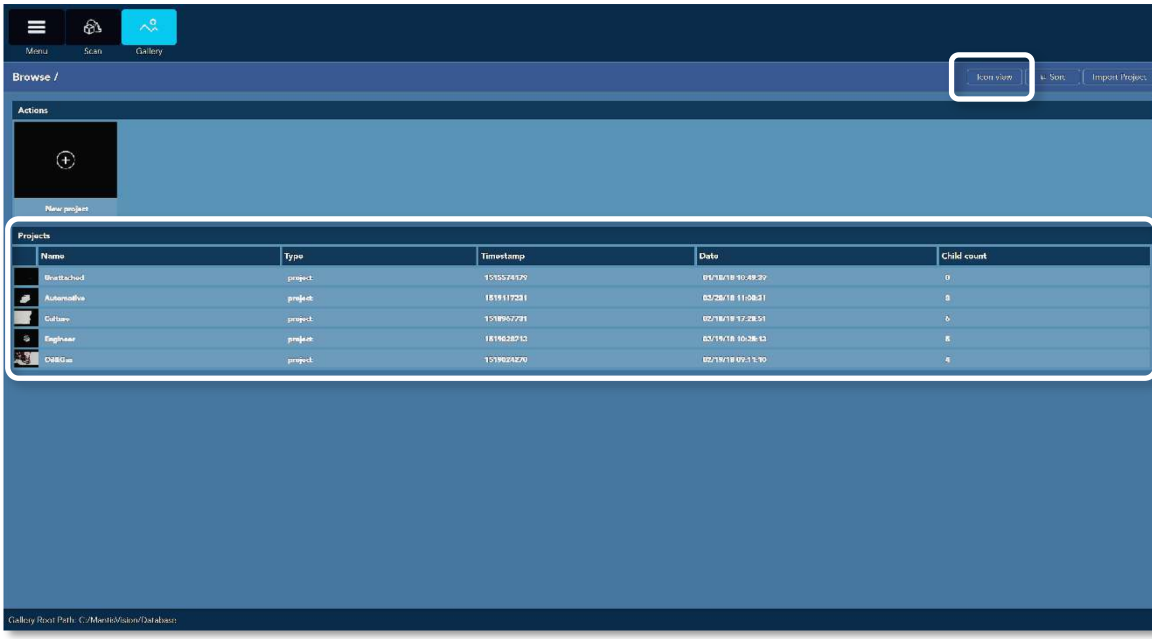


Figure 42 – Gallery View Mode – First Page – File-List View Mode

NOTE:	Same ***List View*** function/command-button also apply to file presentation in page two (2) of the **Main Screen – Gallery View** mode. See Paragraph "Gallery View Mode – Second Page" in page **65 below**.

The Sort Command-Button

The ***Sort*** command-button defines a viewing mask where the scanned/processed files/ records are presented in a user-defined order. Selection of the ***Sort*** command-button opens the ***Sort by*** dialog-box. This dialog-box sets the order-of-presentation definitions for the files/records of the **Projects** by marking one (1) out of six (6) different file parameters as a key for the presentation order.

The parameters available for the sort criteria are:

- ***Name*** – Name of Project/file/record.
- ***Date*** – Date of creation of Project/file/record.
- ***Size*** – Size of Project/file/record.
- ***Frame Count*** – Number of Point-Cloud **Frames** included in the Project/file/record.

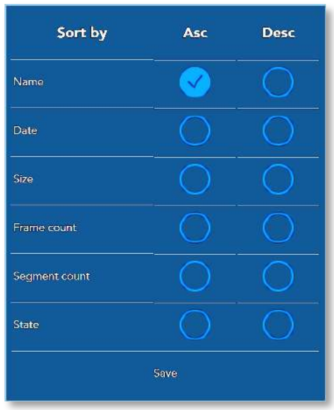


Figure 43 – Gallery View Mode – First Page – Sort by dialog-box

NOTE: The **Frames**' counters presented are the initial Video Frames captured by the IR Sensor and converted into **3D Point-Cloud Frames**. Pending the frame-rate set by the ***MVX*** toolbar (in the ***Settings*** toolbar, **Main Screen – Scan View Mode**), the figure is the arithmetic multiplication of the frame-rate by the scanning time. These **Frames** will be combined, online and/or manually, to **Segments**.

- **Segments Count** – Number of Point-Cloud Segments included in the Project/file/record. The sequence of presentation is set to ***ascending*** or ***descending*** order by selecting the left or right marking column. Once the selection is made, select the ***Save*** command-button to save the sort setup. This saved setup will become the default presentation style up until a new sort setup will be defined.

NOTE: At the early stages of the project, the scan will normally be 'broken' to a few **Segments** since the Echo™ software encountered difficulties in coherent conversion of the **Video Frames** into Point-Cloud due to luck of overlapping geometries. This might happen when the camera is facing the sun, or the scanned object is out of the scanning range. Therefore, the ***Segments Count***, prior to editing, will normally be greater than the expected single **Segment**.

The Import Project Command-Button

Unlike other command-buttons in the *View Control* toolbar, the *Import Project* command-button does not deal with the way projects are being advertised to the user but allow real action with them – importation of complete **Projects** (including all their associated files/records).

Importation is done from external repositories into the system.

Importation of **Projects** from external repositories into Echo™ might be necessary if, for example:

- Several independent scans were made targeted for the assembly of a single **Project** and the user wishes to export them to be manually combined into a single **Project** database, or,
- In many common cases where the user scans his **Project** with a stand-alone laptop computer but wishes to have them processed (edited) on another desktop workstation.

TIP:	Exportation of the **Projects** is done utilizing the ***Change Items*** drop-down menu. See paragraph "The Change Item Drop-Down Menu" in page **46 above**. The exportation of the Projects' data is done into a ***.db*** file format/type. The resulting importation process will, upon reception of the above-mentioned ***.db*** file, disassemble the **Project** back from the exported database file-format into its original components (like the ***.MVX*** file/s as well as other data types originally included in the exported file) and display them in their authentic/related window of **Gallery View Mode – Second Page**.

Selecting this command-button opens an **Import from Search** (***Open***) dialog-box (see Figure 44 **below**).

The Search (***Open***) dialog-box limits the search to ****.db*** file type since importation of **Projects** is done from the database file (and not the ***.MVX*** files).

Highlight the ***.db*** file for importation to select it and then select the ***Open*** command-button to execute the import operation.

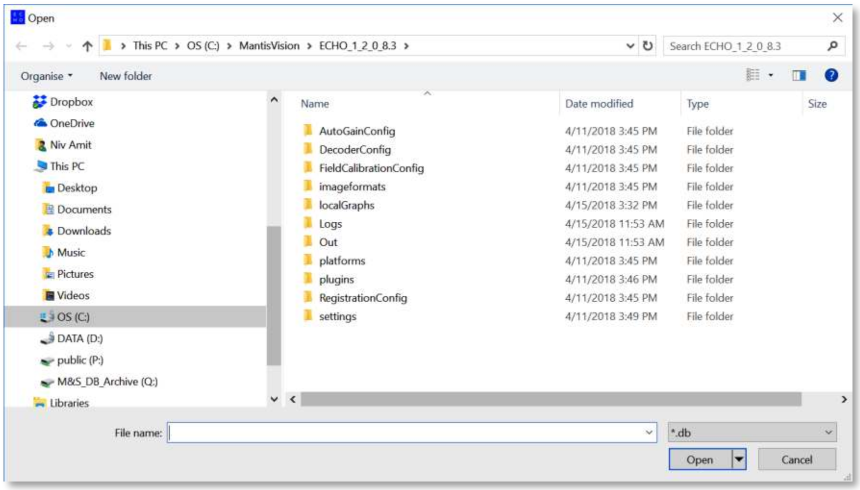


Figure 44 – Gallery View Mode – First Page – Import from Search dialog-box

The Actions Window

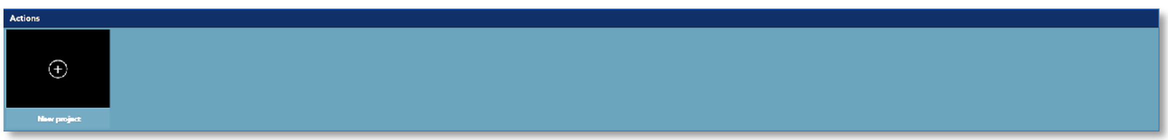


Figure 45 – Gallery View Mode – First Page – Actions window

The ***Actions*** window is in fact not a window but a ***New Project*** command-button initiating the creation of new projects, as detailed below:

Creating a New Project

Select ***New Project*** to initiate the creation of a new project. The first step required is to provide the new project with a name. This is done utilizing the ***Enter a Name*** dialog-box that opens following a selection of the ***New Project*** thumbnail.

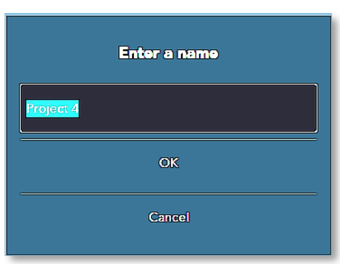


Figure 46 – Gallery View Mode – First Page – Enter a Name dialog-box

A default name ("***Project***") with a sequential number is provided, by default, but may be overwritten to voice a more meaningful project name.

Once the name is set, select the ***OK*** command-button.

A new thumbnail representing this newly added **Project** and carrying its above-given name, will pop-up in the ***Projects*** window (see Figure 48 in page **64 below**).

At the same time, a new sub-directory for storage of this project's files, carrying the same above-given name, will be created in the **Database Repository**.

There is also a possibility to cancel the creation of a new project by selecting the ***Cancel*** command-button.

NOTE: If the ***Enter a Name*** process is skipped and no project name is given prior to commencing a new scan operation, all gathered **Raws** data files will be stored under a special project/directory called **Unattached**. There will be no organizational (e.g. Projects, except for a timestamp) hierarchy in these files. See section "The Unattached 'Project" in page **64 below** for details.

Manipulating Projects' Files and Database Records

To manipulate (Open, Rename, Delete, etc.) an existing project's files and/or its database records; right-click the mouse over the project's thumbnail.

The ***Change Item*** drop-down menu opens.

NOTE: The ***Change Item*** drop-down menu is common to the **Projects** window, the **Raws** window (second page of the **Gallery View** mode), the **Editable** window (second page of the **Gallery View** mode), and the **Spawns** window (second page).

Some of its options are inactive at times (dimmed-out) pending the content of the specific window this menu was invoked from.

Figure 47 – Gallery View Mode – First Page – Main Menu drop-down menu

Projects' files and data records manipulations enabled by the ***Main Menu*** are:

- ***Open*** – used for opening the repository and/or the database records within the second page of **Gallery View** of the specified project, for editing and viewing purposes.

> **NOTE:** This menu option is equal to a mouse click over the **Project**'s thumbnail.

- ***Rename*** – used for changing the name of the **whole project** including its ***Raws***, ***Editable*** and ***Spawns*** files and all of its database records.
- ***Delete*** – used for deletion of the **whole project** (files and database records) or a specific ***Raws*** file or ***Editables*** records or ***Spawns*** records, pending the windows it was invoked from.
- ***Move to*** – used for moving project's ***Raws***, ***Editable*** and ***Spawns*** files and database records from one project to another.

> **NOTE:** The ***Move to*** operation does not leave a copy at the original location.

- *Copy to* – used for creation of a (physical) clone/copy of the **Project**'s ***Raws***, ***Editable*** and ***Spawns*** database records in another **Project**.

> **NOTE:** The ***Copy to*** operation leaves the authentic copy at the primary location.

- *Duplicate* – used for duplication of the project's ***Raws***, ***Editable*** and ***Spawns*** files and database records, within the very same **Project**.
- This is normally required for redundancy and/or backup reasons and/or for splitting the processed job among different users/computers.

> **NOTE:** The ***Duplicate*** operation add a copy with the same name with *_copy* text.

- *Open in folder* – used for opening the specified file or database record in its storage/ directory location (repository).

> **NOTE:** This option is active in **Gallery View mode – First Page** only since only ***Raws*** files are actual files (unlike ***Editables*** and ***Spawns*** which are database records) which can be opened in their repository folder.

- *Export project* – used for exporting complete projects from one computer/repository to another.

> **NOTE:** This option is active in **Gallery View mode – First Page** only since the **First Page** is the only one which presents **Projects**.

These options are further detailed in paragraph "The Change Item Drop-Down Menu" in page 46 above.

The Projects Window

The ***Projects*** window is the **complete gallery of projects** handled by the system from within the specified working repository (see paragraph “Setting the Database Repository” in page **37 above**).

This is the root of the projects’ evolutionary tree of files and database records.

Out of this window users may drills-down into any part or stage of the process for further editing it towards the final 3D product.

Figure 48 – Gallery View Mode – First Page – Projects window

Selection of any of the project’s thumbnail image in the ***Projects*** window (or utilizing the ***Open*** option of the ***Change Item*** drop-down menu), drills-down into the ***Project***’s ***Database*** to discretely show their recorded stage:

- ***Raw*** data files.
- The ***Editable*** database records.
- The ***Spawn*** database records.

These evolutionary database records are presented, in a similar way, but on the second page of the ***Gallery View Mode*** described below.

The ***Projects*** window includes one special (set as default by the Echo™ software) project-like thumbnail named ***Unattached***.

The Unattached ‘Project’

In cases where:

- A new ***Project*** was NOT initiated (with a specified name, see section “Creating a New Project” in page **60 above**), or
- A previously opened **Project** was not selected prior to the initiation of a new scan,

The data captured during the scan (the scan’s ***.MVX*** files) will be stored under a special Project named ***Unattached*** within the ***Projects***’ window.

The names of the files/projects included in such a scan combines the date and time of creation, e.g.: `2018-06-24-15.12.50`.

The ***Change Item*** drop-down menu (see paragraph "The Change Item Drop-Down Menu" in page **46 above**) should be used to move these files into the relevant **Project** by utilizing the ***Move to*** or ***Copy to*** or ***Duplicate*** options.

TIP:	It is recommended to use the ***Move to*** option of the ***Change Item*** drop-down menu so that the originally scan files will be moved to the relevant **Project**. Also recommended is to rename the moved files following this ***Move to*** operation to maintain logical structure of the **Projects**.

NOTE:	The Unattached 'Project' cannot be renamed or deleted and will always be presented on the left-most (first) ***Project*** item/thumbnail in the **Gallery View mode – First Page – Projects** window. Accordingly, most the ***Change Item*** menu options are not active over the **Unattached** '**Project**'.

Gallery View Mode – Second Page

The above-mentioned evolutionary records of the ***Projects*** are presented in the **Main Screen's second page**.

There are three types of evolutionary records:

- ***Raws*** – These are the original scanned files, in ***MVX*** file format, and contain:
  - A layer of calibration data derived from the calibration files (see paragraph "Uploading the Camera's Calibration Files" in page **40 above**).
  - A layer of the IR Sensor's video stream data.
  - A layer of the Color (RGB) Camera's video stream data.

- A layer of the online decoding results in Point-Cloud (3D Vector) format, with XYZ dimensions in addition to RGB (color) data for each point.

> **NOTE:** The layers to be included in the Raws' ***MVX*** files are the data layers that were marked as **active** and **recordable** in the setup of ***Data Layers*** option of the **Scan View** mode, ***Settings*** toolbar.
>
> See section "The Settings Toolbar" in page **152 below** for details.

- ***Editables*** – These are the records of changes made to the above ***Raws*** files.

  Every change (export/import, registration, removal of segments, editing and merging segments, denoise, etc.) made to the original image included in the ***MVX*** files is recorded in database (SQLite™) record format.

  Changes are stored while the data is still in its Point-Cloud format (unlike the **Spawns** described below) therefore – allow measuring the scanned subject.

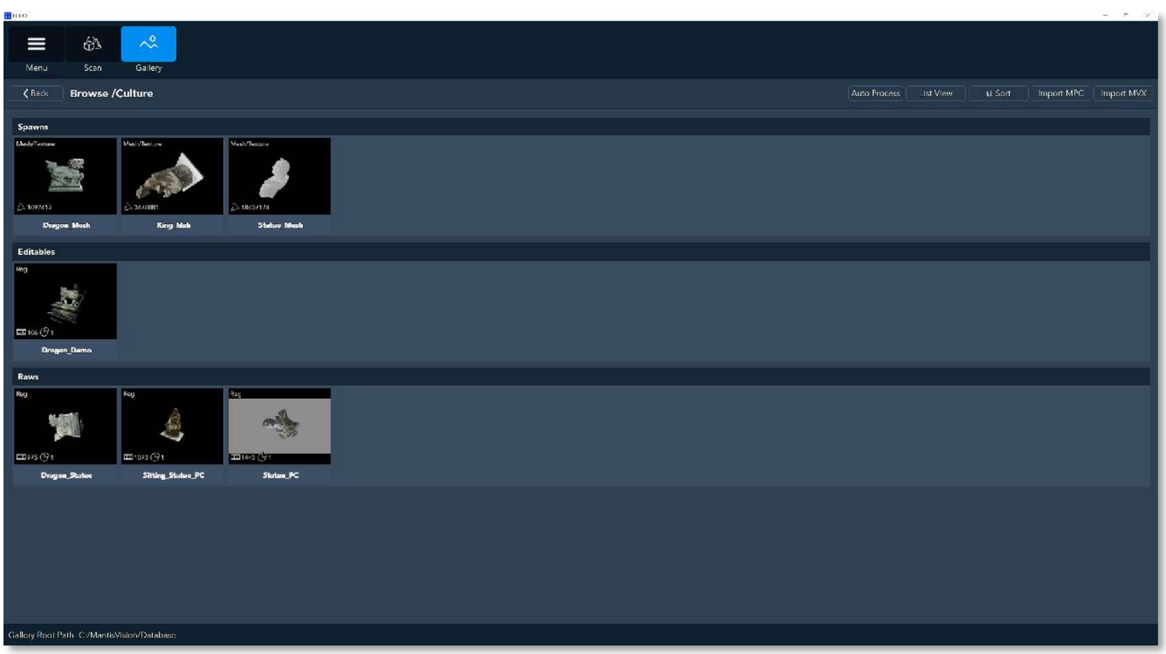


Figure 49 – Gallery View Mode – Second Page

- *Spawns* – These are the final 3D model's data records in the database file where the Point-Cloud is converted to polygons with added **Texture** ('skin') of color data (**Mesh**) derived from the original Color (RGB) Camera's video stream.

NOTE: The Spawns cannot be edited !!!

Components of the Gallery View Mode – Second Page

At the top-left end of the screen there are:

- The **Main Menu** bar of the Echo™ (discussed in paragraph "The Main Bar" in page **45 above**).
- The ***< Back*** command-button which returns the display to Gallery View Mode – First Page discussed in page **54 above**, and
- The ***Browse/xxx*** title presenting which **Project** (the ***xxx***) is being detailed in the **Second Page** (out of all projects presented in the **First Page**).

The ***View Control*** toolbar of the second page is slightly different from the **First Page**:

Figure 50 – Gallery View Mode – Second Page's View Control toolbar

View Control Toolbar – Auto Process Command-Button

The ***Auto Process*** command-button is in fact a short-cut command-button applying the most common project processing steps (as detailed in paragraph Gallery View Mode – Edit (Third) Page **below**) into a single operation.

Selecting the ***Auto Process*** command-button opens the ***Select a file for Auto-Processing*** window:

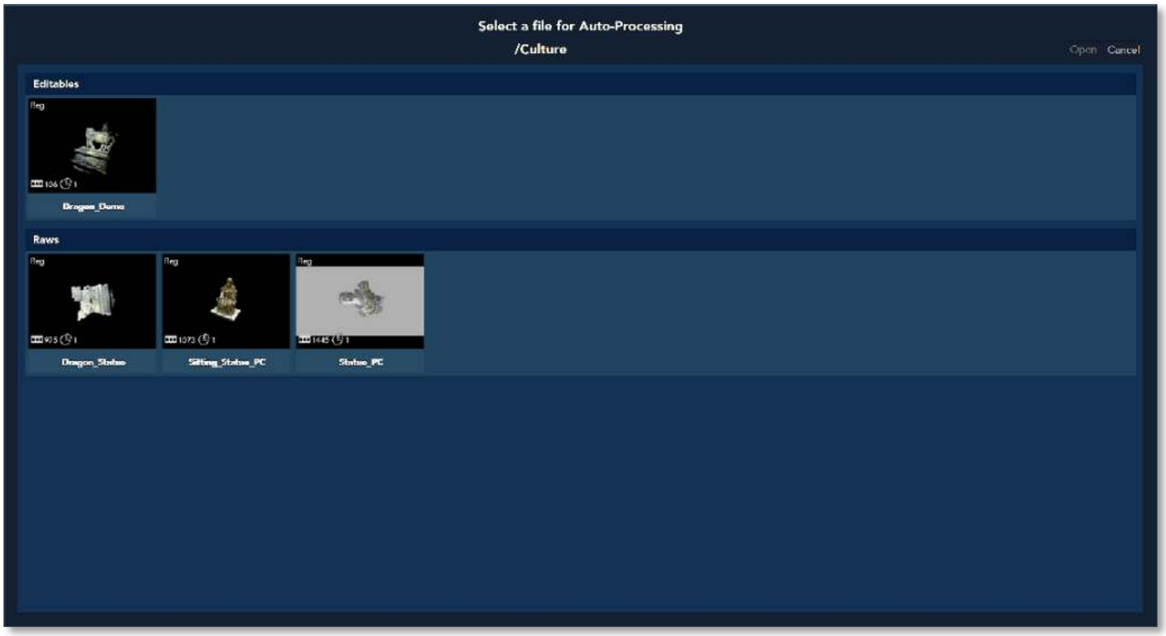


Figure 51 – Second Page – Auto Process – Select a File

The *Select a file for Auto-Processing* window include:

- The ***Editable*** and ***Raws*** windows for selection of the file for processing:

Figure 52 – Auto Process Select File Window – Editables Window

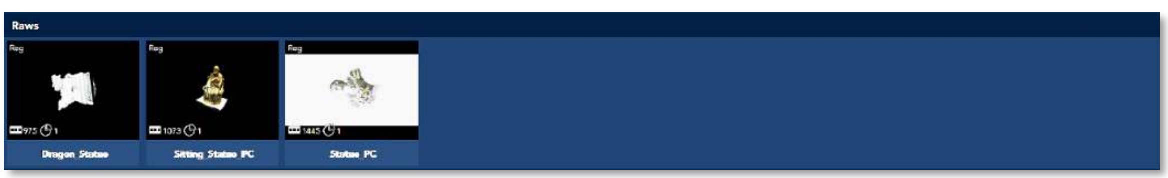


Figure 53 – Auto Process Select File Window – Raws Window

NOTE: No Spawns window will open for selection of a file since Spawns cannot be edited.

- The ***Open*** and the ***Cancel*** command-buttons, at the top-right end of the ***Select a file for Auto-Processing*** window:

Figure 54 – Auto Process Select File Window – Open/Cancel Command-Buttons

Once a file (either Editable or Raw) is selected for ***Auto Processing***, selecting the ***Open*** command-button will open the next step of the process (see Figure 55 below) – the Auto Process Setup window.

Selecting the ***Cancel*** command-button terminates the ***Auto Process***.

Auto Process window is made of four (4) major parts:

- The first (top) three (3) selects which of the operations need to be activated in the ***Auto Process*** procedure by marking their activation radio-buttons ().
- The fourth part sets the name of the resulting (***Auto Process***ed) file.

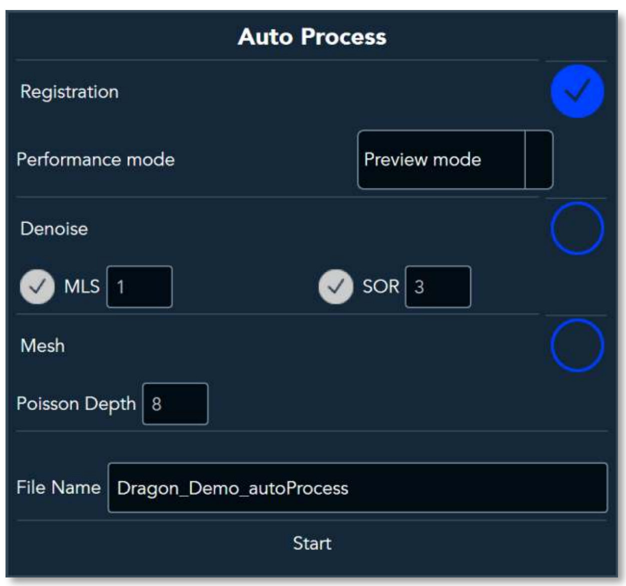


Figure 55 – Auto Process – Auto Process Setup Window

- The ***Registration*** setup part – once activated by selecting the activation radio-buttons , allow selecting ***Performance mode*** between low quality “quick-and-dirty” ***Preview mode*** registration process or ***High-Quality mode***, by means of a drop-down menu:

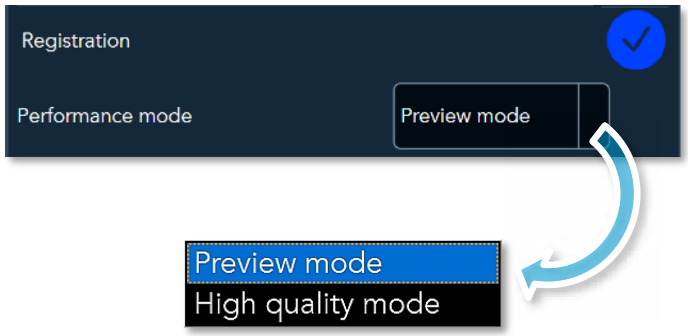


Figure 56 – Auto Process – Process Details Window – Registration Setup

The main difference between these two (2) modes is that the ***Preview mode*** registration utilized a rough estimations' algorithm to quickly produce a registered image, while the ***High-Quality mode*** utilizes a far more precise calculations and require the use of the workstation's **GPU** (Graphics Processing Unit) to provide the results within a reasonable time.

The **High-Quality Registration** is a general image improvement registration process, usually performed prior to all other registration processes (except for the **Online Registration**).

The Echo™ software processes ALL of the scanned object's Frames, Segments and Groups together (and not frame-by-frame like the **Online Registration**) while attempting to have them matched and registered properly.

The **High-Quality Registration** process is further detailed in section "3D Registration Types" in page **295 below**.

- **The *Denoise* setup part** – once activated (by selecting the activation radio-buttons), it also activates the option to select which Denoise Act need to be used (turning their radio-buttons' background color from grey to blue).

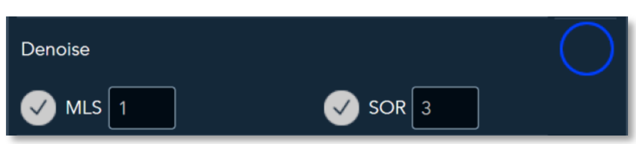


Figure 57 – Auto Process – Process Details Window – Denoise Setup

Details and theoretical background information regarding **Denoise Act** types can be found in section “The Noise Removal (Denoise) Act” on page **97 below**.

- **The *Mesh* setup part** – once activated (by selecting the activation radio-buttons), it enables setting the ***Poisson Depth*** value for meshing.

Figure 58 – Auto Process – Process Details Window – Mesh Setup

Details and theoretical background information regarding **Denoise Act** types can be found in section “3D Meshing (Spawning)” on page **301 below**.

- The fourth part is **the resulting *Fila Name* setup part** – it contains, by default, a suggested file name made of the original file’s name with added ***autoProcess*** text but can be altered manually within the dialog-box.

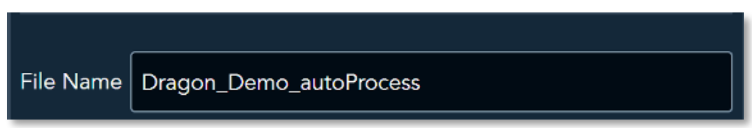


Figure 59 – Auto Process – Process Details Window – File Name Setup

Once all the above selection and setup is done, select the ***Start* command-button** and the ***Auto Process*** begins.

The progress of the ***Auto Process*** is reported via a series of progress-meters, each relating to a specific step of the process according to the Process steps defined for action. The initial progress-meter to be presented is the **Loading progress-meter**:

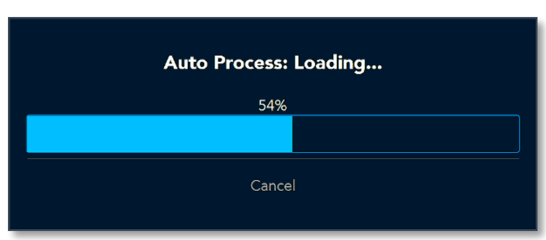


Figure 60 – Auto Process – Execution Progress Meters – Loading

The next progress-meters will pop-up according to the *Auto Process* setup data.

View Control Toolbar – List View and Sort Command-Buttons

The *List View* command-button and the *Sort* command-button perform exactly like their corresponding buttons in the *View Control* toolbar of the **First Page**.

The textual attributes presented on the **Second Page** are:

- *Type* – Type of file/database record.

> **NOTE:** At this point in time only "*take*" type is in use (and thus presented) in **Gallery View Mode – Second Page – List View Mode**.

- *File Size* – The size (volume) of the file (or records) in Bytes.

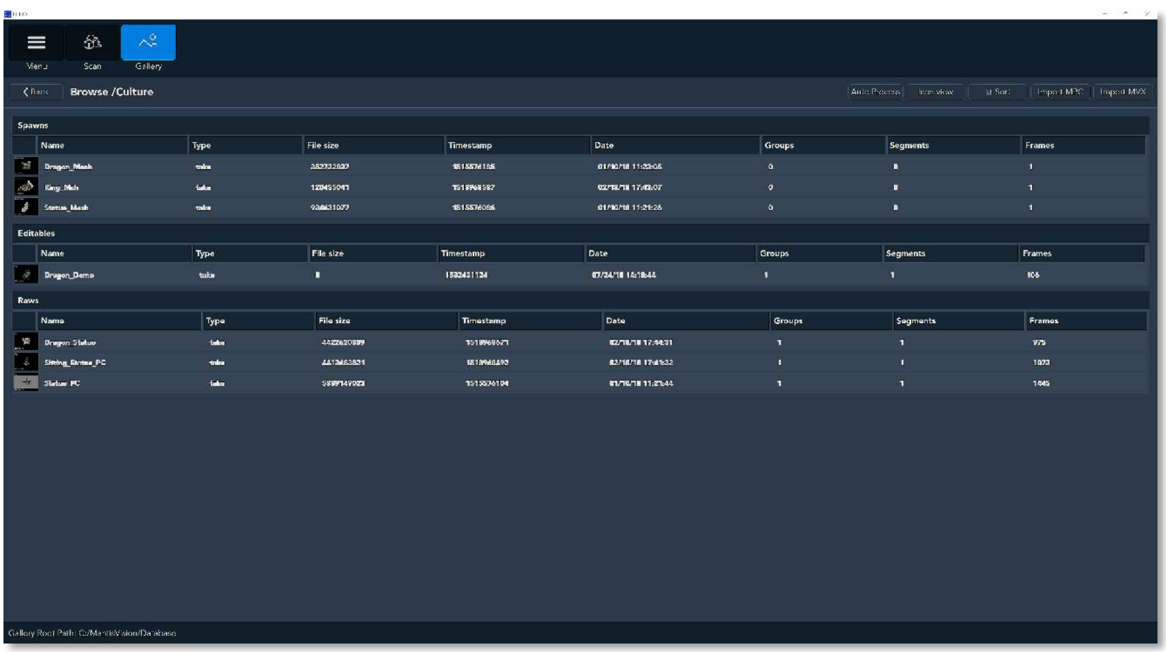


Figure 61 – Gallery View Mode – Second Page – List View Mode

- *Timestamp* – Encoded time stamp representing the date and time of creation of the *Project*/file/record.
- *Date* – Same as Timestamp and representing the date and time of creation of the *Project*/file/record, but not encoded.

- *Groups* – Manual connections between two (2) or more **Segments** creates **Groups**.

> **NOTE:** **Groups** are, in fact, **Segments** too.

- *Segments* – Number of **Segments** included in this file/database records.
- *Frames* – Number of **Point-Cloud Frames** included in this file/database records.

The ***Import*** command-button is replaced in the **Second Page** with:

1. The ***Import MPC*** command-button – serving the purpose of importing legacy Mantis Vision MPC-format files while converting them to the more advanced ***.MVX*** format.

   The MPC format was used in the old ***Kapla Vision*** software product (predecessor of the Echo™ software).

2. The ***Import MVX*** command-button – serving the purpose of importing Mantis Vision's newer MVX-format files from other repositories into the **Project** selected prior to using **Gallery View Mode – Second Page**.

   This innovative format is a flexible file format – a **container**, allowing unrestricted combinations of data arranged in layers, including (but not limited to) all types of video data and formats, 3D data (i.e. Point-Clouds), mesh data, etc.

> **NOTE:** Information regarding the ***.MPC*** and ***.MVX*** file formats, structure and content can be found in Appendix 5 – Mantis Vision Data Files Content and Structure on page 289 below.

View Control Toolbar – Import MPC Command-Button and Dialog-box

MPC is a legacy Mantis Vision format still in use by customers or re-purposed in Echo™.

> **NOTE:** Information regarding the ***.MPC*** file format, structure and content can be found in Appendix 5 – Mantis Vision Data Files Content and Structure in page 289 below.

Selecting the ***Import MPC*** command-button opens the ***Import MPC*** dialog-box:

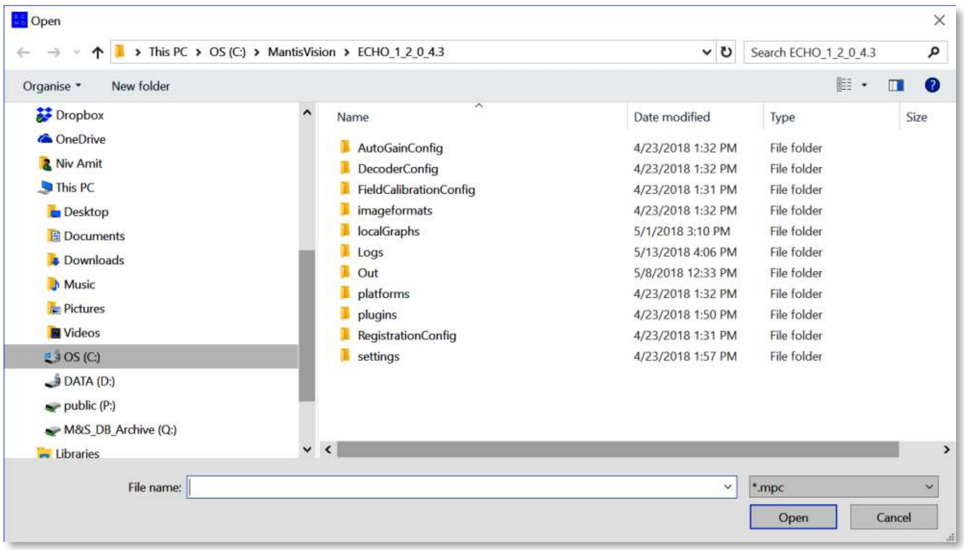


Figure 62 – Gallery View Mode – Second Page – Import MPC dialog-box

NOTE: The *Import MPC* dialog-box restrict the search to files with extension type *.MPC* only.

An *MPC* file to be imported must be accompanied by a corresponding data file carrying the same name but with the extension of *.TOC*.

The imported *.MPC* files will be processed (format converted) for adoption by the new system's format (*.MVX* format).

These imported files will be registered and stored as database records in the ***echo.db*** file and presented in the ***Editables*** window.

View Control Toolbar – Import MVX Command-Button and Dialog-box

The *.MVX* is Mantis Vision's proprietary container file format used by the Echo™ software for storage of scanned 3D data and its associated metadata.

Selecting the ***Import MVX*** command-button opens the Import MVX dialog-box:

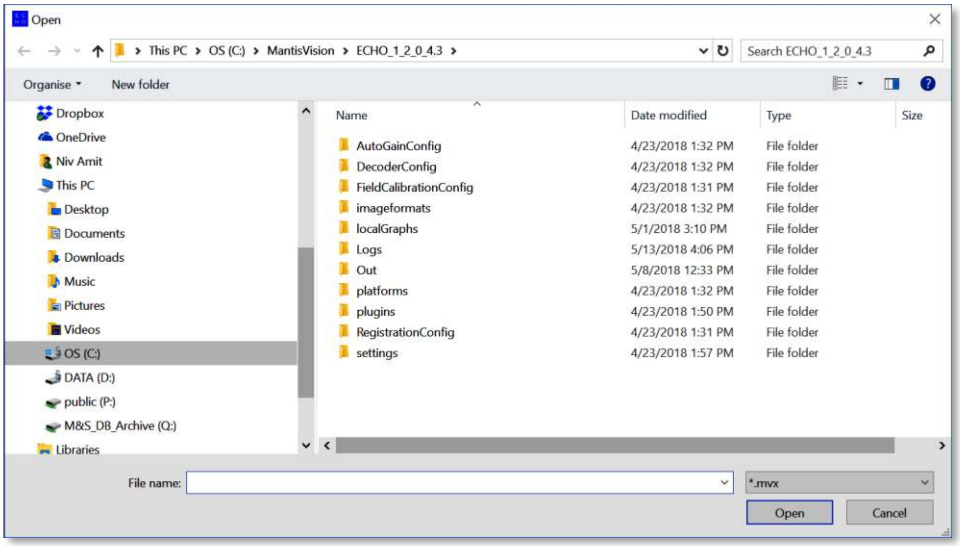


Figure 63 – Gallery View Mode – Second Page – Import MVX dialog-box

NOTE: The *Import MVX* dialog-box restrict the search to files with extension type *.MVX* only.

The imported *.MVX* files will be stored as ***Raws*** files under the ***Project*** opened in the Gallery View mode – First Page.

The Projects' Raws Window

The ***Raws*** window presents the raw materials (files) of the scanned objects.

The video streams of the IR Sensor and the Color (RGB) Camera of the scanned object are stored as layers in *.MVX* files, in addition to other layers as detailed below.

These *.MVX* files are presented in the ***Raws*** window.

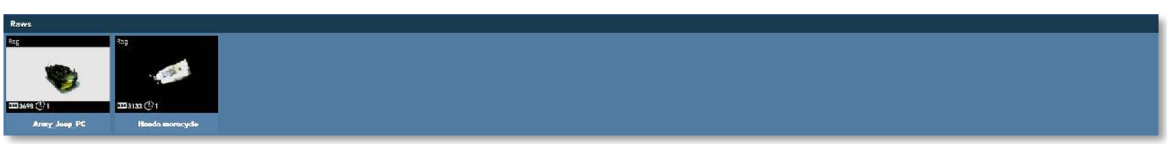


Figure 64 – Gallery View Mode – Raws Window

The IR Sensor video streams are processed online (in parallel with the scan operation) by the decoder program of the Echo™ software, to create a 3D Point-Cloud (a cloud of points where each point has calculated XYZ Cartesian coordinates' values in addition to color data derived from the Color (RGB) Camera's video stream).

During this online process, special algorithms calculate and adjust the data to minimize errors, correct (stitch) unconnected **Segments** and improve the quality of the resulting Point-Cloud.

This whole online post-processing is done to create an instant on-screen image allowing the users to evaluate their quality of work, as well as for immediate improvement of the scanning results.

The resulting Point-Cloud which include XYZ Cartesian coordinates' values in addition to color data, is also stored as a layer in the ***.MVX Raws*** file.

NOTE: The **Raws** data files are the originally scanned data containers (files) and are used as references in the process-flow of Echo™.

Therefore these files are never 'touched' (edited or manipulated in any way) and remain in their original ***.MVX*** format and content.

Any change made to these files will be recorded as database records and presented in the **Editables** window.

In addition to the above-mentioned data layers of the ***.MVX Raws*** files, there is an additional layer of calibration data derived out of the calibration files uploaded during the initial setup of setting up the system.

Selection of any of the thumbnails (or utilizing the ***Open*** option of the ***Change Item*** drop-down menu) will open the file for editing in the ***Edit*** page (the third page of the **Gallery View** mode, see paragraph "The Edit Page for Raws and Editables" in page **83 below**).

Symbolic Information on the Raws' Thumbnails

At the top and bottom of each thumbnail representing a ***Raws*** file, there are some symbols and text data which provide the users with some essential information about the file.

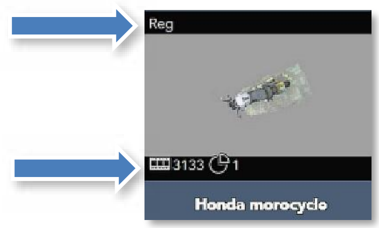


Figure 65 – Symbolic Information on Raws' Thumbnails

Same information is also presented, in text format, in the *List View* mode (see section "The List View Command-Button" in page 56 above and the data fields' information in page 72 above).

Symbol/Text	Meaning	Notes
Reg	Registered (online)	The Point-Cloud Frames in this file are all registered (consecutive).
3133	Number of Point-Cloud Frames	Included in this file.
1	Number of Segments	included in this file.

Table 1 – Symbolic Information on Raws' Thumbnails

NOTE:

The **Frames** and **Segments** counters presented are the initial video stream's Frames, captured by the IR sensors and converted to 3D **Point-Cloud Frames** and **Segments**.

Pending the frame-rate set by the ***MVX*** toolbar (in the ***Settings*** toolbar, **Main Screen – Scan View Mode**, see section "The Settings Toolbar" in page **152 below**), the total number of Point-Cloud **Frames** presented is the arithmetic multiplication of the frame-rate by the scanning time.

These Point-Cloud **Frames** are combined by the Echo™ software, online (and later manually), to **Segments**.

The initial number of **Segments** is usually higher than one (1) due to non-ideal conditions but will be reduces by the different registration processes on a later stage.

The Change Items Drop-Down Menu in Raws Window

There are two (2) option items in the ***Change Items*** drop-down menu (see section “The Change Item Drop-Down Menu” in page 46 above) requiring special attention:

1. The ***Open in folder*** option will open the ***.MVX*** file in the directory where it is stored (unlike ***Editables*** and ***Spawns*** which are database records).
2. The ***Export project*** option is dimmed-out (inactive).

The Projects’ Editables Window

Once a ***Raw*** file is opened and manipulated (ANY manipulation, including export) and saved, it will be presented in the ***Editables*** window.

The changes made in such a case will be registered as database records in the ***echo.db*** file (not as layers in the stand-alone ***.MVX*** file or any other file format).

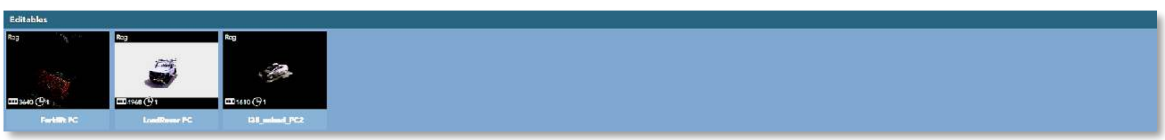


Figure 66 – Gallery View Mode – Editables Database Records

Editables thumbnails, upon any **Save** operation, always represents ALL the changes made to the scanned object’s data, in the selected **Project**, up to their latest version, including the thumbnail’s image.

The image presented in the thumbnail is also modified with every ***Save*** operation of the data being edited to reflect the latest stage in the process.

NOTE:	The above said does not include scanned object following **Mesh** operation. These will be presented in the ***Spawns*** window (see section “The Projects’ Spawns Window” in page 80 below).

Symbolic Information on Editables' Thumbnails

On the top and bottom ends of each of the thumbnails presenting the ***Editables*** records, there are some symbols and text data which provide the users with some more information about these records.

This information is also presented in text format in the **List View** mode (see section "The List View Command-Button" in page 56 above and the data fields' information in page 72 above).

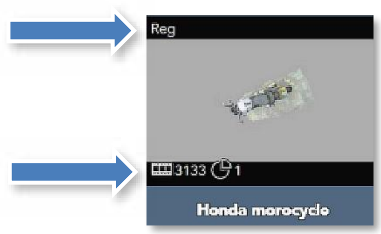


Figure 67 – Symbolic Information on Editables' Thumbnails

The information presented in these symbols and texts is:

Symbol/Text	Meaning	Notes
Reg	Registered	The Point-Cloud Frames in this records are all registered (consecutive).
Decoded	Decoded	The Point-Cloud Frames in this records are decoded (but not registered).
3133	Number of Point-Cloud Frames	Included in this records.
1	Number of Segments	included in this records.

Table 2 – Symbols and Texts Around the Editables' Thumbnails

NOTE: The numbers of **Point-Cloud Frames** and **Segments** displayed on the **Editables** thumbnails are the results of the different registration, editing and denoising process steps executed on these Point-Clouds.

Therefore, in most cases, these numbers will be different to the numbers presented on the related **Raws** thumbnails.

Change Items Drop-Down Menu in Editables Window

There are two (2) option items in the ***Change Items*** drop-down menu (see section "The Change Item Drop-Down Menu" in page **46 above**) requiring special attention:

1. The ***Open in folder*** option will open an error message window, since ***Editables*** are not files (but records of a database):

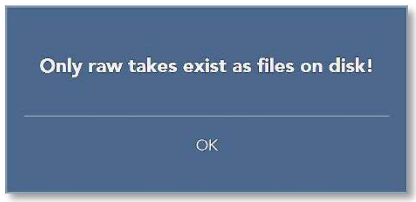


Figure 68 – Error Message for Open in folder Menu Option in Editables Window

2. The ***Export project*** option is dimmed-out (inactive).

The Projects' Spawns Window

The **Spawns** window represents the final editing stage of the 3D model – the **Mesh**.

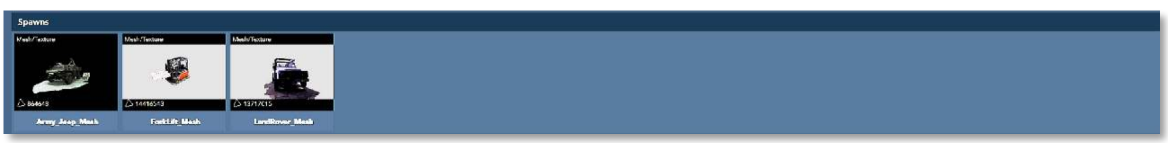


Figure 69 – Gallery View Mode – Spawns Database Records

The database records included in this window are the 3D scanned objects following **Mesh** processing.

For the **Mesh** process, the Point-Cloud is converted to polygons to be 'painted' with **Texture** ('skin') of color.

The colors used for the Texture are derived from the original Color (RGB) Camera's video stream to create a complete real-life look-alike **3D Model**.

Symbolic Information on Spawns' Thumbnails

On the top and bottom ends of each of the thumbnails presenting the ***Spawns*** records, there are some symbols and text data which provide the users with some more information about the records.

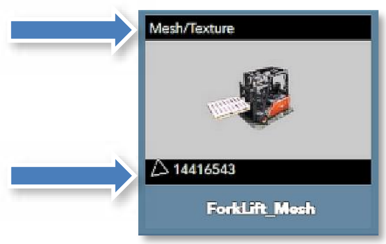


Figure 70 – Symbolic Information on Spawns' Thumbnails

This information is also presented, in text format, in the ***List View*** mode (see section "The List View Command-Button" in page 56 above and the data fields' information in page 72 above).

The information provided in these symbols and texts is presented in Table 3 below:

Symbol/Text	Meaning	Notes
Mesh/Colored	Spawn (Mesh) performed on this Model	Mesh on Point-Cloud
Mesh/Texture	Spawn (Mesh) performed on this Model	Mesh on polygons
	Number of Polygons	Included in this Model

Table 3 – Symbols and Texts Around the Spawns' Thumbnails

The Mesh type indicated in this symbolic information; ***Colored*** – on Point-Cloud and ***Texture*** – on Polygons, is set, during the creation of the spawn, with the ***Choose spawn type*** drop-down menu which is activated by selecting the ***Spawn*** command-button in the Extra Functions toolbar.

See details in section "The Extra Functions Toolbar" in page 98 below.

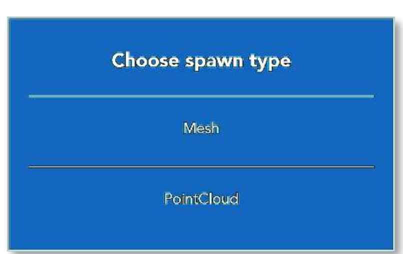


Figure 71 – Choose Spawn Type drop-down menu

Change Items Drop-Down Menu in Spawns Window

There are two (2) option items in the ***Change Items*** drop-down menu (see section "The Change Item Drop-Down Menu" in page **46 above**) requiring special attention:

1. The ***Open in folder*** option will open an error message window, since ***Spawns*** are not files (but records of a database):

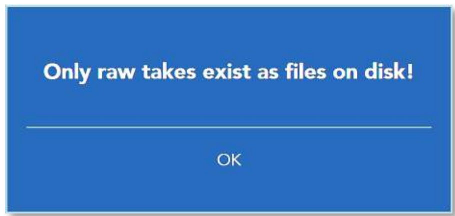


Figure 72 – Error Message for Open in folder Menu Option in Spawns Window

2. The ***Export project*** option is dimmed-out (inactive).

Mouse Functions in 3D Editing

Prior to drilling-down into the details of the **Gallery View Mode – Edit Page**, where the scanned model is being edited, following is a useful table of some mouse practicalities to support the edit act:

Left Key	Right Key	Other	Action
✚			Turns the model/Segment on Y-Axis
	✚		Turns the model/Segment on X-Axis
✚	✚		Drag the model/Segment around
✚		Ctrl	Turns the selected Segment on Z-Axis
✚	✚	Shift	Turns the whole model even if a Segment was selected

Table 4 – Mouse Usage in 3D Editing

Gallery View Mode – Edit (Third) Page

Selection of any thumbnail in **Main Menu – Gallery View Mode – Second Page** will open the file (or records) selected for editing in the **Main Menu – Gallery View Mode – Edit Page** (third page of the **Main Menu – Gallery View Mode**).

The **Edit Page**’s **User Interface (UI)** is built to deal with the specific type of file (or records) to be edited and include only the relevant tools required for processing the scanned objects in their specific status within the process.

For example – Spawns’ images which are restricted to minimal modifications, will be open in an **Edit Page** which does not include most of the editing toolbars and command-buttons since Spawns models are typically not editable.

Therefore, there are two (2) types of **Edit Page**:

1. Edit Page for **Raws** and **Editables**, and
2. Edit Page for **Spawns**.

Both are very similar editing pages only that the **Edit Page for Spawns** include fewer editing tools than the **Edit Page for Raws and Editables**.

The Edit Page for Raws and Editables

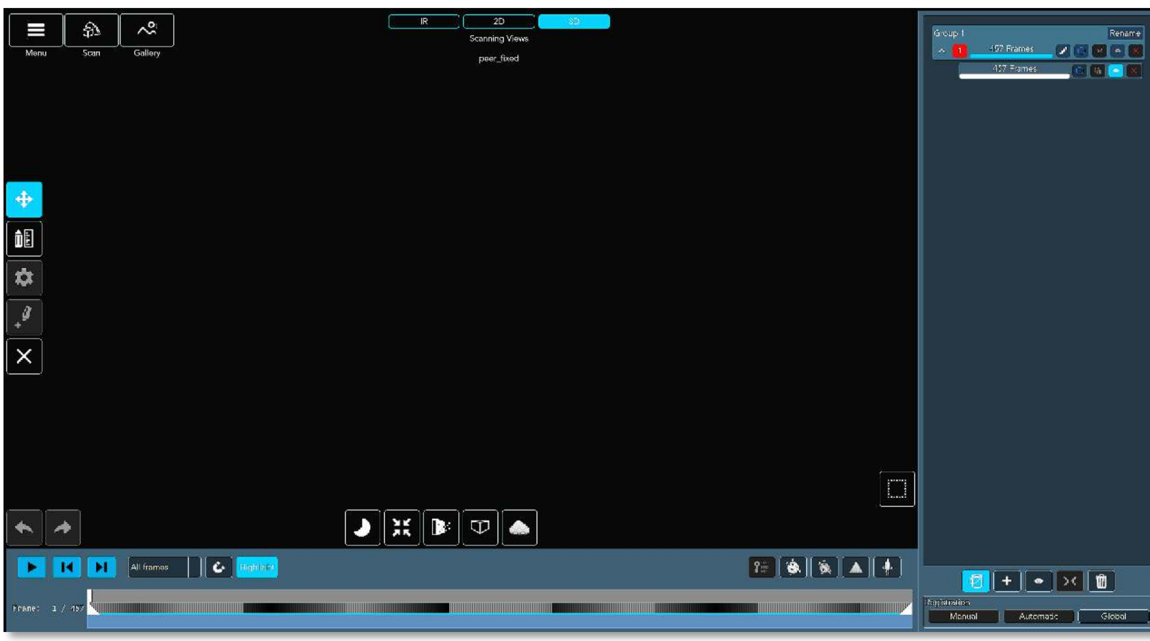


Figure 73 – Edit Page for Raws and Editables

In fact, this is more of a **View Page** than an **Edit Page**. These edit pages are detailed below.

The **Edit Page for Raws and Editables** contains all the toolbars and command-buttons required for all types of editing 3D Point-Clouds.

These include (clockwise, from top-left corner of the screen):

The Main Menu Bar

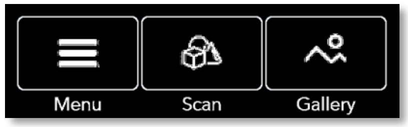


Figure 74 – Edit Page for Raws and Editables – Main Menu Bar

See details of the **Main Menu bar** in paragraph "The Main Bar" in page **45 above**.

The Scanning Views Toolbar

The **Scanning Views** toolbar allows selection of mode of display of the edited files/records from one of the three (3) data layers point-of-view:

1. *IR* – Infra-red (IR) video stream data layer recorded and stored in the *.MVX* file, and/or
2. *2D* – color (RGB) video stream data layer recorded and stored in the *.MVX* file, and/or
3. *3D* – 3D Point-Cloud layer processed out of the IR data and stored in the *.MVX* file.

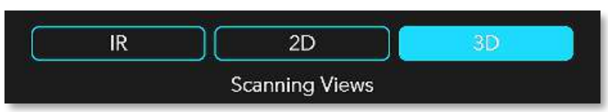


Figure 75 – Edit Page for Raws and Editables – Scanning Views toolbar

These data layers are set to be recorded and stored in the *.MVX* file by the ***Data Layers***' drop-down menu activated with the ***Data Layers*** command-button in the *MVX* menu option of the ***Settings*** toolbar in the ***Main Screen – Scan View*** mode page.

See section "The Settings Toolbar" in page **152 below** for more details.

Command-buttons of data layers not included in the **Project**'s *.MVX* file will not show on the ***Scanning Views*** toolbar.

The Segments Billboard

The vertical ribbon at the right-most side of the screen is used as a billboard presenting every step, in a chronological order, of the editing process.

NOTE: Groups are artificial collections of Segments. Therefore, Groups should be referred to same as Segments.

Figure 76 – Edit Page for Raws and Editables – Segments Billboard

The billboard also allows control over the editing process for each specific step, Group or Segment as well as global editing capabilities.

For these purposes, each step in the process is represented by a Group Action bar.

The **Group Action bar** is a graphic toolbar record-keeping changes made during each step of the edit process and include action (editing) command-buttons as well:

Figure 77 – Segments Billboard – Group Action bar

A new **Group Action bar** is added to the **Segments Billboard** each time a change (edit) is made to the scanned object and saved.

The **Group Action bar** include two (2) types of toolbars:

- The **Group toolbar** – A toolbar with tools required for editing the **Group**:

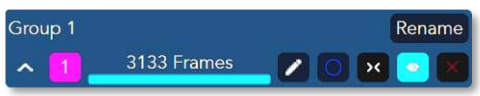


Figure 78 – Segments Billboard – Group Action Bar – Group toolbar

NOTE:	Only one (1) **Group toolbar** may be included in every **Group Action bar**.

The tools included in the **Group toolbar** are:

- Group 1 – is the **Group's Name**:

  By default, this is a **Group** counter generating a default name for a Group with a serial number (i.e. ***Group 1*** in Figure 78 **above**).

  The name set by the counter can be altered to a more expressive name by the:

- Rename – Group's **Rename** command-button:

  Selection of the ***Rename*** command-button opens an ***Enter a New Name*** dialog-box where a new name is over-typed to replace the ***Group Number*** text.

  Once a new name is typed, select the ***OK*** command-button to admit the change or the ***Cancel*** command-button to reject it.

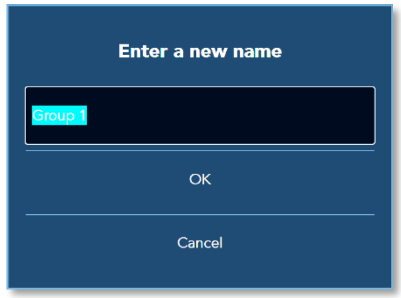


Figure 79 – Enter a New Name dialog-box

NOTE:	While changing the **Group** name there is a need to take in consideration that other editing operations might be affected. *Example:* Ungrouping a Group named ***Group 1*** creates a related **Subordinated Group** – ***Group 1 (1)*** where the relations to the original **Group** is obvious. Using other names might make the relations difficult to understand.

- – **Delete Group** command-button:

  The selected (see item “Group Select command-button” below) **Group** will be erased from the **Project** being processed.

  Selection of the **Delete Group** command-button opens a confirmation drop-down menu:

Figure 80 – Delete Group Confirmation drop-down menu

Select the ***Yes*** command-button to authorize the deletion or the ***No*** command-button to cancel it.

- – **Group View On-Off** command-button:

  The **Group View On-Off** command-button controls whether the selected Group (see item "Group Select command-button" below) will be displayed among other Groups of the scanned subject or not.

- – **Groups Merge** command-button:

  If a **Group** is divided into two (2) or more **subordinated-Groups**, this command-button enables merging them back into the **top-level Group**.

  The Groups need to be selected (see item "Group Select command-button" below) prior to a **Merge** command.

- – **Group Select** command-button:

  This command-button selects a specific **Group** for further editing (see, for example, the above **Delete** and **Merge** operations).

  Once selected, the icon is changed to .

- – **Group Edit** command-button:

  This command-button enables the marked Group to be edited.

- – **Group's Frame Counter**:

  The **Group's Frame Counter** displays the number of 3D Point-Cloud **Frames** included in the **Group**.

  In case the Group was fragmented (**Split**), the counter will show the relative number of Frames included in the selected subordinated-Group.

- – **Group ID**. The **Group ID** is serving two (2) purposes:

  - **Group ID Number** (counter) – for the number of the **Group** being edited within the object.

- **Group Color Identifier** – the **Group ID Number**'s background color (set by the Echo™ software) is used for dyeing the edited Group with a (same) identifying color.

  This Color Identifier may be switched on/off with the **Original Colors command-button** (see section "The Segments Action Toolbar" **below**) to ease the identification within the edited object, as can be seen in Figure 81 below:

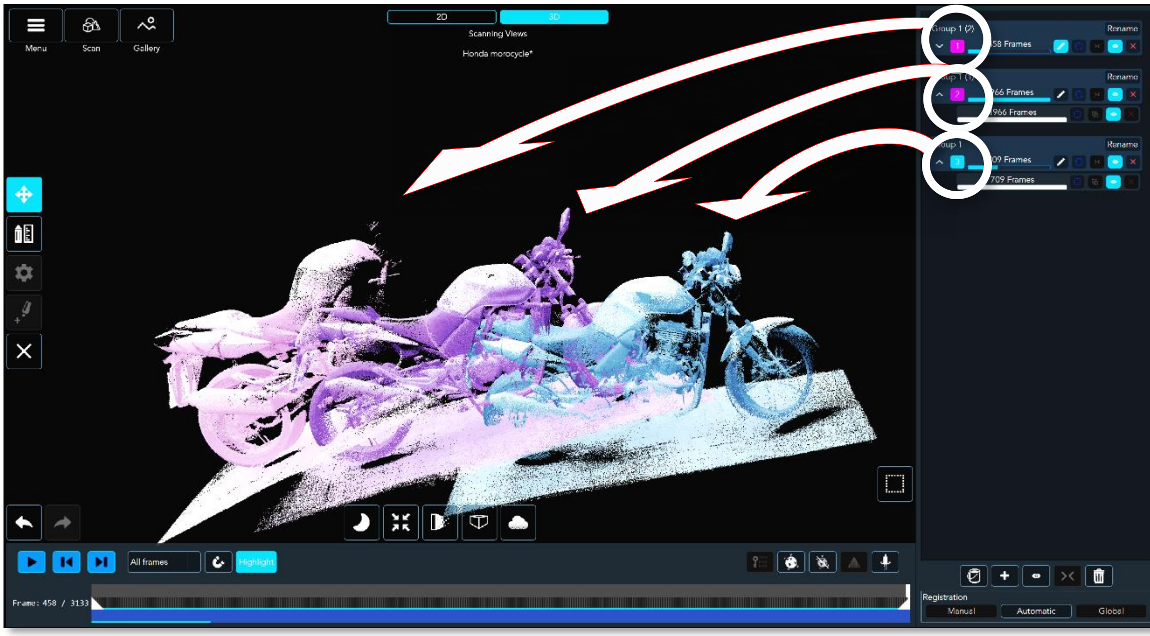


Figure 81 – Group Number's Color used for Group Identification

-  – **Minimize View** command-button:

  This command-button simplifies the displayed information by hiding the **Segments toolbars**. Once in minimized display mode, the tool's icon is changed to . For example, following is a **Group Action bar** in maximum (full) display mode and in minimized display mode:

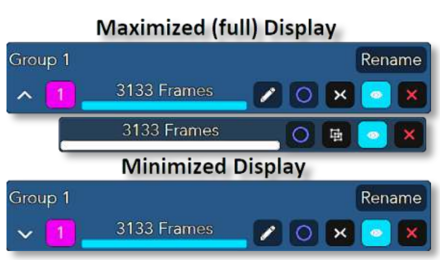


Figure 82 – Maximized (full) Vs. Minimized Group Action Bar Display

- The **Segments toolbar** – A toolbar with tools required for editing the **Segments**:

Figure 83 – Segments Billboard – Group Action Bar – Segments toolbar

NOTE: More than one (1) S**egments toolbar**s may be included in every **Group Action bar** since a **Group** may contain more than one (1) **Segment**. See example in Figure 84 **below**.

Figure 84 – Segments Billboard – Group Action bar with several Segments' toolbars

The tools included in the Segments toolbar are:

- – **Delete Segment** command-button:

  The selected (see item "Segment Select command-button" below) **Segment** will be erased from the **Project** being processed.

  Selecting the **Delete Segment** command-button opens a confirmation drop-down menu:

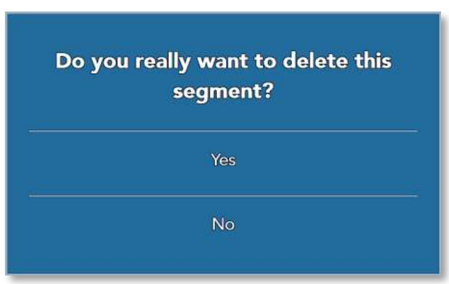


Figure 85 – Delete Segment Confirmation drop-down menu

  Select the ***Yes*** command-button to approve the deletion or the ***No*** command-button to cancel it.

- – **Segment View On-Off** command-button:

  The **Segment View On-Off** command-button controls whether the selected Segment (see item "Segment Select command-button" below) will be displayed among other Segments of the scanned subject or not.

- – **Segments Extraction** command-button – The selected Segment will be extracted into a separate **Group**, thus will get a new **Group ID** number and color.

  The new Group's name will be the source Group's name with additional (***number***) indicating the ID number of the **Source Group** (e.g. ***Group1(1)*** in Figure 86 **below**) as follows:

Figure 86 – Segments Billboard – Group Action Bar – Extracted Group

- – **Segment Select** command-button – This command-button selects a specific **Segment** for further editing (see, for example, the above **Delete** and **Ungroup** operations).

  Once selected, the icon is changed to .

- 363 Frames – **Segments' Frame Counter** – The **Segments' Frame Counter** displays the number of 3D Point-Cloud **Frames** included in the **Segment**.

  In case the Segment was fragmented (**Split**), the counter will show the relative number of **Frames** included in the selected **subordinated-Segment**.

At the bottom of the **Segments Billboard** there are two (2) additional toolbars supporting the different processing actions available for **Segments**:

- **The Segments Action toolbar** – an aggregation of general action tools required for editing purposes, and
- **The Registration toolbar** – providing tools for registration of Segments.

The Segments Action Toolbar

Five (5) general Segments-related tools were aggregated into **Segments Action** toolbar:

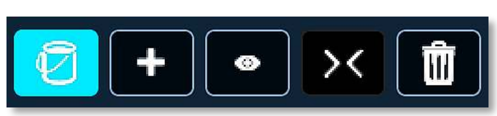


Figure 87 – Segments Billboard – Segments Action toolbar

- – **Original Colors** – This command-button switches the on-screen Groups in-between their original (RGB video based) colors and the ID color (see Figure 81 **above**) committed for the Groups in the Group Action bars.

  It supports the registration process (especially with the **Manual Registration**, see section “The Registration Toolbar” **below**) by providing color distinction tool which helps overlapping the consecutive Groups.

- – **Add New Take** command-button – The Add New Take command-button enables adding Takes to the edited Groups.

  Once selected, the **Add New Take dialog-box** will open (this is, in fact, a reflection of the **Gallery View mode – Second page**):

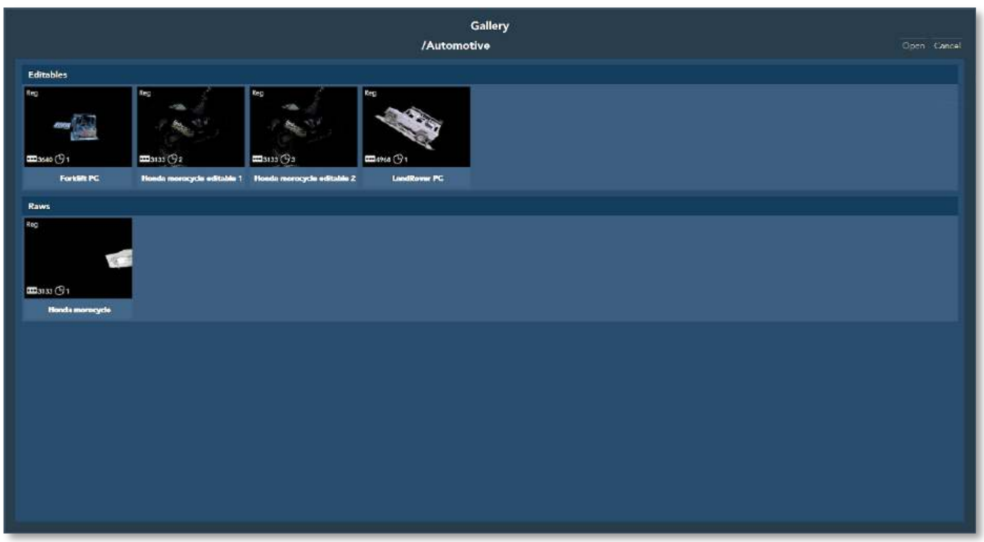


Figure 88 – Segments Action Toolbar – Add New Take dialog-box

NOTE:	**Add New Take** opens the Gallery of the same Project **ONLY**. Takes cannot be added/imported from other Projects utilizing this tool.

The Take to be added need to be highlighted (selected) and the ***Open*** command-button – to be selected (or ***Cancel***, if so needed), to add this Take to the edited Segment.

- – **Toggle Visible** command-button:

The Toggle Visible command-button switches OFF all displayed Groups.

This is a valuable tool for the manual registration cases where there is a need to combine (register) two (2) Groups where the edited object includes many more Groups and the specific two (2) need to be distinguished from the other.

In such a case, the user should **Toggle Visible** (turn OFF) ALL the Groups and then turn ON the required two (2) Groups utilizing the **Group View On-Off** command-button ( ) of the required Groups.

- – **Merge Groups** command-button:

  This is, in fact, a **Forced Registration** operation for the cases where other registration methods were not successful but there is still a need to combine the Groups together as if they were registered.

- – **Delete Small Segments** command-button:

  In many cases, within a scanned Project there will be some Segments with relatively small number of Frames which are typically redundant and include useless information for the final model.

  Such Segments, in most cases, distract the editing process and have nothing to contribute to the final model.

  Therefore, these Segments should better be deleted from the Project.

  The **Delete Small Segments** command-button serves this purpose – when selected, it opens the **Remove Segments with Frame-Count less than** dialog-box:

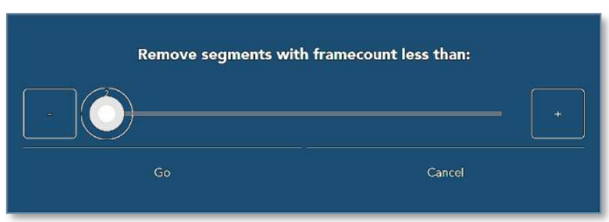


Figure 89 – Segments Action toolbar – Remove Segments with Frame-count less than dialog-box

Using the or the command-buttons or by shifting the trimmer control-button, the minimal number of Frames is set, and the *Go* command-button need to be selected to set the minimal Frames' count of Segments to be left in the scanned object.

The Registration Toolbar

The other toolbar provided within the Segments' Billboard is the **Registration toolbar** which supports the generation of three (3) types of alignment and registration of the scanned object (out of five types total, see section "3D Registration Types" below for details).

Figure 90 – Segments Billboard – Registration toolbar

The registration types supported by this toolbar are:

- **Manual Registration** – Following Online Registration and the attempt to rectify registration issues utilizing the Automatic Registration mechanism (see below), in some cases there is no other option but to manually correct registration mismatches by manual alignment of the Segments one to another.

  The **Manual Registration** is the tool for this purpose.

  The idea is to manually align (overlap) every two (2) Segments, as (visually) close as possible, and let the Echo™ complete the job accurately and "stich" these two (2) Segments together.

  This is done by selecting the two (2) Segments to be registered, moving them around (rotate, tilt, etc.) until they overlap each other and then activate the **Manual Registration** process by selecting the ***Manual*** command-button in the Registration toolbar.

- **Automatic Registration** – Following the Online Registration process, it is recommended to run Automatic Registration.

  Unlike Online Registration which processes the Project frame-by-frame, the **Automatic Registration** process all of the Project's Frames, Segments and Groups together **simultaneously**.

  This **Automatic Registration** will rectify most of the registration issues left-over by the Online Registration and will yield a "cleaner" and better-registered Project for the succeeding editing stages.

- **Global Registration** – This is a special registration process recommended for the final stage of editing the **Project**.

Like the Automatic Registration process, it takes in consideration all the Project's **Frames**, **Segments** and **Groups** but concentrates on fine-tuning the registration between them while fixing special errors like accumulative registration errors etc.

Therefore, no point running this process before the **Project** is fully aligned and registered and built of a single **Segment**.

The Timeline Toolbar

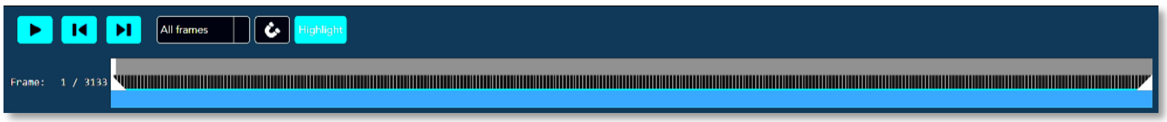


Figure 91 – Edit Page for Raws and Editables – Timeline toolbar

The **Timeline toolbar** presents the process of formation of the Project, correlated with the scan order, in a timely manner and pending the selected **Frames' Display** type:

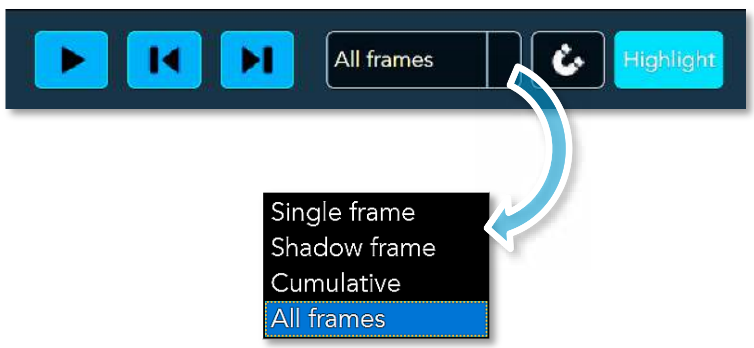


Figure 92 – Timeline Toolbar – Frames' Display Drop-down Menu

Utilizing the **Frames' Display drop-down menu**, the display can be set to present in:

- A **Single Frame** mode – where a single **Frame**, selected by the **Pointer** (see Figure 93 **below**), is displayed individually on the screen.

  This display mode is useful for the cases where a specific **Frame** need to be closely examined.

- A **Shadow Frame** mode – where a single, selected Frame is displayed on screen along with its previous Frame.

  This display mode is useful when in search for mis-registration between **Segments** allowing very fine alignment between the two (2) **Frames** that caused the mis-registration.

- A **Cumulative** mode – where the display is being built-up frame-by-frame.

  This mode is useful where the histogram of the **Project** need examination.
- An **All Frames** mode – a display which include all **Frames** at once.

For precise selection of the **Frames** handled by this toolbar, the timeline provides two (2) mechanisms:

- A **Pointer** – designating to a specific single **Frame** within the entire range of **Frames** included in the object.
- Two **Delimiters** – designating (and limiting) the range of **Frames**, within the entire range of **Frames** included in the object, to be displayed.

Both are dragged into position by the mouse and the text to the left of the timeline details the Frame number pointed to.

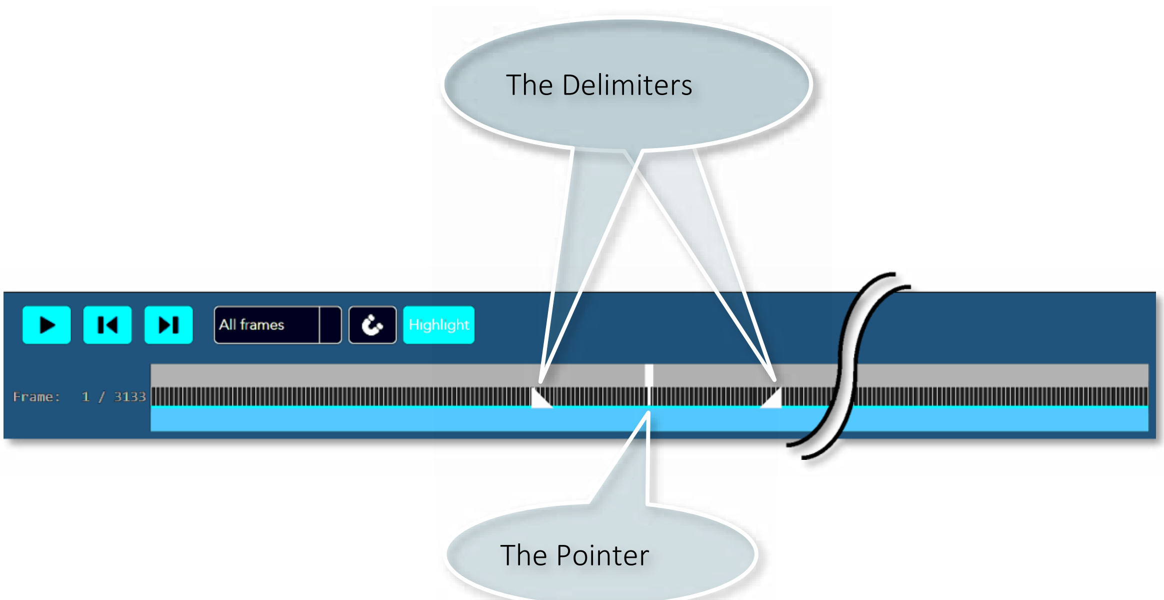


Figure 93 – Timeline toolbar – Pointer and Delimiters

Right-clicking on the **Pointer** opens the **Pointer's Action** drop-down menu:

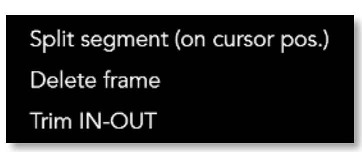


Figure 94 – Timeline toolbar – Pointer's Action Drop-down Menu

The **Pointer's Action** drop-down menu has three (3) action options enabling:

- **Split the Segment** (or Group) on the Pointer's position (Frame), thus allowing a very precise split on a specific Frame.
- **Deleting** the Frame designated by the Pointer.
- Combined with the **Delimiters** (marking a range of Frames) – **trimming** the Frames inside or outside of the **Delimiters**' range.

In addition to the **Timeline**, **Pointer** and **Delimiters** there some other tools available:

-  – **Play** (Run Forward) – Play (run) the display of formation of the Project forward.
-  – **Previous Frame** – Go back one Frame on the Timeline.
-  – **Next Frame** – Go forward one Frame on the Timeline.
-  – **Camera Magnet** – Associates between the 2D (color) on-screen presentation of the Project to the 3D presentation to show the same scene for comparison.
- 

 – **Highlight** the current Frame.

The Noise Removal (Denoise) Act

NOTE:	Theoretical background about Noise Removal methods used in Echo™ can be found in Appendix 7 – 3D Noise Cleaning (Denoise) Types on page **298 below**.

The Echo™ software optionally use two (2) different **Denoise algorithms** for "cleaning-out" the model by the **Denoise Act**:

1. The **MLS (Moving Least Squares) algorithm** – a **smoothing algorithm** which shifts the outlier (noise) points onto a more realistic position, closer to the object's surface, in the Point-Cloud, **but does not remove any of them**.
2. The **SOR (Statistical Outlier Removal) algorithm** – which is a **cleaning algorithm**, completely removing the outlier (noise) points from the Point-Cloud model.

NOTE: Both Denoise algorithms may be used simultaneously, but the process will take much longer to complete.

When activating both Denoise algorithms (in automatic or manual mode), the MLS algorithm **MUST ALWAYS** run first since it shifts the noise points but does not remove any of them, while the SOR algorithm will remove the remaining distant points afterwards.
Denoise may be executed only when the project is completely aligned, merged and fully registered (include only one Segment).

The Extra Functions Toolbar

The **Extra Functions toolbar** resides within the **Timeline** toolbar.

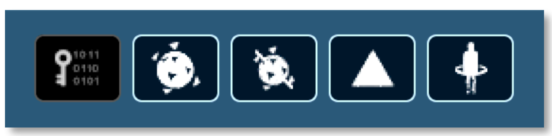


Figure 95 – Edit Page for Raws and Editables – Extra Functions toolbar

This toolbar aggregates five (5) different tools into a single toolbar to support the following functions:

-  – **Decode** (offline) – This tool triggers offline decoding of the originally scanned IR video stream which was not previously decoded online (if so marked in the ***MVX Settings***, see page **155 below**).

-  – **High Quality** (HQ) **Registration** – A general image improvement registration process, usually performed prior to all other registration processes (except for the Online Registration performed throughout the scan).

  The Echo™ software processes ALL of the scanned object's Frames, Segments and Groups together (and not frame-by-frame like the Online Registration) attempting to have them aligned, matched and registered properly.

  During this process, a progress meter is presented:

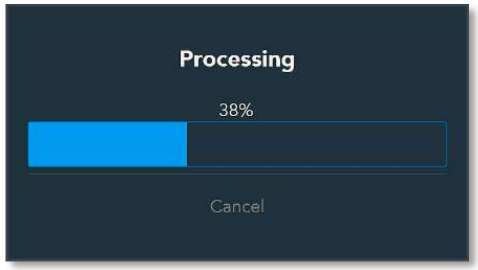


Figure 96 – Extra Functions toolbar – HQ Registration progress meter

NOTE: More information regarding the Registration types available in the Echo™ software can be found in section "3D Registration Types" in page **295 below**.

-  – **Remove Registration** – This tool allows removal of the initial **Online Registration** performed by the Echo™ software during the scan.
-  – **Denoise** – This is the noise removal (**Denoise**) tool.

NOTE: Denoise may be executed only when the project is completely aligned, merged and fully registered (comprised of a single **Segment**).

See backgrounder and explanation on The Noise Removal (Denoise) Act in page **97 above**.

Selecting this command-button and the **Denoise** setup dialog-box opens (see Figure 97 **below**).

In this dialog-box, the specific Denoise algorithm options (**MLS** or **SOR**) need to be selected by marking the associated check-box .

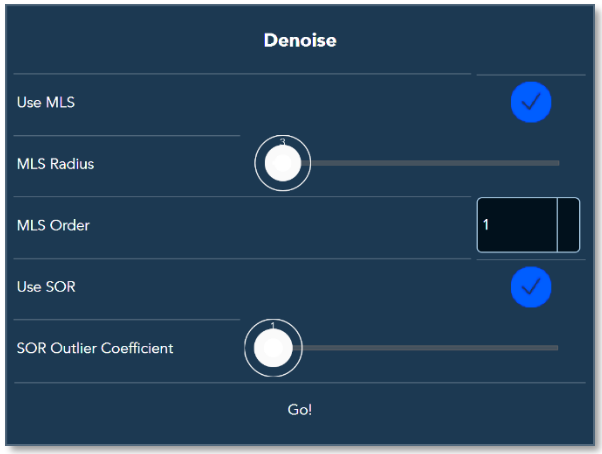


Figure 97 – The Extra Functions toolbar – Denoise Setup dialog-box

NOTE: Both Denoise algorithms may be used simultaneously, but the process will take much longer to complete.

When activating both Denoise algorithms (in automatic or manual mode), the MLS algorithm **MUST ALWAYS** run first since it shifts the noise points but does not remove any of them, while the SOR algorithm will remove the remaining distant points afterwards.

- If the MLS Denoise option was selected, there is a need to:
  - **Define MLS Radius** by dragging the trimmer control-button to the desired value (displayed above the trimmer control-button), and
  - **Define the MLS Order** by selecting first (1st) order or second (2nd) order (see backgrounder regarding MLS Order in page **97 above**) from the drop-down menu.
- If SOR Denoise option was selected, there is a need to set the **SOR Outlier Coefficient** value by dragging the trimmer's control-button to the desired value (displayed above the trimmer control-button).

  SOR Outlier Coefficient assumes that the value of 1 is closer to the target and the value of 10 is distant from the target.

Under normal conditions the value of the SOR Outlier Coefficient should be between one (1) and three (3).

Once set, select the ***Go!*** command-button to execute. A progress meter will open to show the processing progression (this might take a while…) and the result will be displayed at the end of the process.

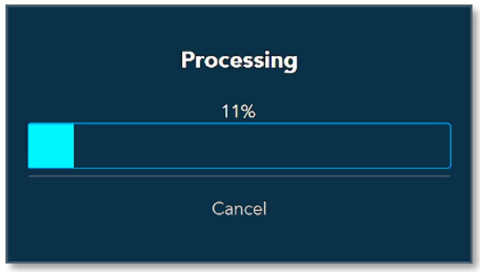


Figure 98 – The Extra Functions toolbar – Denoise progress meter

-  – Spawn – The Spawns are the 3D scan operation resulting models.

Following the scan operation and the different edit operations explained herein, all aimed towards building a single-segment 3D Point-Cloud model, and in order to give this model life-like appearance as well as preparing it for the final usage (i.e. export to other 3D applications, 3D printing, etc.), including a major reduction of the model file size, there is a need to wrap-up the model and cover it with solid surfaces before exporting it to the next step of processing.

This is achieved by the Mesh operation and the resulting files are presented in the Projects' Spawn Window (see page 80 above).

NOTE:	Spawns can be created only when the Project is fully aligned, merged and registered (comprised of a single Segment).

Selecting the ***Spawn*** command-button and the ***Enter Spawn Name*** dialog-box opens:

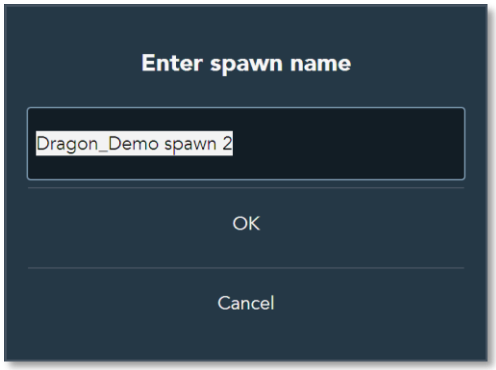


Figure 99 – The Extra Functions toolbar – Enter Spawn Name dialog-box

A default name for the new Spawn model, derived out of the original Project's name, is provided but may be over-written to a more meaningful name within the Name field.

It needs to be approved by selecting the ***OK*** command-button. There is also the option to cancel this operation by selecting the ***Cancel*** command-button.

Once approved, the type of the Spawn should be selected in the ***Choose Spawn Type*** drop-down menu that opens:

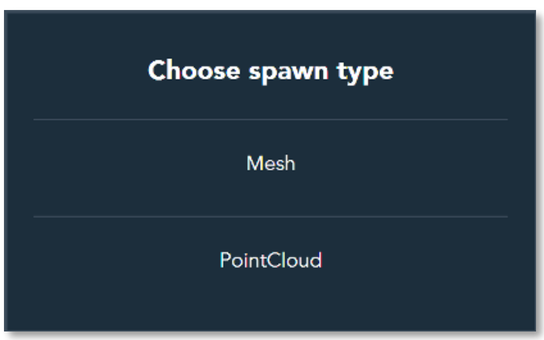


Figure 100 – The Extra Functions toolbar – Choose Spawn Type drop-down menu

There are two (2) type options available in Echo™ to select from:

- Mesh – Where the 3D Point-Cloud model will be "covered" by a "skin" of polygons.

The polygons color will be derived out of the recorded RGB video stream.

- **Point-Cloud** – Where the original 3D Point-Cloud model will be "painted" with colors derived out of the recorded RGB video stream.

Creation of Mesh Spawns

Once the **Mesh Spawn** option is selected (in the ***Choose Spawn Type*** drop-down menu, see Figure 100 **above**), **Mesh Creation Setup dialog-box** opens (see Figure 101 **below**).

The ***Quality Preset*** option should be set **FIRST** since it will govern the structure and offering of options of the **Mesh Creation Setup dialog-box**.

The ***Quality Preset*** drop-down menu presents four (4) quality options, divided into two (2) groups:

- The **Default (Standard) Quality Mesh Spawns** – which include three (3) preset options: ***Low***, ***Medium*** and ***High*** (different **Poisson Depth** values, see details in section "Creation of Default (Standard) Quality Mesh Spawns" below), and
- The **Custom Quality Mesh Spawns** – where the **Mesh Creation Setup dialog-box** expands to include more settings options.

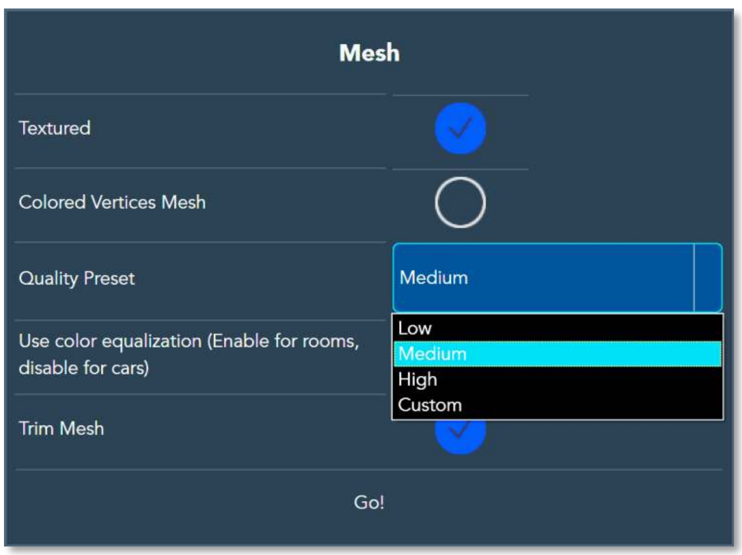


Figure 101 – Mesh Spawn Setup dialog-box – Quality Preset drop-down menu

The following two (2) sections details these two (2) ***Quality Preset*** options:

Creation of Default (Standard) Quality Mesh Spawns

Once any of the three preset quality options (***Low***, ***Medium*** and ***High***) was selected, the **Mesh Creation Setup dialog-box** is shaped to its simple format:

Figure 102 – The Extra Functions toolbar – Default Mesh Quality Setup dialog-box

- Select, by marking the appropriate check-box, if a ***Textured Mesh*** or ***Colored Vertices Mesh*** should be created.
- From the ***Quality Preset*** drop-down menu, select ***Quality Preset – Low*** which represent **Poisson Depth** preset value of eight (8), or ***Quality Preset – Medium*** which represent the preset value of nine (9) or ***Quality Preset – High*** which represent the preset value of ten (10).

  The **Poisson Depth** value determines the resolution in which the vertices and polygons will be calculated – the higher the value is set to, the higher resolution will be used, meaning – the vertices and polygons will be smaller.

  But, take in considerations that for smaller vertices and polygons many more of them will be required to complete the model while more time and computational resources will be essential to process the data.
- Select, by marking the check-box, if ***Color Equalization*** need to be used in the Mesh calculations.
- Select, by marking the check-box, if the ***Mesh*** need to be ***Trimmed***.

Once all the above parameters are set, select the ***Go!*** command-button to execute the Mesh compilation.

A ***Processing*** progress meter will be displayed to report the progress of the Meshing calculation:

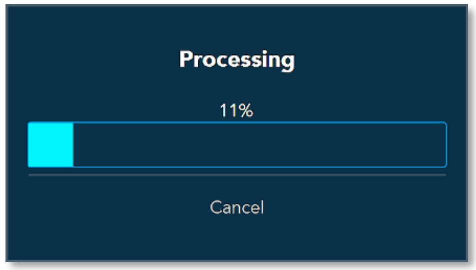


Figure 103 – Extra Functions toolbar – Default Mesh Quality progress meter

As soon as the process is complete, the ***Spawn Created and Saved in Gallery*** message-box will be presented:

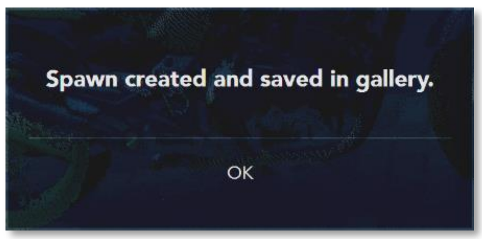


Figure 104 – The Extra Functions toolbar – Spawn Created and Saved dialog-box

The final Meshed model can be found under The Projects' Spawns Window (see details in page 80 above).

Select the ***OK*** command-button to complete this process.

Creation of Custom Quality Mesh Spawns

Once the ***Custom*** quality option was selected, the Mesh Creation Setup dialog-box is shaped to its more complex format:

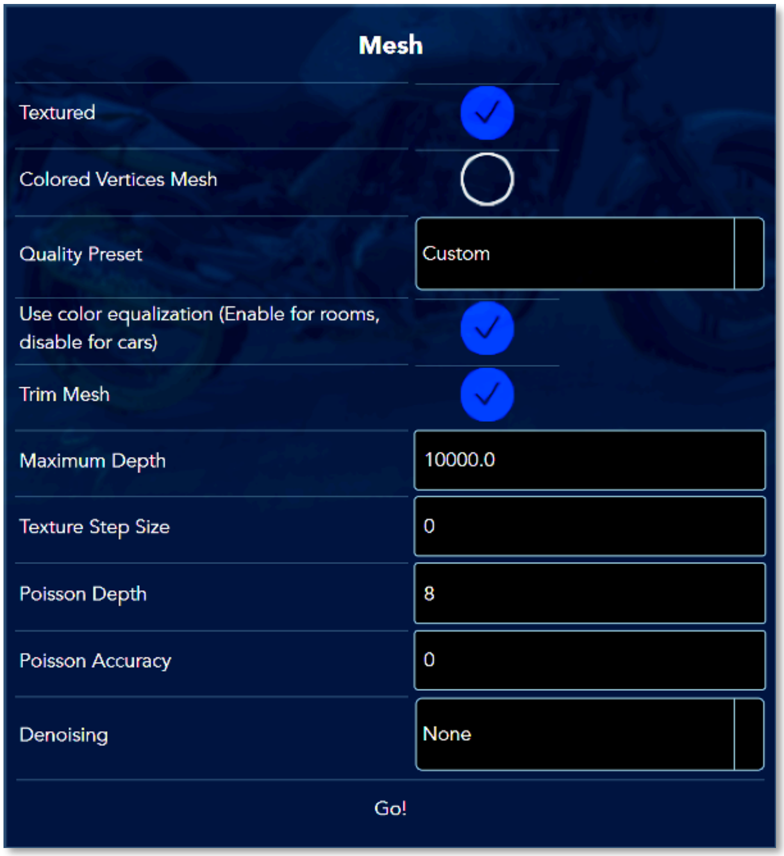


Figure 105 – The Extra Functions toolbar – Custom Mesh Quality Setup dialog-box

- Select, by marking the appropriate check-box, if a ***Textured Mesh*** or ***Colored Vertices Mesh*** is needed.
- The ***Quality Preset*** was already set to ***Custom*** for this case.
- Select, by marking the check-box, if ***Color Equalization*** need to be used in the Mesh calculations.
- Select, by marking the check-box, if the ***Mesh*** need to be ***Trimmed***.
- Set the ***Maximum Depth*** parameter.
- Set the ***Texture Step Size*** parameter. This parameter sets how will the RGB video frames be applied onto the polygons in the coloring process.

  The values of this parameter are the number of frames in the RGB stream to be sampled and applied onto each polygon (i.e. the value of five (5) means that every fifth RGB frame is to be sampled and processed for coloring the corresponding polygon).

The default value for this parameter is zero (0) meaning – every RGB frame is processed to color the corresponding polygon.

Recommended values are five (5) and ten (10).

- Set the ***Poisson Depth*** parameter.

  The ***Poisson Depth*** value determines the resolution in which the vertices and polygons will be calculated – the higher the value is set to, the higher resolution will be used, meaning – the vertices and polygons will be smaller.

  Take in considerations that for smaller vertices and polygons many more of them will be required to complete the model while more time and computational resources will be essential to process the data.

- Set the ***Poisson Accuracy*** parameter.
- From the ***Denoising*** drop-down menu, select if Denoising should be done (the ***Quality*** option) to the Point-Cloud prior to the Meshing or not (the ***None*** option).

Once all the above parameters are set, select the ***Go!*** command-button. The ***Processing*** progress meter will be displayed to report the progress of the Meshing process.

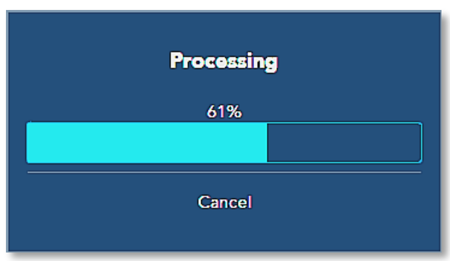


Figure 106 – Extra Functions toolbar – Custom Mesh Quality progress meter

As soon as the process is complete, the ***Spawn Created and Saved in Gallery*** message-box will be presented:

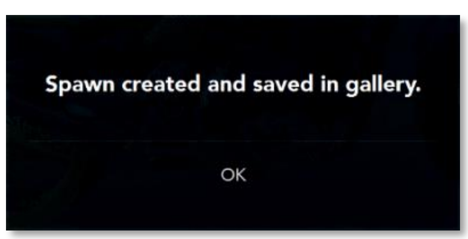


Figure 107 – The Extra Functions toolbar – Spawn Created and Saved dialog-box

The final Meshed model can be found under The Projects' Spawns Window (see details in page **80 above**).

Select the ***OK*** command-button to complete this process.

Creation of Point-Cloud Spawns

Spawns can also be created in a Point-Cloud format.

This is done by creating, out of the single **Segment** (following all edit actions required) Point-Cloud mesh look-alike model made of **Vertices** and colored by the RGB video stream data derivatives, to make it real-life look-alike.

The resulting model, even if in Point-Cloud format, is stored in The Projects' Spawns Window (see details in page **80 above**) and cannot be edited.

Once Point-Cloud Spawn option is selected in the ***Choose Spawn Type*** drop-down menu (see Figure 100 in page **102 above**), the **Point-Cloud Mesh Setup dialog-box** will open:

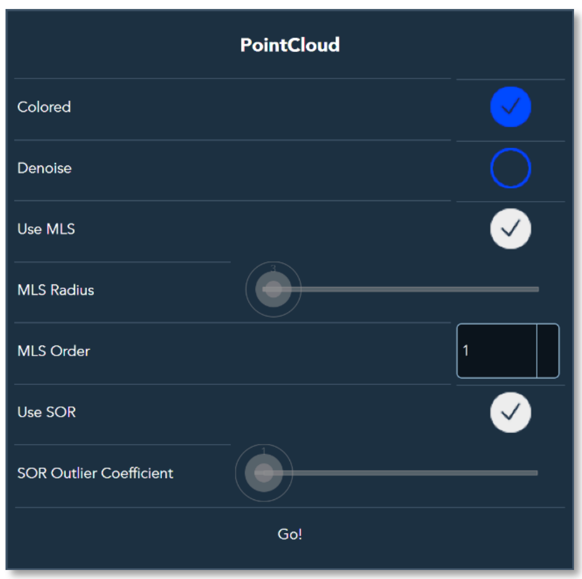


Figure 108 – The Extra Functions toolbar – Point-Cloud Mesh Setup dialog-box

The following parameters need to be set:

- Select, by marking the check-box , if the ***Mesh*** need to be ***Colored***.

  In case the Point-Cloud was not Denoised previously:

- Select, by marking the check-box , if ***Denoise*** need to be performed, prior to the Meshing process.

See backgrounder and explanation on The Noise Removal (Denoise) Act in page **97 above**.

In case Denoise was selected:

- The specific Denoise algorithm options (**MLS** or **SOR**) need to be selected by marking the associated check-box.

> **NOTE:** Both Denoise algorithms may be used simultaneously, but the process will take much longer to complete.

- If the MLS Denoise option was selected, there is a need to:
  - **Define the MLS Radius** by dragging the trimmer's control-button to the desired value (displayed above the trimmer's control-button), and
  - **Define the MLS Order** by selecting first (1st) order or second (2nd) order (see backgrounder regarding MLS Order in page **97 above**) from the drop-down menu.
- If **SOR Denoise** option was selected, there is a need to set the **SOR Outlier Coefficient** value by dragging the trimmer's control-button to the desired value (the value is displayed above the trimmer's control-button).

  SOR Outlier Coefficient assumes that the value of one (1) is closer to the target and the value of ten (10) is distant away from the target. Under normal conditions the value of the SOR Outlier Coefficient should be between one (1) and three (3).

Once all parameters are set, select the ***Go!*** command-button to apply and execute.

A progress meter will open to show the process progression (this might take a while especially if Denoise was selected).

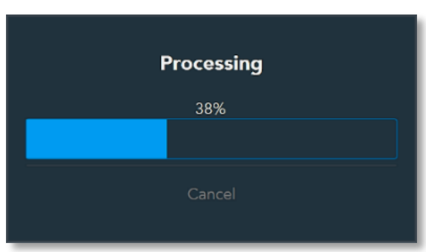


Figure 109 – Extra Functions toolbar – Point-Cloud Mesh Creation progress meter

As soon as the process is complete, the ***Spawn Created and Saved in Gallery*** message-box will be presented:

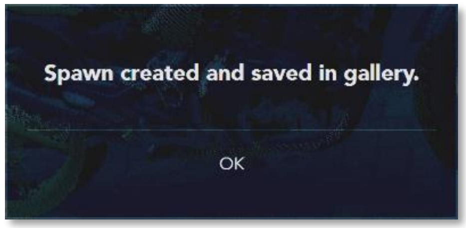


Figure 110 – The Extra Functions toolbar – Spawn Created and Saved dialog-box

The final Meshed model can be found under The Projects' Spawns Window (see details in page **80 above**).

Select the ***OK*** command-button to complete and terminate this process.

The Selection Toolbar

At the bottom-right side of the **Gallery View Mode – Edit Page** there is one of the most useful command-buttons of the Echo™, used to open a toolbar for the selection of slices of the model, mainly for deleting of surplus data.

Figure 111 – Gallery View Mode – Edit Page – The Selection command-button

Once selected, the **Selection toolbar** will open (see Figure 112 **below**).

This toolbar includes eight (8) selection tools (command-buttons):

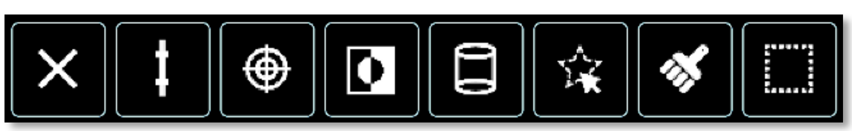


Figure 112 – Gallery View Mode – Edit Page – The Selection toolbar

These tools (command-buttons) are:

-  – **The *Rectangle* Cut command-button** – which enable selection and cutting of a rectangle-shaped portion, out of the 3D model.

A presentation of this tool's action is provided in Figure 113 **below**:

❶ – is the original object to process.

❷ – is the rectangle drawn (utilizing the mouse) over the object.

❸ – is the rectangle selected (following the draw act).

❹ – is the rectangle portion cut-out of the object.

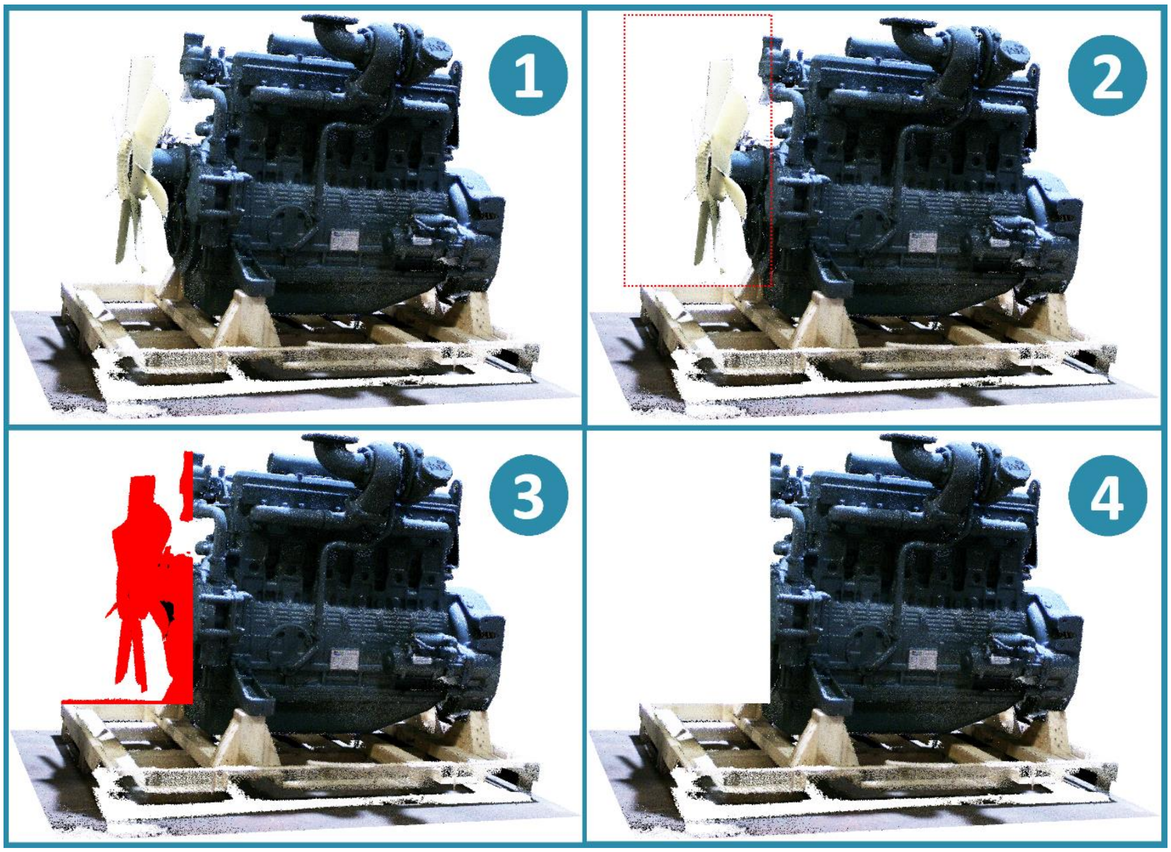


Figure 113 – Selection toolbar – Rectangle Shape Select and Cut

Once the rectangle is selected, to cut it out – select the ***Delete Selection*** command-button available in the ***Measurement*** toolbar (see page **130 below**).

-  – **The *Spray* command-button** – which enables cutting Airbrush-shaped slice.

The ***Spray*** tool is functionally equivalent to the airbrush tool used by most image processing software applications.

Such a tool is mainly used for drawing soft areas of color and retouching purposes.

It is a software tool emulating an old hand-held painting tool (Airbrush) which used compressed air to spray ink.

The shape created by the ***Spray*** tool contains thick center layer fading out towards its edges thus marking a blurred border portion.

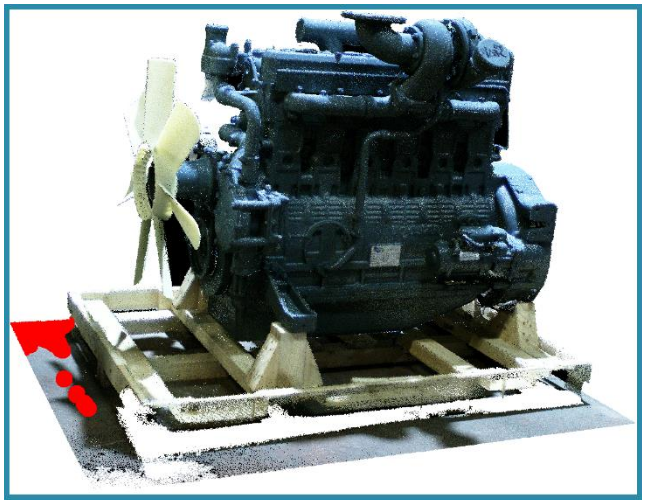


Figure 114 – Selection toolbar – Spray Shape Select and Cut

Once the required shape is selected, to cut it out – select the ***Delete Selection*** command-button of the ***Measurement*** toolbar (see page 130 below).

-  – The *Freehand* command-button – which enables selecting and cutting-out a free-drawn shape portion of the model.

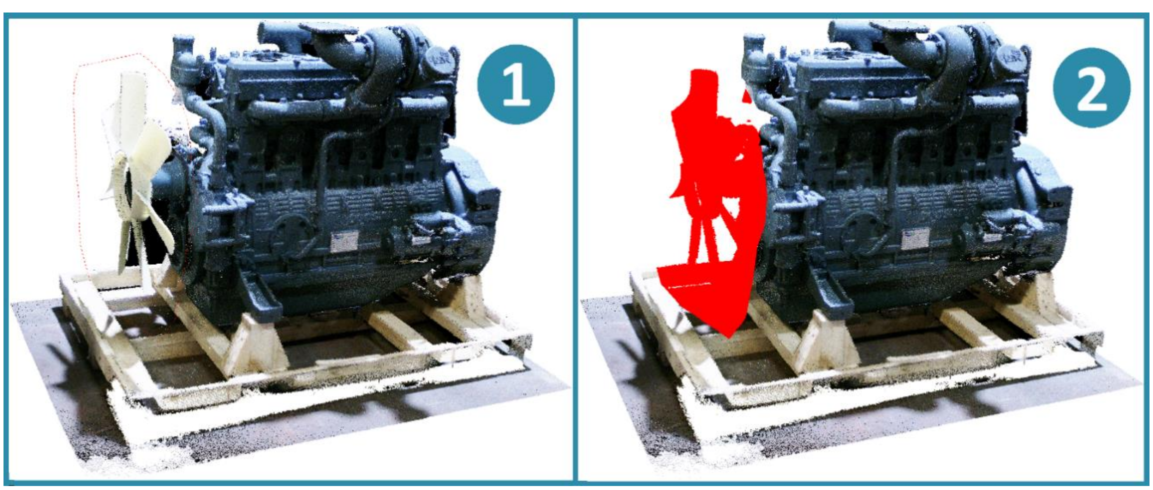


Figure 115 – Selection toolbar – Freehand Shape Select and Cut

A presentation of how this tool is functioning is provided in Figure 115 **above** and include:

❶ – is the free-drawn shape over the object (same item used as in Figure 113 **above**).

❷ – is an emphasis of the selected free-drawn portion (following the above drawing step).

Once the shape is drawn and selected, select the ***Delete Selection*** command-button available in the ***Measurement*** toolbar (see page **130 below**) to delete it of the image.

-  – **The *Cylinder* command-button** – which enables selecting and cutting a cylinder-shaped portion.

  A cylinder-shaped cutting tool is useful in cases where there is a need to isolate and delete a rod-style obstacle (e.g. a person standing in the middle of a scanned room).

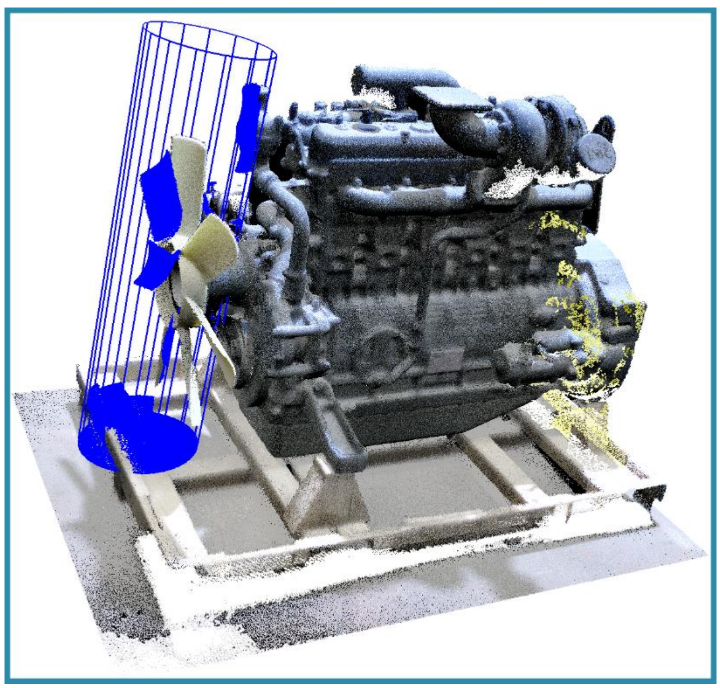


Figure 116 – Selection toolbar – Cylinder Shape Select and Cut

Once the ***Cylinder*** command-button is selected, a cylinder-shaped “enclosure” will be displayed over the object.

The cylinder size (length and diameter), as well as its position and direction, can be altered utilizing the mouse.

Once the cylinder is set to cover the required area, the ***Apply*** command-button  (added for this purpose below the ***Cylinder*** command-button) should be selected to apply and execute the cut.

-  – The *Invert* command-button – which enables inversion of the selected portion by any of the above-described selection tools (***Rectangle***, ***Spray***, ***Freehand*** and ***Cylinder***).

  Once any of these tools is used to mark the desired portion for cut, this selection can be inverted.

  Inversion, in this case, means that instead of cutting out the points incorporated in the marked portion of the Point-Cloud, the remaining points (incorporated outside the marked portion) will be cut out.

  The purpose of this tool is to allow the user to decide which part will be cut out and which will remain in the image.

  For example – using the ***Rectangle*** select and cut tool presented in Figure 113 (page 111 above), while subsequently selecting the ***Invert*** command-button, causes the selected portion (marked as ❸ in Figure 113 and in Figure 117 below) and the resulting cutout (marked as ❹ in Figure 113 and in Figure 117 below) to look like:

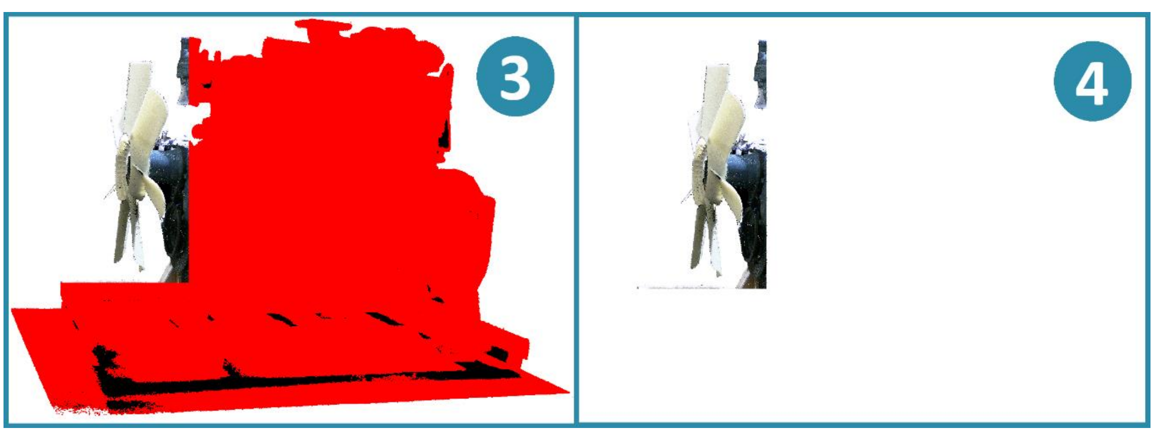


Figure 117 – Selection toolbar – Rectangle Shape Select and Invert

-  – The *Accuracy* command-button – same as selecting and cutting with the above-described graphic tools, there is also an option to mark a selected type of points, within the Point-Cloud, by specifying some 3D data information types of these points.

A perfect example would be the **Accuracy Filter** activated by selecting the ***Accuracy*** command-button.

Within the characterizing data of the points (XYZ Cartesian coordinates, RGB values, etc.), there is a special data item regarding the point's description called **Accuracy**.

The **Accuracy Value** is a statistical analysis figure resulting from the calculation of how accurate this point should be considered.

The **Accuracy Value**, for example, take in considerations an **estimated depth error** value whereas a point sampled near the camera's scanning range limits will get a much lower score then a point sampled at the camera's ultimate focal point.

The **Accuracy Filter**, activated by the ***Accuracy*** command-button, allow the user to specify a spectrum of 'accuracies' which need to be cut-out (or remain, if activated combined with the above-mentioned ***Invert*** command-button).

Figure 118 – The Selection toolbar – Accuracy trimmer

The filter's spectrum should be specified by dragging the trimmer's control-buttons (minimum and maximum) to the desired accuracy percentage (%) values.

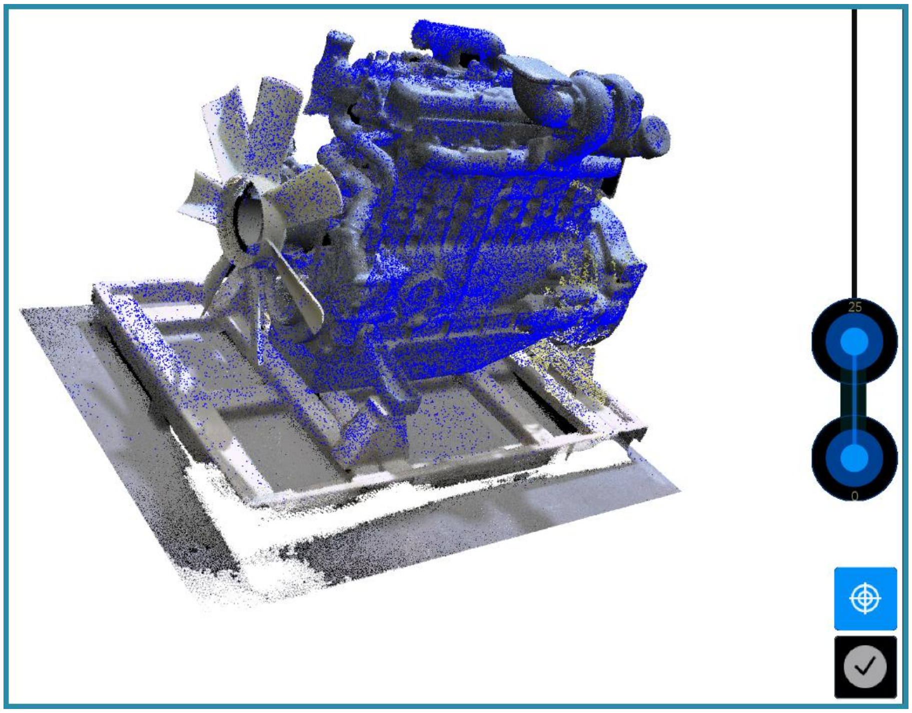


Figure 119 – The Selection toolbar – Accuracy Trimmed to 0÷25%

In the above example, the **Accuracy Value**s were set to zero (0) upto twenty-five (25) percent (%).

The blue-painted points on the object indicates that the low accuracy-probability points (0-25%) of the object were selected.

Once these values are set, select the ***Apply*** command-button  (added for this purpose below the ***Accuracy*** command-button) to apply and execute the cut.

-  – **The *Range* command-button** – same as selecting and cutting with the above-described graphic tools, there is also an option to mark a selected type of points, within the Point-Cloud, by specifying some 3D data information types of these points.

  Same as with the above-described **Accuracy Filter**, there is also an option to set a **Range Filter**.

  This filter specifies a range of distances from the scanning camera position, within (or out of, if used in conjunction with the ***Invert*** command-button) which the filter-matching points need to be cut-out.

The **Range Filter** is activated by the ***Range*** command-button:

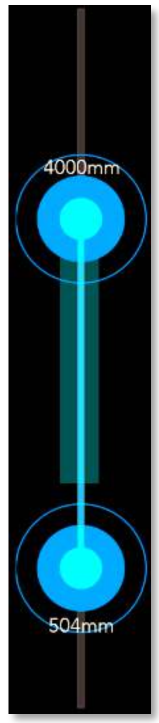


Figure 120 – The Selection toolbar – Range – Range trimmer

The filter's margins should be specified by dragging the trimmer's control-buttons (minimum and maximum) to the desired values (in millimeters).

For example; following is an object with ***Range*** boundaries set to 200÷726mm:

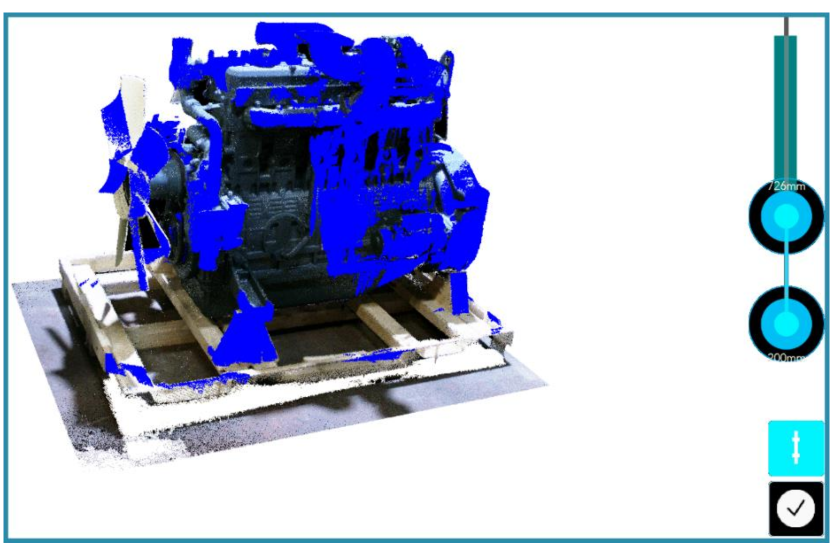


Figure 121 – The Selection toolbar – Range Trimmed to 200÷726mm

All points which are within the 200mm to 726mm range from the camera's stand-point are selected (marked with blue color).

Once these values are set, select the ***Apply*** command-button  (added for this purpose below the ***Range*** command-button) to apply and execute the cut.

Same as all other **Selection Tools** described above, this filter could be used in conjunction with the ***Invert*** command-button to specify if the points within the range or out of the range should be cut-out.

-  – **The *Deselect* command-button** – used for cancelation of Selection Tools activated with the added ***Apply*** command-button (e.g. ***Cylinder***, ***Accuracy***, ***Range***).

3D Navigation of the Displayed Object

Before proceeding to the next subject of **Display Control**, there is a need to understand how to 3D navigate the object on the display.

3D navigation includes:

- **Moving** (sometime referred to as **Dragging**) the object.
- **Rotating** the object.
- **Zooming** (display scaling) the object.

For the users' convenience most of the navigation control is done utilizing the mouse, its button-switches and its scrolling-wheel.

To control the use's perspective in the **Gallery View Mode – Edit Page** by moving or rotating the observation point, or by zooming in or out, use the mouse to control these effects as follows:

- **Move/Drag** – click on the object's image to select it, hold-down **both** left and right mouse-buttons and drag the image to the desired position.
- **Rotation**:
  - **In X-Axis** – click on the object's image to select it, hold-down the left mouse-button and slide the mouse horizontally.
  - **In Y-Axis** – click on the object's image to select it, hold-down the left mouse-button and slide the mouse vertically.
- **Zoom In/Out** – click on the object's image to select it and with the mouse scrolling-wheel zoom the object's image in and out.

The Display Control Toolbar

The **Display Control toolbar** sets the best screen viewing options.

It includes five (5) command-buttons, four (4) out of which will open, upon selection, their own toolbar:

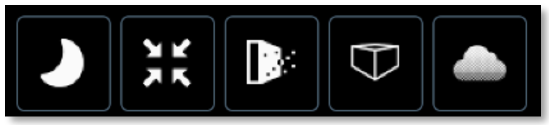


Figure 122 – Gallery View Mode – Edit Page – Display Control toolbar

The command-buttons included are:

-  – **The *Rendering Setup* command-button** – the ***Rendering Setup*** command-button controls the rendering of the object's image thus supports finding the proper blend between the geometry and texture of the scan.

  Selecting this command-button open the **Rendering Setup** toolbar:

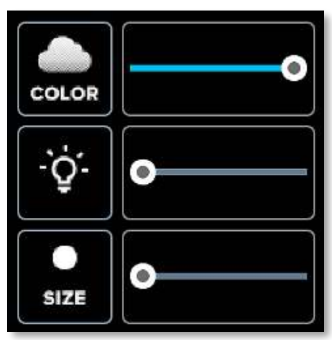
  

  Figure 123 – Gallery View Mode – Edit Page – Rendering Setup toolbar

  The Rendering Setup toolbar allow, by means of trimmers, control of:

  - **Points'** (of the whole object) **Visible Size**
  - **Points'** (of the whole object) **Intensity**, and
  - **Points'** (of the whole object) **Color** (saturation of color).

-  – **The *Projection Mode* command-button** – the ***Projection Mode*** command-button controls the way the object will be projected to the user.

> **NOTE:** The object need to be aligned to the reference ***Ground*** (see page **122 below**) PRIOR TO the settings of the ***Projection Mode***.

Selecting this command-button open the ***Projection Mode*** toolbar:

Figure 124 – Gallery View Mode – Edit Page – Projection Mode toolbar

The ***Projection Mode*** toolbar include three (3) command-buttons, two (2) out of which open their own toolbar.

-  – **The *Perspective* command-button** – the Perspective command-button controls the viewpoint at which the object will be presented by creating an illusion of 3D perspective – nearer objects will appear bigger.
-  – **The *Perspective Direction* command-button** – on top of the perspective set by the above-mentioned ***Perspective*** command-button, the ***Perspective Direction*** command-button sets the direction in which the set perspective will be presented (e.g. from Top, from Right, etc.).

> **NOTE:** The object need to be aligned to the reference ***Ground*** (see page **122 below**) PRIOR TO the settings of the ***Perspective***, ***Perspective Direction*** and the ***Orthogonal*** viewing modes.

Selecting the ***Perspective*** command-button and the ***Perspective Direction*** toolbar opens:

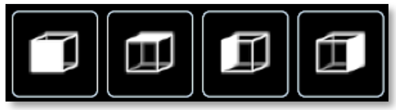


Figure 125 – Gallery View Mode – Edit Page – Perspective Direction toolbar

The *Perspective Direction* toolbar include four (4) command-buttons:

-  – The *Perspective Front* command-button – presents the object, in perspective mode, from its FRONT side.
-  – The *Perspective Top* command-button – presents the object, in perspective mode, from its TOP side.
-  – The *Perspective Left* command-button – presents the object, in perspective mode, from its LEFT side.
-  – The *Perspective Right* command-button – presents the object, in perspective mode, from its RIGHT side.

-  – The *Orthogonal* command-button – the ***Orthogonal*** command-button switches the display mode to Orthogonal view mode where all points are displayed using the same scale.

-  – The *Widgets* command-button – the ***Widgets*** command-button sets two (2) reference items of the object's image – the reference ***Ground*** and the reference ***Center of Rotation***.

Selecting the ***Widgets*** command-button open the **Widgets Setup** toolbar:

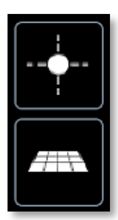


Figure 126 – Gallery View Mode – Edit Page – Widgets Setup toolbar

The **Widgets Setup** toolbar include two (2) command-buttons for settings two (2) fundamental reference items:

-  – **The *Ground* command-button** – setting a reference ***Ground* Plane**

  The ***Ground* Plane** simplifies the work in 3D environment by providing a reference plane on which, allegedly, the scanned object is "standing".

  During the online decoding phase of the scan, the algorithm uses the scan starting-point as the reference ***Center of Rotation*** and from there, also calculates the Preliminary ***Ground*** Plane.

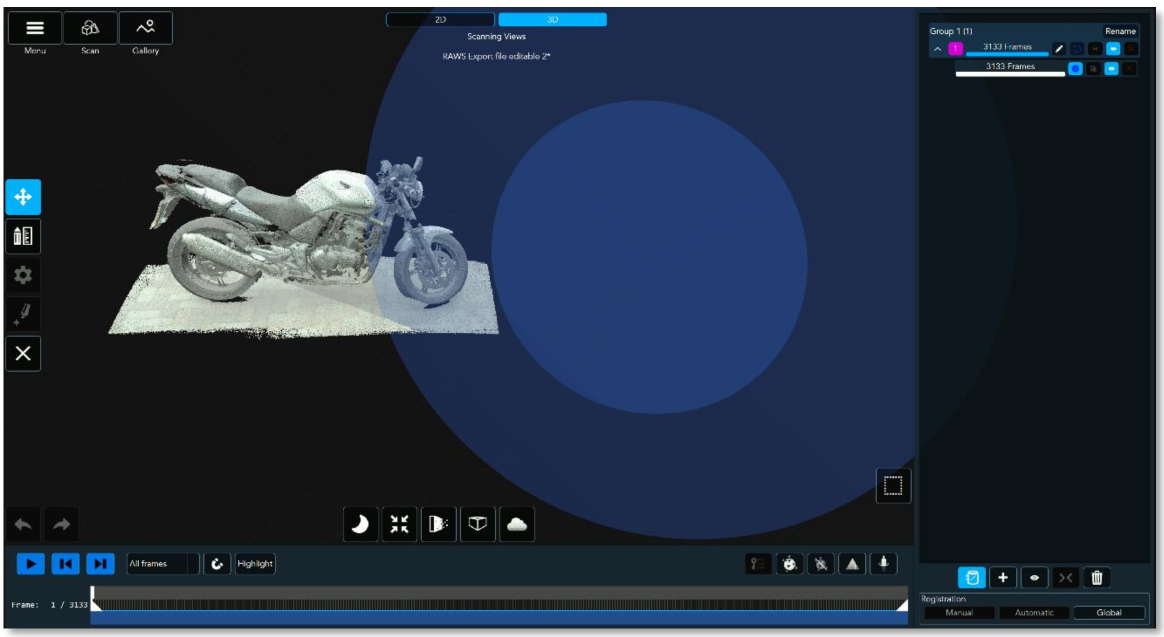


Figure 127 – Gallery View Mode – Edit Page – Preliminary Ground Plane

Ground Settings is activated by selecting the ***Ground*** command-button from the **Widgets toolbar**.

Once activated, a **Preliminary Ground Plane** will be displayed (see Figure 127 **above**) behind the scanned object.

Shift it onto a more practical position – **Move**/**Rotate**/**Zoom** the object's image together with the **Preliminary Ground Plane** (see section "3D Navigation of the Displayed Object" in page 118 **above**) as demonstrated in Figure 128 **below**.

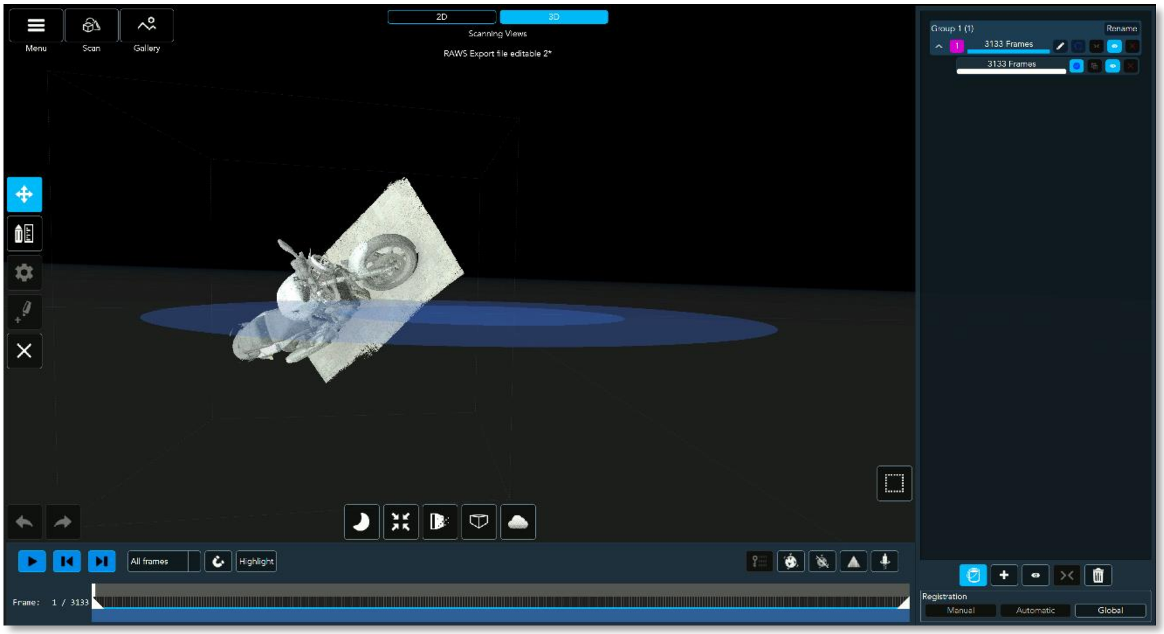


Figure 128 – Gallery View Mode – Edit Page – Ground Plane Positioned

To align the object's image to the **Ground Plane**:

I. Select the **Segment** to be aligned by selecting the appropriate **Group Edit** command-button () from the **Segments Billboard**,

II. **Move**/**Rotate**/**Zoom** the image until it is aligned over the **Ground Plane** (see Figure 129 **below**) properly.

NOTE:	**Ground Settings** does not require the object's model to be fully aligned, registered and made of a single Segment/ Group. The settings could be done separately for each Segment/ Group/Frame.

Once aligned, the image will remain aligned for the rest of the edit process.

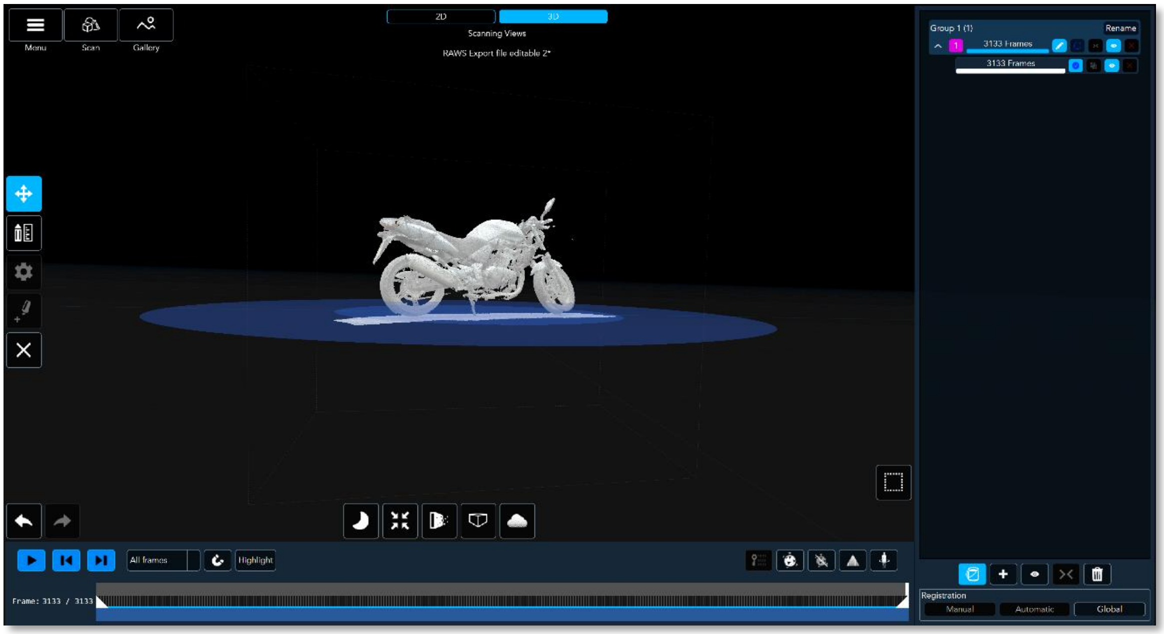
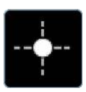


Figure 129 – Gallery View Mode – Edit Page – Object Aligned to Ground Plane

-  – The *Center of Rotation* command-button – setting a *Center of Rotation* simplifies the work in 3D environment by providing a reference coordinate system which, allegedly, the scanned object is “aligned to”.

  The origin of these coordinates (the origin of a Euclidean space is a special point used as a fixed point of reference for the geometry of the surrounding space) is the 3D Object’s image *Center of Rotation*.

  During the online decoding phase of the scan, the algorithm uses the scan starting-point as the reference *Center of Rotation* and from there, also calculates the Preliminary ***Ground*** Plane.

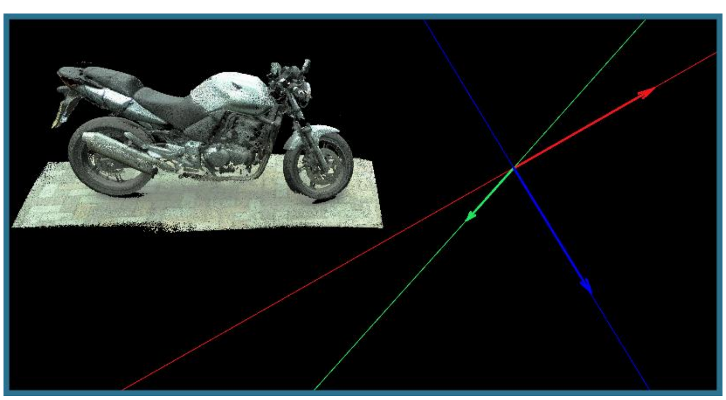


Figure 130 – Center of Rotation

Following the activation of the ***Center of Rotation***, double-click with the mouse left-button over the point where the Center of Rotation should be.

Figure 131 – New Center of Rotation Marked

-  – The *Center View* command-button – once the ***Center of Rotation*** is set, selecting the ***Center View*** command-button will position the object's image so that the ***Center of Rotation*** will match the center of the screen.
-  – The *Background Mode* command-button – sets the desired background colors for the desktop and working space.

  It offers two (2) preset colors in addition to a full-color palette allowing selection of any color.

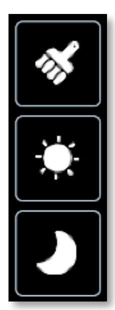


Figure 132 – Gallery View Mode – Edit Page – The Background Mode toolbar

The two (2) preset background colors are:

-  – The *Dark* command-button – enabling dark background color, and
-  – The *Bright* command-button – enabling much lighter background color.

An expanded selection of any color is available through the third (3^{rd}) option:

-  – The *Custom* command-button – enabling full-color pallet, in five (5) forms, out of which any color may be set.

Selecting this option open the ***Pick a Color*** toolbar:

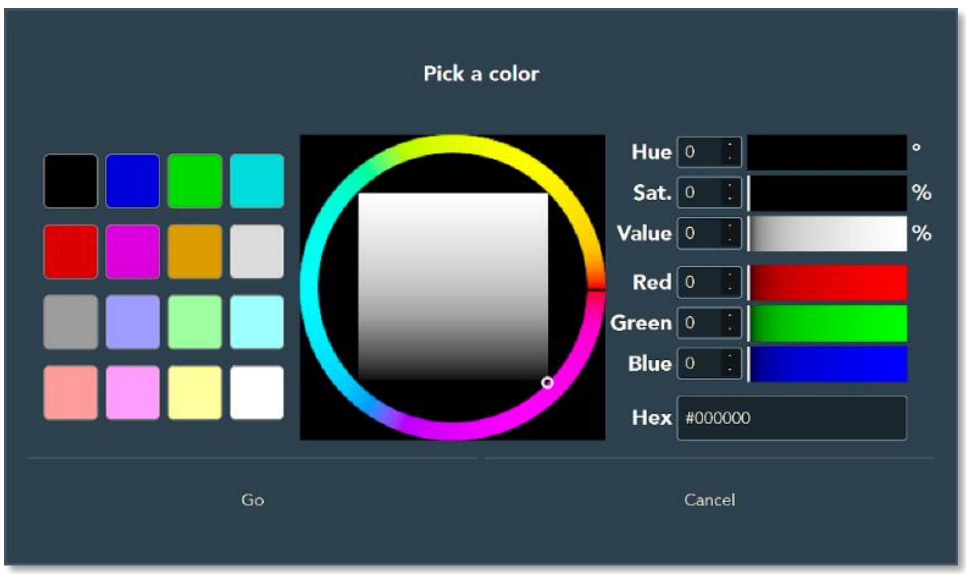


Figure 133 – Gallery View Mode – Edit Page – The Pick a Color toolbar

Picking the desired color is possible via five (5) different setting tools:

- The Preset Pallet of Colors – a matrix of sixteen (16) preset colors.
- The Color and Intensity Dialers – a trimmer-like dialers allowing free settings of the color.
- Hue, Saturation and Intensity value setting – manual value settings.
- RGB value settings – manual value settings, and
- Hexadecimal color code number entry.

Once the background color is set, select the ***Go*** command-button for acceptation or the ***Cancel*** command-button to cancel the background color setup procedure.

The Measurement Toolbar

The Measurement toolbar is an added-value instrument for the users of the Echo™ software.

Since the 3D model created by the Echo™ software is very accurate, this toolbar allows measuring different items on the model's image.

Figure 134 – Gallery View Mode – Edit Page – The Measurement toolbar

The toolbar combines five (5) command-buttons as follows:

-  – **The *Navigate* command-button** – the ***Navigate*** command-button is the default mode of display for the **Gallery View Mode – Edit Page**.
-  – **The *Measurement Tools* command-button** – is a set of command-buttons allowing accurate measurements on the model.

  Selecting the ***Measurement Tools*** command-button open the ***Measurement Tools*** toolbar:

Figure 135 – Gallery View Mode – Edit Page – The Measurement Tools toolbar

With this ***Measurement Tools*** toolbar, a ***Measurement Billboard*** also opens, on the left side of the screen, for the display of the measurements' values.

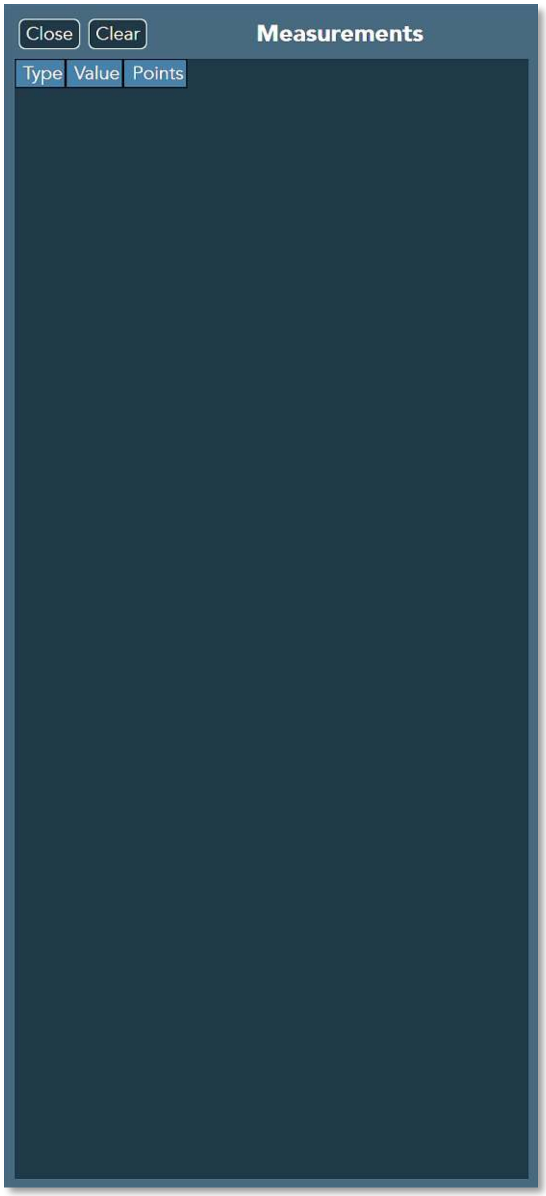


Figure 136 – Gallery View Mode – Edit Page – The Measurement Billboard

The measurement values will be presented in a table with three (3) columns, where:

- The left-most column representing the ***Type*** of measurement,
- The center column representing the ***Value***, and
- The right-most column – the 3D Point-Cloud's data used for the calculation of the ***Value***.

This billboard may be shut-off by selecting the ***Close*** command-button (at the top-left side of the billboard) as well as cleared from its content, by selecting the ***Clear*** command-button next to it.

The ***Measurement Tools*** toolbar include six (6) tools (command-buttons):

-  – **The *Line to Line* command-button** – this tool is used for measuring the distance between the **centers** of two (2) drawn lines.

  These lines are drawn over the object's image by double-clicking with the mouse on each line-end point.

-  – **The *Point to Line* command-button** – this tool is used for measuring the distance between a point and the end of a drawn line.

  The line is drawn first over the object's image by double-clicking with the mouse on each line-end and then the point is marked by double-clicking the mouse over the desired position.

-  – **The *Point to Plane* command-button** – this tool is used for measuring the distance between a point and the center of a drawn plane.

  The plane is drawn first over the object's image by double-clicking with the mouse on each plane's vertex and then the point is marked by double-clicking the mouse over the desired position.

-  – **The *Angel* command-button** – this tool allows measuring the angle between two (2) lines creating an angel.

  The angel (the two lines) is created by marking its three (3) points (by double-clicking on each point).

-  – **The *Distance* command-button** – this tool allows measuring the distance between two (2) points.

  The two (2) points are marked by double-clicking the mouse over each one of them.

-  – **The *Point* command-button** – this tool presents the three-dimensions (3D) X,Y,Z values of the point marked.

  The point is marked by double-clicking the mouse over the required point.

-  – **The *Decimation* command-button** and the  ***Mark for Registration*** command-button are dimmed-out (inactive) – these tools are not yet released for users.

-  – **The *Delete* Selection command-button** – this tool is used as an execution trigger for all **Delete** commands of the ***Selection*** toolbar (see section "The Selection Toolbar" in page **110 above**).

The Undo/Redo Command-Buttons

Some commands included in the **Gallery View Mode – Edit Page**'s toolbars allow ***Undo*** – erasure of the last change done to the model as well as negating the last command done to the file being edited thus reverting it to an older state.

The opposite of undo is ***Redo*** – the ***Redo*** command reverses the ***Undo*** command or advances the buffer to a more current state.

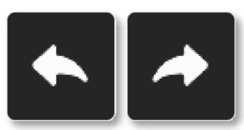


Figure 137 – Gallery View Mode – Edit Page – Undo and Redo command-buttons

The Edit Page for Spawns

The **Edit Page for Spawns** is mostly identical to the **Edit Page for Raws and Editables** (see page **83 above**) except for one major concept – **Spawns** are wrapped-up files and thus – **cannot be edited!**

For that reason, all editing tools, toolbars and their supporting items (billboards, measuring tools, etc.) were omitted from the **Edit Page for Spawns**.

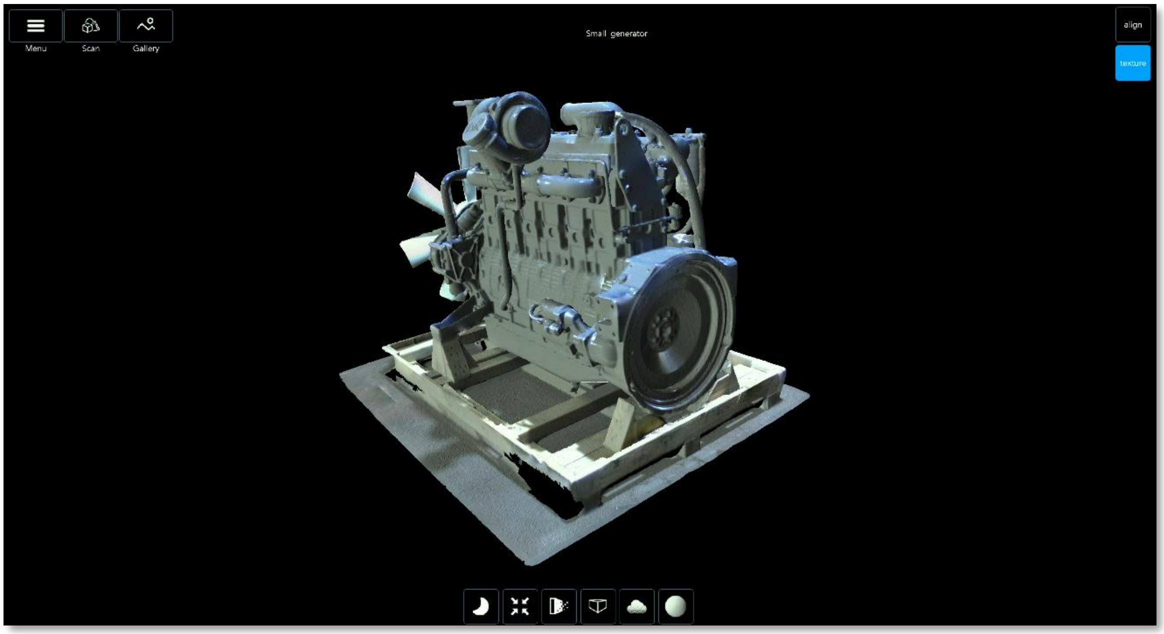


Figure 138 – Gallery View Mode – Edit Page for Spawns

The remaining tools are:

- The **Main Menu** bar
- The **Display Control** toolbar
- The **Align** and the **Texture** command-buttons

These are detailed below:

The Main Menu Bar

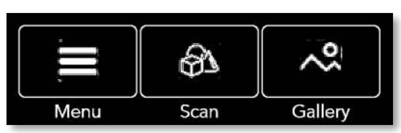


Figure 139 – Gallery View Mode – Edit Page for Spawns – Main Menu Bar

See details of the **Main Menu bar** in paragraph "The Main Bar" in page **45 above**.

The Display Control Toolbar

The **Display Control** toolbar sets for best screen viewing options.

It includes six (6) command-buttons, five (5) out of which open their own toolbar as detailed below.

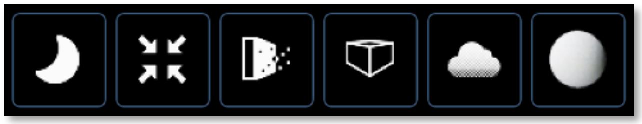


Figure 140 – Gallery View Mode – Edit Page for Spawns – Display Control toolbar

The **Display Control** toolbar of the **Edit Page for Spawns** differ from the **Display Control** toolbar of the **Edit Page for Raws and Editables** by an added command-button for ***Rendering Mode***:

-  – **The *Rendering Mode* command-button** – controls what rendering mode will be used for the screen display.

  These rendering modes could be – ***Normal*** (Mesh) or ***Wireframe*** or both (***Normal + Wireframe***).

  Selecting the ***Rendering Mode*** command-button open the ***Rendering Mode*** toolbar (see Figure 141 **below**):

Figure 141 – Gallery View Mode – Edit Page for Spawns – Rendering Mode toolbar

The tools (display options) included in the ***Rendering Mode*** toolbar are:

-  – **The *Normal* Mode command-button** – display the texture of the 3D model:

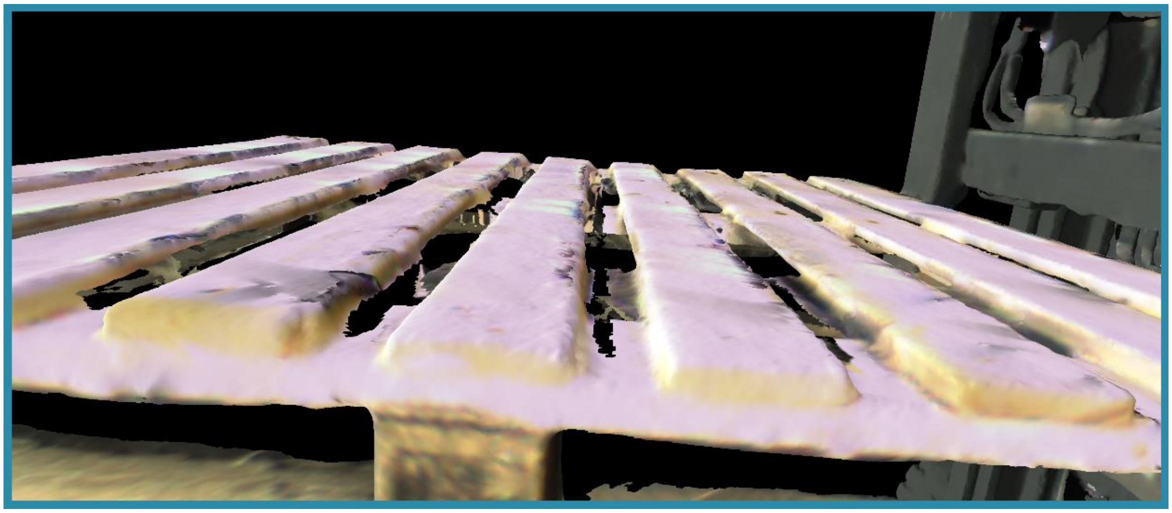


Figure 142 – Rendering Mode toolbar – Normal Mode

-  – The *Wireframe* Mode command-button – display the polygons calculated for the creation of the texture (see Figure 143 below).
-  – The *Normal + Wireframe* Mode command-button – display both the texture and the polygons of the model (see Figure 144 below).

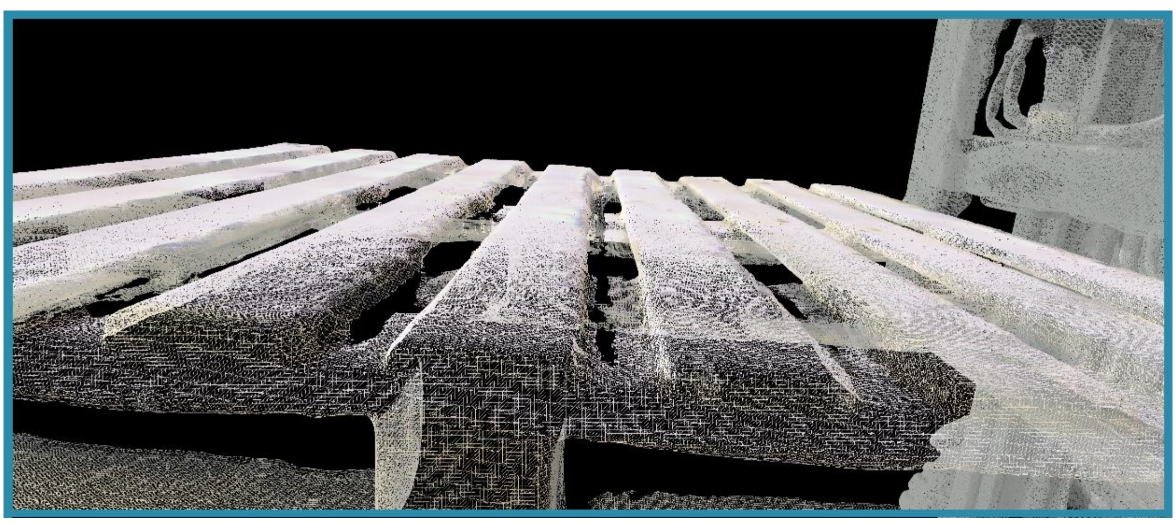


Figure 143 – Rendering Mode toolbar – Wireframe Mode

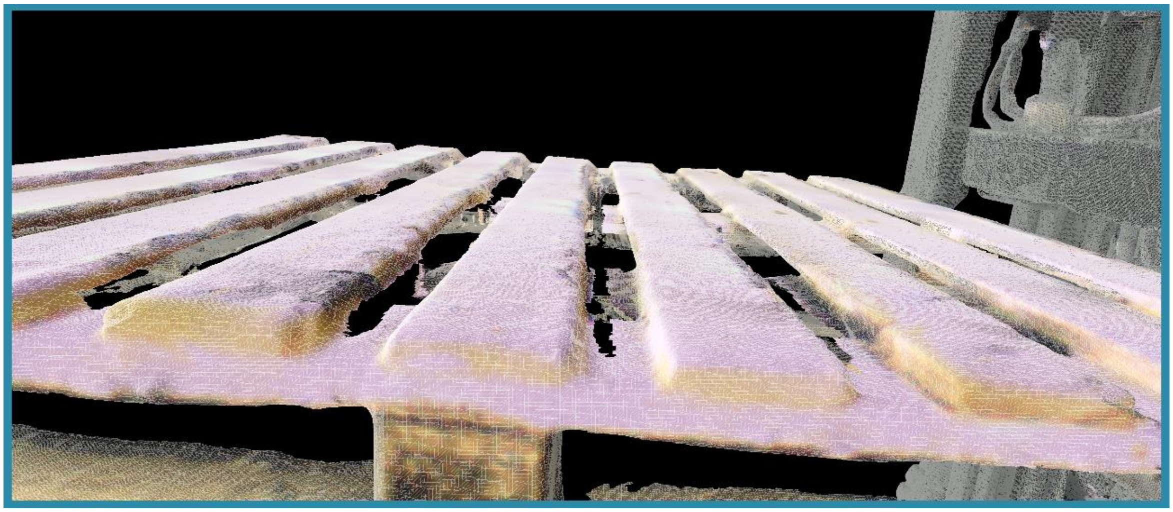


Figure 144 – Rendering Mode toolbar – Normal + Wireframe Mode

-  – The *Rendering Setup* command-button – the *Rendering Setup* command-button controls the rendering of the object.

  Selecting this command-button open the Rendering Setup toolbar:

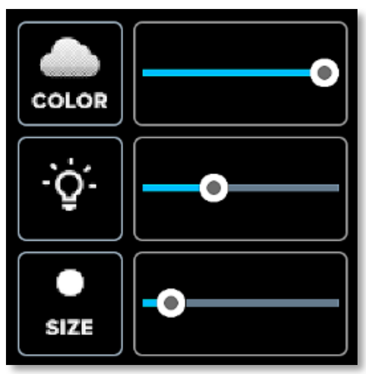


Figure 145 – Gallery View Mode – Edit Page for Spawns – Rendering Setup toolbar

The Rendering Setup toolbar allow, by means of trimmers, control of:

-  – The *Projection Mode* command-button – the *Projection Mode* command-button controls the way the object will be projected to the user.

  - Points' (of the whole object) Visible Size
  - Points' (of the whole object) Intensity, and
  - Points' (of the whole object) Color (saturation of color).

NOTE: The object need to be aligned to the reference ***Ground*** (see page 137 below) PRIOR TO the settings of the ***Projection Mode***.

Selecting this command-button open the ***Projection Mode*** toolbar:

Figure 146 – Gallery View Mode – Edit Page for Spawns – Projection Mode toolbar

The ***Projection Mode*** toolbar include three (3) command-buttons, two (2) out of which open their own toolbar.

-  – **The *Perspective* command-button** – the Perspective command-button controls the viewpoint at which the object will be presented by creating an illusion of 3D perspective – nearer objects will appear bigger.
-  – **The *Perspective Direction* command-button** – on top of the perspective set by the above-mentioned ***Perspective*** command-button, the ***Perspective Direction*** command-button sets the direction in which the set perspective will be presented (e.g. from Top, from Right, etc.).

NOTE: The object need to be aligned to the reference ***Ground*** (see page 137 below) PRIOR TO the settings of the ***Perspective***, ***Perspective Direction*** and the ***Orthogonal*** viewing modes.

Selecting the ***Perspective*** command-button and the ***Perspective Direction*** toolbar opens:

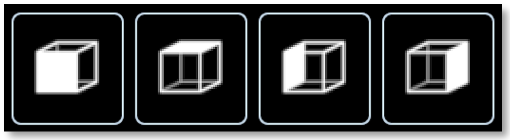


Figure 147 – Gallery View Mode – Edit Page for Spawns – Perspective Direction toolbar

The ***Perspective Direction*** toolbar include four (4) command-buttons:

- ♦  – **The *Perspective Front* command-button** – presents the object, in perspective mode, from its FRONT side.
- ♦  – **The *Perspective Top* command-button** – presents the object, in perspective mode, from its TOP side.
- ♦  – **The *Perspective Left* command-button** – presents the object, in perspective mode, from its LEFT side.
- ♦  – **The *Perspective Right* command-button** – presents the object, in perspective mode, from its RIGHT side.

-  – **The *Orthogonal* command-button** – the ***Orthogonal*** command-button switches the display mode to Orthogonal view mode.

  In Orthogonal view mode, all points of the object are displayed using the same scale.

-  – **The *Widgets* command-button** – the ***Widgets*** command-button sets two (2) reference items of the object's image:
  - The reference ***Ground*** and
  - The reference ***Center of Rotation***.

  Selecting the ***Widgets*** command-button open the **Widgets Setup** toolbar:

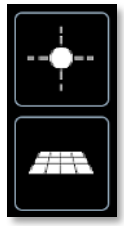


Figure 148 – Gallery View Mode – Edit Page for Spawns – Widgets toolbar

The **Widgets Setup** toolbar include two (2) command-buttons for settings fundamental reference item:

-  – **The *Ground* command-button** – setting a ***Ground* Plane** simplifies the work in 3D environment by providing a reference plane on which, allegedly, the scanned object is "standing".

  During the online decoding phase of the scan, the algorithm uses the scan starting-point as the reference ***Center of Rotation*** and from there, also calculates the Preliminary ***Ground*** Plane.

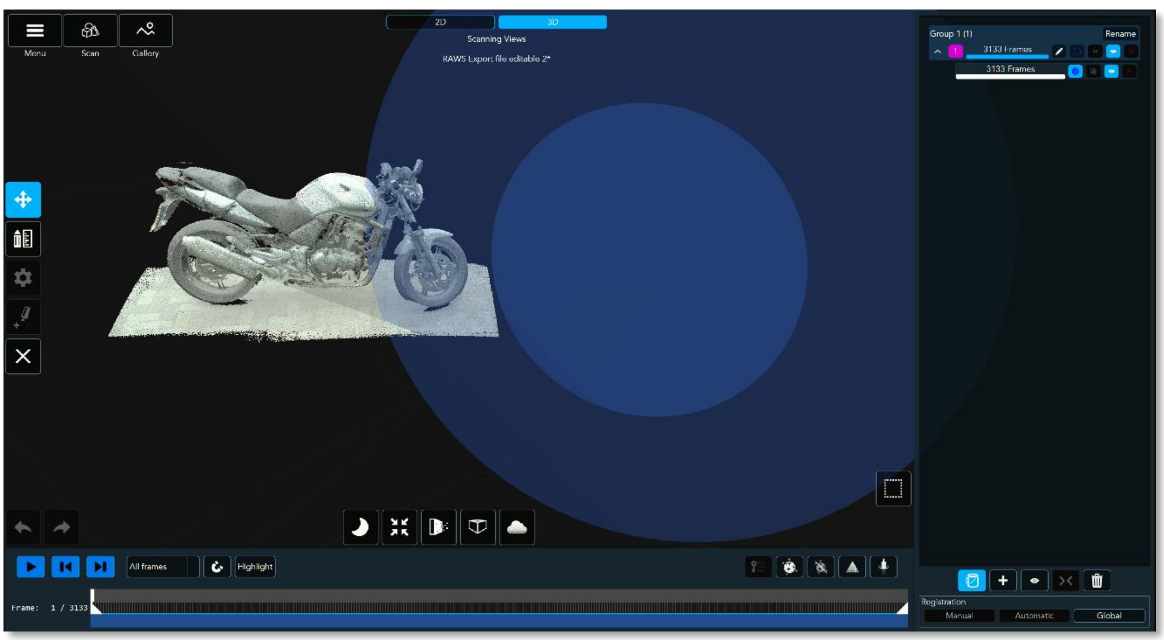


Figure 149 – Edit Page for Spawns – Preliminary Ground Plane

Ground Settings is activated by selecting the ***Ground*** command-button.

Once activated, a **Preliminary Ground Plane** will be displayed (see Figure 149 above) behind the scanned object.

Shift it onto a more practical position – **Move**/**Rotate**/**Zoom** the object's image together with the **Preliminary Ground Plane** (see section "3D Navigation of the Displayed Object" in page 118 **above**) as demonstrated in Figure 150 **below**:

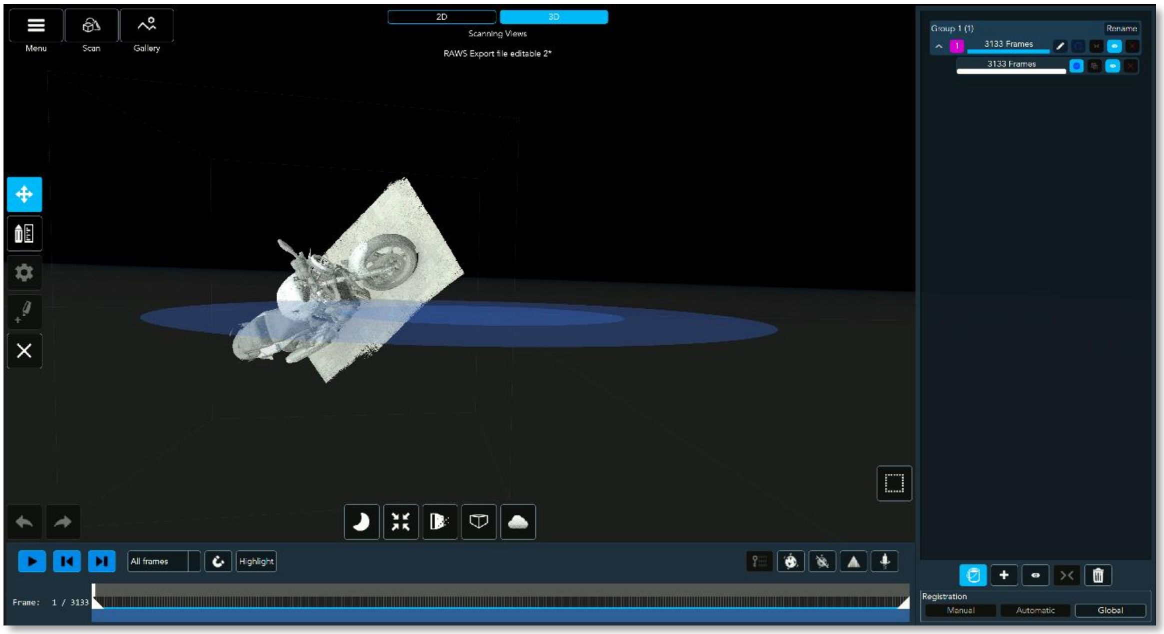


Figure 150 – Edit Page for Spawns – Ground Plane Positioned

To align the object's image to the **Ground Plane** – select the **Segment** to be aligned by selecting the appropriate **Group Edit** command-button () from the **Segments Billboard** and **Move**/**Rotate**/**Zoom** the image until aligned over the **Ground Plane** (see Figure 151 **below**) properly.

NOTE: **Ground Settings** does not require the object's model to be fully aligned, registered and made of a single Segment/ Group.
The settings could be done separately for each Segment/ Group/Frame.

Once aligned, the image will remain aligned for the rest of the edit process.

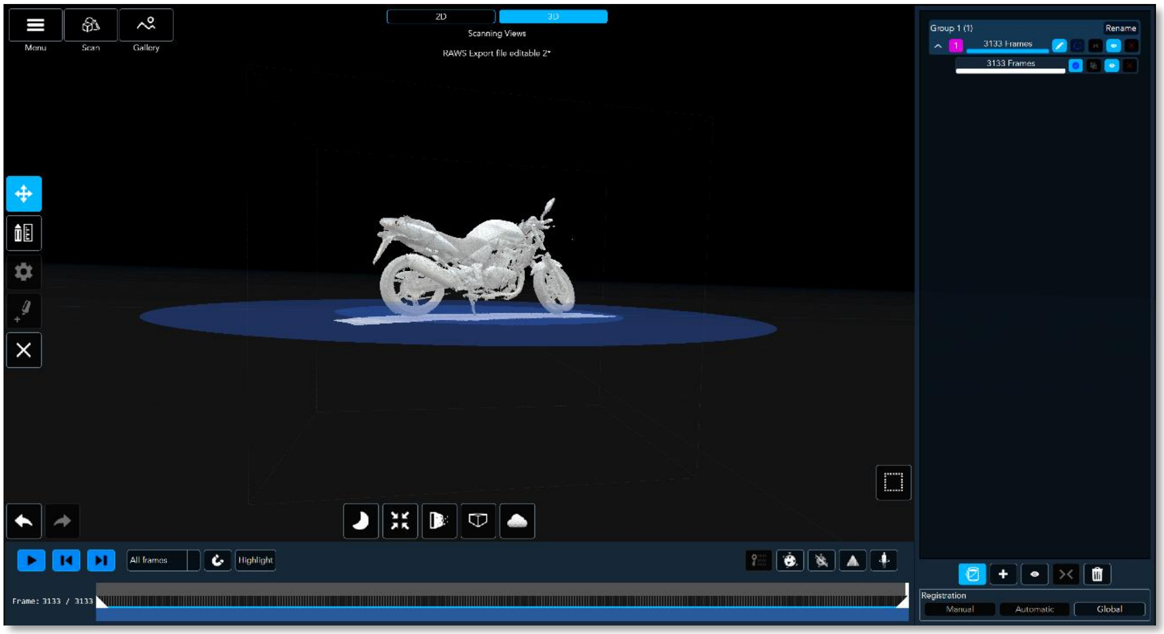
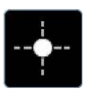


Figure 151 – Edit Page for Spawns – Object Aligned to Ground Plane

-  – The *Center of Rotation* command-button – setting a ***Center of Rotation*** simplifies the work in 3D environment by providing a reference coordinate system which, allegedly, the scanned object is "aligned to".

  The origin of these coordinates (the origin of a Euclidean space is a special point used as a fixed point of reference for the geometry of the surrounding space) is the 3D Object's image ***Center of Rotation***.

  During the online decoding phase of the scan, the algorithm uses the scan starting-point as the reference ***Center of Rotation*** and from there, also calculates the Preliminary ***Ground* Plane**.

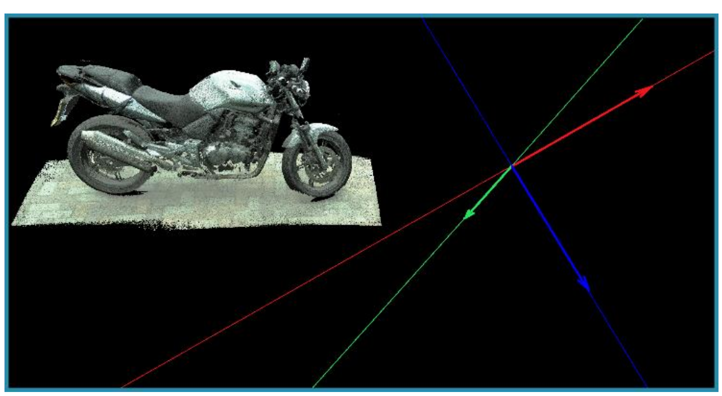


Figure 152 – Edit Page for Spawns – Center of Rotation

Following the activation of the ***Center of Rotation***, double-click with the mouse left-button over the point where the Center of Rotation should be.

Figure 153 – Edit Page for Spawns – New Center of Rotation Marked

-  – The ***Center View*** command-button – once the ***Center of Rotation*** is set, selecting the ***Center View*** command-button will position the object's image so that the ***Center of Rotation*** will match the center of the screen.
-  – The ***Background Mode*** command-button – sets the desired background colors for the desktop and working space. It offers two (2) preset colors in addition to a full-color palette allowing selection of any color.

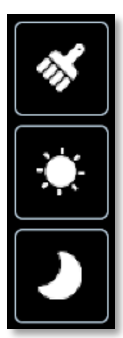


Figure 154 – Gallery View Mode – Edit Page for Spawns – Background Mode toolbar

The two (2) preset background colors are:

-  – **The *Dark* command-button** – enabling dark background color, and
-  – **The *Bright* command-button** – enabling much lighter background color.

An expanded selection of any color is available through the third (3rd) option:

-  – **The *Custom* command-button** – enabling full-color pallet, in five (5) forms, out of which any color may be set.

Selecting this option open the ***Pick a Color*** toolbar:

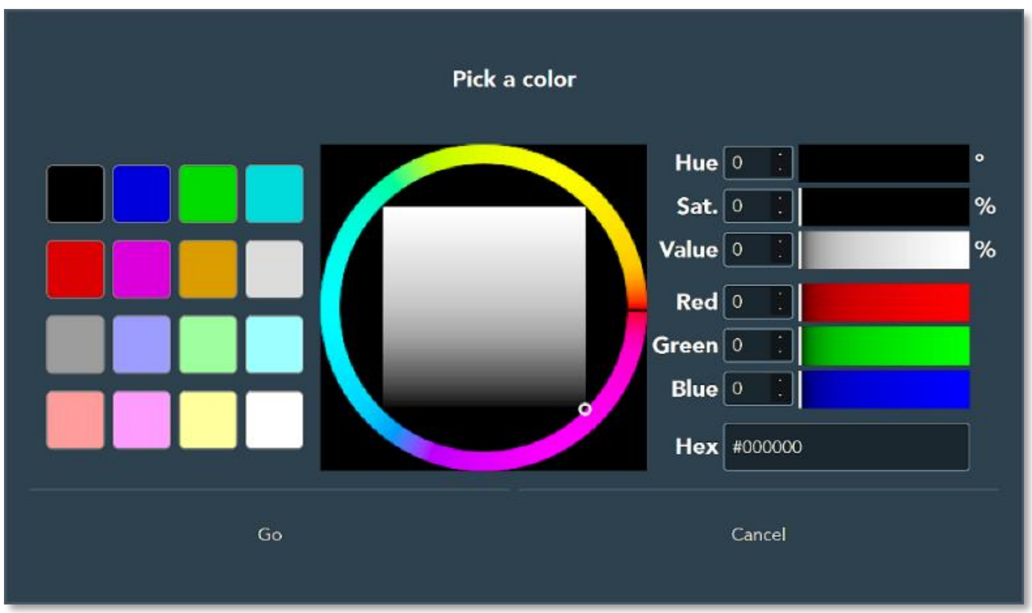


Figure 155 – Gallery View Mode – Edit Page for Spawns – Pick a Color toolbar

Picking the desired color is possible via five (5) different setting tools:

- **The Preset Pallet of Colors** – a matrix of sixteen (16) preset colors.
- **The Color and Intensity Dialers** – a trimmer-like dialers allowing free settings of the color.
- **Hue**, **Saturation** and **Intensity** value setting – manual value settings.
- **RGB** value settings – manual value settings, and
- **Hexadecimal color code** number entry.

Once the background color is set, select the ***Go*** command-button for acceptation or the ***Cancel*** command-button to cancel the background color setup procedure.

The Align Command-Button

One other command-button special for the **Edit Page for Spawns** is the ***Align*** command-button.

It is an ON/OFF command-button allowing rotation/drag of the spawned object's image (Mesh or Point-Cloud) with or without the alignment (XYZ) axis thus enabling alignment of the object for export.

Figure 156 – Gallery View Mode – Edit Page for Spawns – Align command-button

The Texture Command-Button

One other command-button special for the **Edit Page for Spawns** is the ***Texture*** command-button.

The ***Texture*** command-button allow prompt removal of the color data off the spawned model.

Removing the texture from meshed model allow viewing the scanned object without the texture (sourced from the Color (RGB) Camera).

Figure 157 – Gallery View Mode – Edit Page for Spawns – Texture command-button

The Main Menu in Gallery View Mode – Edit Page

While in **Gallery View mode – Edit Page** (both for **Raws and Editables** and for **Spawns**), the Echo™ software also changes the **Main Menu** (see paragraph "The Main Menu" in page **166 below** for details) to include three (3) more command-buttons enabling two (2) file saving options and an export option.

These are detailed in paragraph “Main Menu in Both Gallery View Mode’s Edit Page” in page 186 below.

Figure 158 – Main Menu in Gallery View Mode – Edit Page

Synopsis of the Scan View Mode

The **Scan View** represents the second purpose of the Echo™ software – control of the 3D scanning operations.

The purpose of scanning includes:

- Control of all possible viewing modes,
- Control of the IR Sensor scanning parameters and the Color (RGB) Camera scanning parameters,
- Control of the ***Projector***’s parameters.

The main two (2) tools used in the **Scan View Mode** are the ***Scanning Views*** toolbar and the ***Settings*** command-button and its associated ***Settings*** toolbar.

These may be used independently but combined can guarantee top-notch scanning results.

Main Screen – Scan View Mode

Selecting **Scan View** Mode is done by selection of the ***Scan*** command-button from the *Main Menu* bar.

It turns the Echo™ software into the camera's control and monitoring software for scan operation:

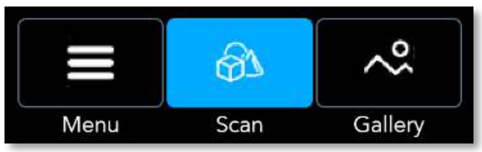


Figure 159 – The Main Menu Bar – Scan View command-button

Select the ***Scan*** command-button and the **Scan View Mode** screen will open:

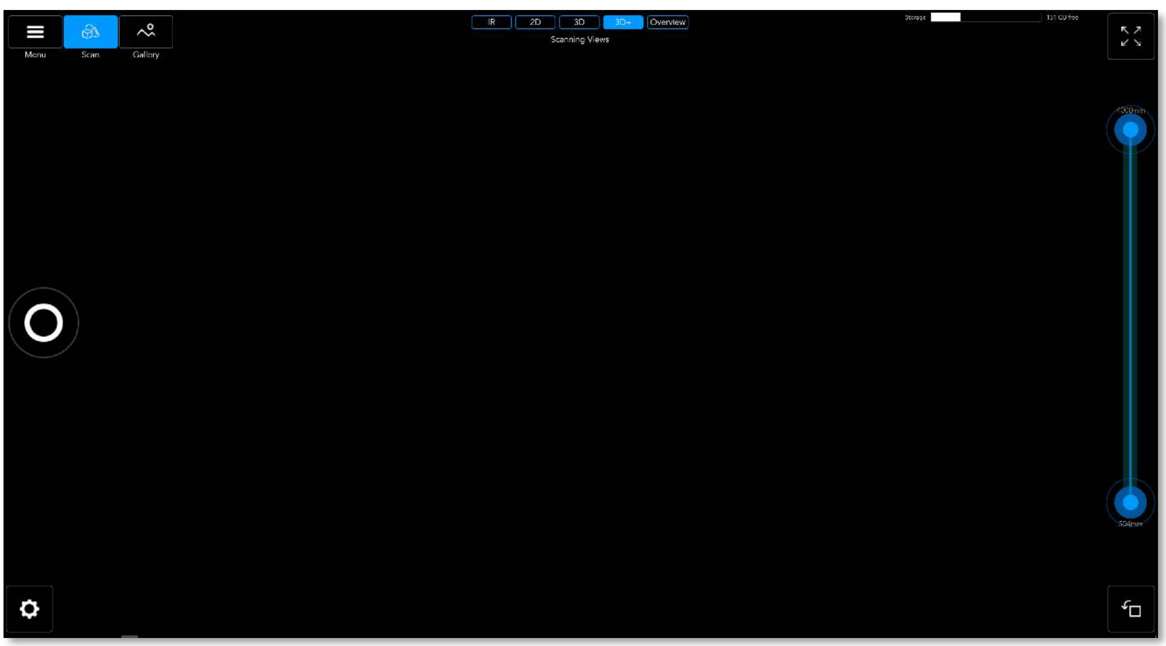


Figure 160 – Main Screen – Scan View Mode

Once the **Scan View Mode** is triggered, the Echo™ will initialize and attempt to link with the camera via the USB cable, while displaying to the user the following message-box:

Figure 161 – Scan View – "Start recorder…" message-box

The progress meter in this message-box presents the status of the initiation step.

If no camera is found connected and active, or the FTDI driver was not installed (see page 26 above), the following message-box will pop-up:

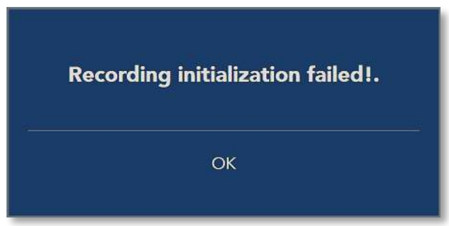


Figure 162 – Scan View – "Recording Initialization failed!" message-box

NOTE:	The above also means that the camera need to be connected and powered up PRIOR to turning Scan View Mode on.

In case the camera is connected and powered-on, the "*Start recorder…*" message-box will disappear after a few seconds and the display will turn into the previously used Scan View Mode.

The Scan View Mode screen include the following components/tools (clockwise in Figure 160 above, from top-left corner of the screen):

- The *Main Menu* bar – detailed in paragraph "The Main Bar" in page 45 above.
- The *Scanning Views* toolbar – controlling the scan (camera) views' modes presented in the Scan View Mode screen.
- The *Storage* meter – presenting the amount of free disk space left for the next scans.
- The *Switch to full-screen* command-button.

- The *Scan Range Limiter* tool.
- The *Rotate View* command-button.
- The *Settings* command-button which opens the *Settings* toolbar.
- The *Start Recording* command-button which emulates the camera's **Power/Scan Button**.

These are all detailed below:

The Scanning Views Toolbar

The *Scanning Views* toolbar controls the five (5) different camera viewing modes:

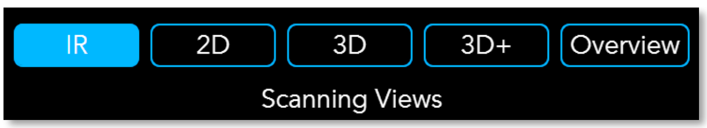


Figure 163 – Scan View – The Scanning Views toolbar

These are:

- **IR** – **Infra-red** captured **Video Pattern View Mode** – This view mode presents the Mantis Vision's unique pattern's video stream and is used for checking the pattern's coverage of the scanned object.
- **2D** – **Color Video** (RGB) **View Mode** – This view mode presents the color (RGB) video stream captured at the same time (in parallel) with the **IR video**.

  The color data will be used, in a later stage of the process, for retrieval of color values for the Point-Cloud model as well as for the Mesh textures created for the resulting 3D model.
- **3D** – **Decoded Single Frame Point-Cloud View Mode** – This view mode presents the **IR** scanned data subsequent to the decoding act (in Point-Cloud format compared to video format of the **IR View Mode**), in a single-frame manner.
- **3D+** – **3D Model Built in Real-Time while Decoding View Mode** – This view mode presents the scanned object similar to the above-described **3D Decoded Single Frame Point-Cloud View Mode** but, unlike the 3D View Mode which displays single frames, the **3D+ View Mode** displays complete **Segments**.

The above-described **Scanning Views** referred to the camera's point-of-view.

There is an additional scanning view mode which refer to an 'external' point-of-view:

- **Overview** – **Scanned 3D Object** – The image in this view mode is rotatable and also checked for missing data.

The IR View Mode

Selection of the ***IR*** command-button of the ***Scanning Views*** toolbar enables IR video stream viewing mode of the scan – the view from the IR Sensor.

The purpose of this view mode is to check the Mantis Vision unique projected pattern's coverage of the scanned object and adjustments to the Projector and the IR Sensor for generation of scans with highest qualities.

NOTE:	The IR Sensor and the Projector affects the quality of the 3D data (Point-Clouds and depth-maps), not of the mesh texture.

The projected pattern need to cover the largest area possible on the scanned object (or space) since the camera's decoding algorithm (part of the Echo™ software) will process only pattern-covered areas into Point-Clouds.

Adjustments that can be made to affect scan and the **IR View Mode** are detailed in section "Setting the IR Sensor in IR View Mode" in page **160 below**.

The 2D View Mode

Selection of the ***2D*** command-button of the ***Scanning Views*** toolbar enables viewing of the color (RGB) video captured during the scan – the view from the Color (RGB) Camera.

This projection provides the color data values for the points of the Point-Cloud which will be used for the mesh textures in a later stage of processing the scanned data.

Adjustments that can be made to affect the scan and the **2D View Mode** are detailed in section "Setting the Color (RGB) Camera in 2D View Mode" in page **163 below**.

NOTE:	The Color (RGB) Camera affects the quality of the mesh texture, not of the 3D data.

The 3D View Mode

Selection of the ***3D*** command-button of the ***Scanning Views*** toolbar enables viewing of the Point-Cloud decoding of a single frame (including color).

The camera's single Frame Point-Cloud may contain up to seventy thousand (70,000) points in its cloud with a field of diagonal view 80°.

TIP:	This is the recommended view mode for normal scanning.

The 3D+ View Mode

Selection of the ***3D+*** command-button of the ***Scanning Views*** toolbar enables view of online registration (real-time model stitching). This is done by presenting the current **Frame** of the Point-Cloud along with (**✚**) all other Frames which were decoded during the same scan.

Providing the ***Settings*** of ***Allow Multi-segment*** (see section "The Settings Menu Option" in page **168 below**) was marked, whenever the Point-Cloud Frames' online registration cannot be made (missing Points for registration), the ***3D+*** view will start a new **Group** of segmentation and **Frame** registration will start again.

The Overview View Mode

Selection of the ***Overview*** command-button of the ***Scanning Views*** toolbar enables same view as in ***3D+*** View Mode (see above). But, the view in ***Overview Mode*** will not be projected from the camera point-of-view but from an external point-of-view for better perspective.

NOTE:	Changing the Scanning Views does not affect the scanning data.

The Storage Meter

The ***Storage*** meter presents to the user the amount of free storage space in the workstation's hard-disk left for the next scanning sessions.

Figure 164 – Main Screen – Scan View – The Storage Meter

The Laptop Battery Gauge

The ***Laptop Battery Gauge*** presents to the user the amount of energy left in the workstation's batteries for the next scanning sessions.

Figure 165 – Main Screen – Scan View – The Laptop Battery Gauge

The Scanner Battery Gauge

The ***Scanner Battery Gauge*** presents to the user the amount of energy left in the camera's batteries for the next scanning sessions.

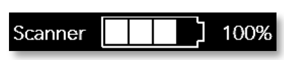


Figure 166 – Main Screen – Scan View – The Scanner Battery Gauge

The Switch to Full Screen Command-Button

The ***Switch to Full Screen*** command-button enlarges the screen display to full-screen view mode, where Windows™ operating system's top ***Quick Access*** toolbar and bottom ***Task Bar*** are not included.

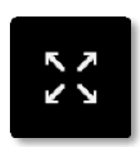


Figure 167 – Scan View – Switch to Full Screen command-button

The purpose of this command-button is to enlarge the screen to display as much as possible of the Echo™ displayed data.

The ***Switch to Full Screen*** command-button is functionally equivalent to the ***Main Menu***'s ***Full-Screen*** option (see paragraph "The Full-screen Menu Option" in page 170 below).

Once in full-screen mode, to return to the normal mode, select the ***Switch to Normal Screen*** command-button:

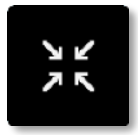


Figure 168 – Scan View – Switch to Normal Screen command-button

The Scanning Range Limiter

The ***Scanning Range Limiter*** allows dynamic control over the minimum and maximum scanning range.

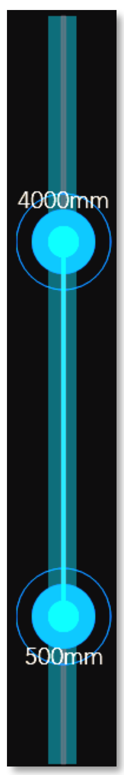


Figure 169 – Scan View – Scanning Range Limiter

It allows definition of restricted scanning zone – minimum and maximum distances, from the camera, where capturing of scanned videos will occur.

The Rotate View Command-Button

The ***Rotate View*** command-button enables rotation of the viewed scanning scene.

NOTE:	Rotating the views only affects the displayed information, not the recorded scan data.

Originally, the camera was designed to work in horizontal position, but, it would function equally right in vertical position (or any other).

Figure 170 – Vertical and Horizontal Scan Positions

The ***Rotate View*** command-button was added to the scanning tools to compensate for these possible positions.

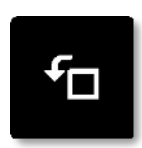


Figure 171 – Scan View – Rotate View command-button

Selecting the ***Rotate View*** command-button will rotate the scanned image, on the screen ONLY, by 90^0 counter-clockwise.

Adjusting Scan Parameters Combined with Viewing Options

The Scan View Mode also enable fine-tuning the camera towards top-notch scanning results.

This is done utilizing the ***Settings*** command-button (at the bottom-left side of the Main Screen – Scan View Mode) and its associated ***Settings*** toolbar combined with the corresponding Scanning Views.

The Settings Command-Button

The ***Settings*** command-button resides at the bottom-left corner of the Main Screen – Scan View Mode:

Figure 172 – Scan View – Settings command-button

It enables setup control, throughout the scan operations, over the ***Projector***'s illumination, the ***IR Sensor***'s captured video, the ***Color (RGB) Camera***'s captured video, recording, decoding and rendering qualities as well as general camera configuration files' setup and camera selection.

The Settings Toolbar

Selecting the ***Settings*** command-button opens the ***Settings*** toolbar:

Figure 173 – Scan View – Settings toolbar

It includes six (6) command-buttons:

- *Switch-OFF* command-button – for turning-off the ***Settings*** toolbar upon termination of the setup act.

Figure 174 – Scan View – Settings toolbar – Switch-OFF command-button

- *IR* command-button – for activation of the parameters' modification toolbar for the Infra-Red (**IR**) channel including the **Projector** and the **IR Sensor**.

  Selection of the *IR* command-button opens the ***IR Settings*** toolbar which enables fine-tuning of the IR Illumination (***Projector***) parameters as well as sets the **IR Sensor**'s video capturing parameters, to achieve optimal configuration for 3D scanning.

  The ***IR Settings*** toolbar and its functions are detailed in section "Setting the IR Sensor in IR View Mode" in page **160 below**.

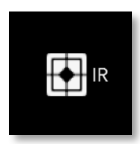


Figure 175 – Scan View – Settings toolbar – IR command-button

- *Color* command-button – for activation of the parameters' modification toolbar of the color video channel – the ***Color (RGB) Camera***.

Figure 176 – Scan View – Settings toolbar – Color command-button

Selection of the *Color* command-button opens the **Color (RGB) Camera Settings** toolbar which enables fine-tuning of the color video data received by the Color (RGB) Camera.

The **Color (RGB) Camera Settings** toolbar and its functions are detailed in section "Setting the Color (RGB) Camera in 2D View Mode" in page **163 below**.

- *MVX* command-button – for activation of the setup toolbar for the:
  - Captured ***Data Layers*** selection and recording and,
  - Capturing frequency/speed (Frame Rate – ***FPS***).

> **NOTE:** Settings of the above parameters determines the structure and content of the scanned/recorded **Raw .MVX** file.

Figure 177 – Scan View – Settings toolbar – MVX command-button

Selection of the ***MVX*** command-button opens the ***MVX Settings*** toolbar:

Figure 178 – Scan View – Settings toolbar – MVX Settings toolbar

- Selection of the ***Data Layers*** command-button of the **MVX Settings** toolbar opens the **Layers** definition dialog-box (see Figure 179 **below**) where all **MVX**-possible layers to be included are detailed and can be marked as:
  - ***Active*** (or non-active) mode, and
  - Included in the ***Rec***orded ***.MVX*** file or not.

  The options available for activation and recording are:
  - ***2D IR Texture*** – IR Video stream from the **IR Sensor**.

    The IR video stream must always be active (which is why cannot be altered in the **Data Layers** dialog-box) but may not necessarily be recorded (included in the ***.MVX*** file as a layer).

Figure 179 – Scan View – Settings toolbar – MVX Layers dialog-box

- *2D Color Texture* – Color Video stream from the **Color (RGB) Camera**.

  The color video stream might be switched off as well as not recorded (included in the *.MVX* file as a layer).

- *3D Point-Cloud* – The online-decoded Point-Cloud (out of the IR video stream).

  The online Point-Cloud might be switched off (can be decoded offline on a later stage of the process, see page **155 above**) as well as not recorded (included in the *.MVX* file as a layer).

- *Live Registration* – Live Registration done on the Point-Cloud's Frames.

  The Live Registration performed by the Echo™ software (following the decoding algorithm) between the **Frames** of the decoded Point-Cloud might also be canceled and/or not recorded (included in the *.MVX* file as a layer).

Each of the above four (4) options represents a layer of data in the initial (***Raws***) file of the ***Project*** created during scan.

Following settings of the above options, select the ***Save*** command-button to save the configuration of the *.MVX* file created during scan.

- Regarding the color and IR video's capturing rate (*FPS*) – selection of the or the command-buttons sets the video frames' capturing speed from one (1) up to eight (8) frames-per-second (*FPS*).

- ***Rendering*** command-button – for activation of the modification toolbar for post-scan rendering viewer configuration of:
  - The ***Point-Cloud Intensity***,
  - The ***Point-Cloud Saturation***,
  - The ***Particle Size*** and,
  - The ***Camera Distance***.

Figure 180 – Scan View – Settings toolbar – Rendering command-button

Selecting the ***Rendering*** command-button (out of the ***Settings*** toolbar) opens the **Rendering Setup** toolbar:

Figure 181 – Scan View – Settings toolbar – Rendering Setup toolbar

The **Rendering Setup** toolbar combines four (4) settings trimmers:

- The **Point-Cloud Intensity** trimmer – setting the intensity of the points included in the Point-Cloud.
- The **Point-Cloud Saturation** trimmer – setting the level of saturation of the color information of the points.
- The **Particle Size** trimmer – setting the particle size of the points on screen (does not affect the scanned data).
- The **Camera Distance** trimmer – setting the distance of the camera on screen in zoom-like mode. This tool affects the display only.

Each one of the above four (4) trimmers is controlled either by dragging the trimmer's button to the desired value or by utilizing the and the buttons at the trimmers' ends.

The Point-Cloud Intensity Trimmer

The ***Point-Cloud Intensity*** trimmer sets the intensity of the points included in the Point-Cloud.

NOTE: The ***Point-Cloud Intensity*** trimmer affects the screen display ONLY (not the scanned data).

It is mainly used for scanning cases where the scanned object is not properly illuminated, and its details are not clear for the user.

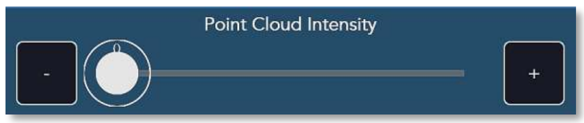


Figure 182 – Scan View – Rendering Setup toolbar – Point-Cloud Intensity trimmer

The Point-Cloud Saturation Trimmer

The ***Point-Cloud Saturation*** trimmer sets the saturation of the color of the points included in the Point-Cloud.

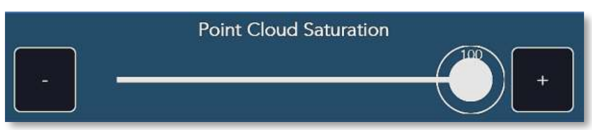


Figure 183 – Scan View – Rendering Setup toolbar – Point-Cloud Saturation trimmer

NOTE: The ***Point-Cloud Saturation*** trimmer affects the screen display ONLY (not the scanned data).

The Particle Size Trimmer

The ***Particle Size*** trimmer sets the particle size of the points on screen.

Figure 184 – Scan View – Rendering Setup toolbar – Particle Size trimmer

NOTE: The ***Particle Size*** trimmer affects the screen display ONLY (not the scanned data).

The Camera Distance Trimmer

The trimmer sets the distance of the camera on screen in zoom-like mode.

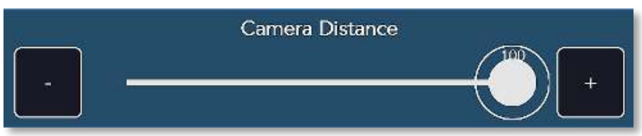


Figure 185 – Scan View – Rendering Setup toolbar – Camera Distance trimmer

NOTE: The ***Camera Distance*** trimmer affects the screen display ONLY (not the scanned data).

This is a visual tool supporting the need to zoom in and out of the displayed model during the scan act.

- ***Camera*** – The ***Camera*** command-button opens the ***Cameras*** dialog-box which allows adding, selecting and deleting cameras connected and defined for scanning with the system.

The selection (or addition or deletion of Cameras should be done prior to the scan act.

Figure 186 – Scan View – Camera command-button

Selecting the ***Camera*** command-button opens the ***Cameras*** dialog-box:

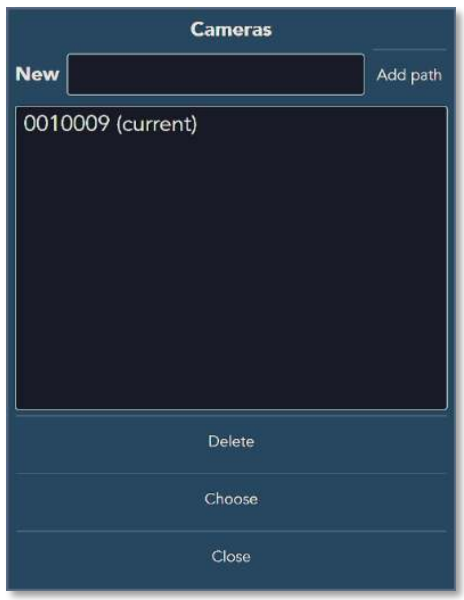


Figure 187 – Scan View – Settings toolbar – The Cameras dialog-box

The ***Cameras*** dialog-box include three (3) components:

- The ***New*** bar with its associated ***Add Path*** command-button is where a new Camera's name is to be added.
- The **Cameras' Library** window which contains the names of all previously defined Cameras for the system, and
- The **Menu** including three menu options' command-buttons:
    - The **Delete** option/command-button – for the deletion of a previously defined camera.

      To delete such a camera – select it from the ***Center Window*** by highlighting its name and then select the ***Delete*** command-button.

The camera will disappear from the list in the **Center** window and all its associated calibration files will be deleted from the **Calibration Files Repository**.

NOTE:	Since the Echo™ software needs to have at least one camera defined for the system, the last remaining camera on the list cannot be deleted!

- The **Choose** option/command-button – for the selection of a previously defined camera.

  To select a camera off the list – click over the camera's name to highlight it and then select the ***Choose*** command-button to set it as the system's camera.

NOTE:	The camera will remain highlighted (and thus – connected) as long as no other camera replaces it as the system's default camera.

- The **Close** option/command-button – for termination of the Cameras' setup process.

Setting the IR Sensor in IR View Mode

Selection of the ***IR*** command-button in the ***Scanning Views*** toolbar (see section "The IR View Mode" in page **147 above**) enables IR viewing mode of the scan operation – the view from the **IR Sensor** and supports setting the operation parameters of the **IR Sensor** and the **Projector**.

The purpose of this view mode is to check the Mantis Vision unique pattern's coverage of the scanned object.

The pattern needs to cover the largest area possible on the scanned object (or space) since the camera's decoder (the "Engine" of the Echo™ software) will process only pattern-covered areas into Point-Cloud.

While in **IR View Mode**, selection of the ***Settings*** command-button ➤ ***IR*** command-button opens the ***IR Settings*** toolbar:

Figure 188 – Scan View – IR Settings toolbar

The *IR Settings* toolbar is built from three (3) main sections:

- The Auto/Manual Mode Selection command-buttons – on the right-most side of the toolbar, which sets the IR Sensor to work in automatic (***Auto***) or ***Manual*** mode:

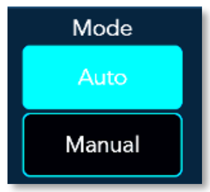


Figure 189 – Scan View – Auto/Manual Selection command-buttons

When in ***Auto*** Mode; the IR settings are calculated and set by the system. Therefore, all other parts of the ***IR Settings*** toolbar are deactivated.

NOTE: For settings of the IR Sensor it is recommended to always work in Auto mode.

When in ***Manual*** Mode:

- ***Gain*** and ***Exposure*** of the IR Sensor (***Camera***)can be manually adjusted, according to luminance conditions on the scanned object, utilizing the ***Camera*** sub-toolbar and selection of the − or + command-buttons, or by dragging the center of the slide-tool to the desired position, and
- ***Pulse*** Width, Diode Current and Delay of Pulse of the ***Laser Projector*** can be manually adjusted, according to the resulting scan image, by utilizing the ***Laser*** sub-toolbar and selection of the − or + command-buttons, or by dragging the center of the slide to the desired position.

- The IR ***Camera*** Settings toolbar enables manual control of two (2) parameters of the ***IR Sensor***:

- *Gain* – The Gain sets the multiplication factor of the light-to-signal ratio of the ***IR Sensor*** so that, in cases where the scanned object has low return of the projected pattern, the ***IR Sensor*** will still produce enough video information for the 3D decoding process.
- *Exposure* – The exposure control sets (same as in photography) the amount of light per scanned object's area which will reach the ***IR Sensor***. "Correct" exposure may be defined as an exposure that achieves the effect the photographer intended.

  The ***IR Sensor*** has a physically-limited beneficial exposure range (dynamic range). If the actual exposure is outside this range, the sensor cannot record it accurately. For example; out-of-range values would be recorded as "black" (under-exposed) or "white" (over-exposed) rather than the precisely graduated shades of tone required to describe "detail".

  Therefore, the purpose of exposure adjustment is to control the physical amount of light from the scene that can reach the sensor, so that 'significant' areas of shadow and highlight detail do not exceed the sensor's useful exposure range. This ensures that no 'significant' information is lost during capture.

NOTE:	Users may carefully overexpose or underexpose the photograph to eliminate "insignificant" or "unwanted" detail; to make, for example, a white cloth appears perfectly clean.

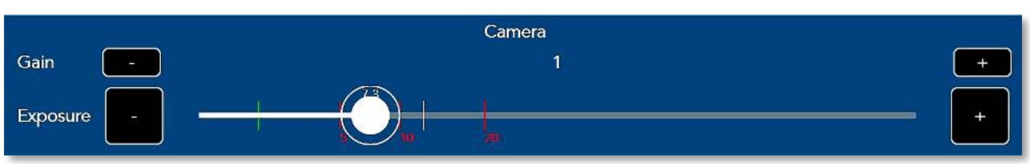


Figure 190 – Scan View – IR Sensor (Camera) Settings toolbar

- The ***Laser Projector Settings*** toolbar controls three (3) IR illumination factors of the ***Projector***:
  - *Pulse* – the width of the IR ***Projector***'s driving pulse.
  - *Current* – the amount of current driving the ***Projector***.
  - *Delay* – latency of the driving pulse.

Multiplication of the above-mentioned three (3) factors sets the amount of energy driving the ***Projector***.

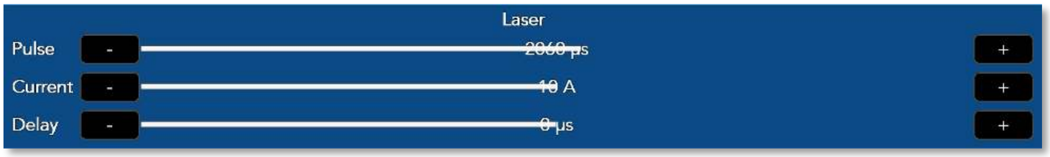


Figure 191 – Scan View – Laser Projector Settings toolbar

> **NOTE:** For eye safety reasons, the amount of **Current** driving the ***Projector*** is limited by the camera's firmware to 15A regardless of the measurement displayed by the **Laser Projector Settings** toolbar.

Setting the Color (RGB) Camera in 2D View Mode

Selection of the ***2D*** command-button in the ***Scanning Views*** toolbar (see section "The 2D View Mode" in page **147 above**) enables color video viewing mode of the scan operation – the view from the **Color (RGB) Camera**.

The purpose of this view mode is to check the acquired color video data (which will be used, later in the process, for generation of the **Mesh**) of the scanned object.

The color data need to be as accurate and close to real life's colors so that the end resulting model will look like the original object.

This viewing mode also helps in setting the operation parameters of the **Color (RGB) Camera**.

While in **2D View Mode**, selection of the ***Color*** command-button from the ***Settings*** toolbar, opens the ***Color Settings*** toolbar:

Figure 192 – Scan View – Color Settings toolbar

The ***Color Settings*** toolbar include four (4) tools:

- The *White Balance* command-button activating automatic white-level balancing procedure,
- The *Mode* selection menu selecting automatic or manual mode of settings of the Color (RGB) Camera,
- The *Gain* and command-buttons which control the Color (RGB) Camera's gain settings, and
- The *Exposure* trimmer controlling the amount of light recorded by the Color (RGB) Camera.

NOTE: Unlike the *IR Settings*, it is recommended to work in Manual mode when setting the Color (RGB) Camera.

The process of setting the Color (RGB) Camera is a repetitive loop which works as follows:

1. Select Manual mode of settings with the *Auto/Manual Selection* command-button:

Figure 193 – Color Settings toolbar – Auto/Manual Selection command-button

2. Aim the camera towards the scanned object and reduce the exposure value downwards, utilizing the and command-buttons (or by dragging the *Exposure* trimmer's control-button), until there are no more "burned" stains (extremely white area) in the image.

Figure 194 – Color Settings toolbar – Exposure Control Trimmer

Verify that there are no "burned" stains and that the image is not too dark.

3. Aim the camera towards a white wall and select the *White Balance* command-button in the *Color Settings* toolbar.

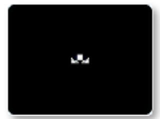


Figure 195 – Color Settings toolbar – White Balance command-button

The system will process the video data from the **Color (RGB) Camera** to find anomalies in exposure values and set the exposure to the best resulting value.

4. Check the image to see that the white balancing procedure explained in the above step 3, did not create unbalanced color areas in the image (usually these unbalanced color areas will be "painted" with green/blue tint).

   If some unbalanced areas are still found – repeat the process from section 12 **above**.

   If not – go to step 6 **below**.

5. During this repetitive setting loop, the value of the ***Gain*** might also be adjusted, with the - and + command-buttons, to achieve better white balancing results.

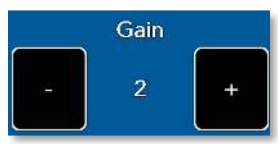


Figure 196 – Color Settings toolbar – Gain Control

NOTE: Values of 1-2 **ONLY** should be used in this ***Gain*** settings step.

Normally the value of 2 serves well in indoor scanning sessions while the value of 1 serves well for outdoor scanning sessions.

6. Once **White Balance** (no "burned" stains) with no color unbalanced (areas "painted" with green/blue color) is achieved (might take a few loops through the above-described process), select the ***Color*** command-button to terminate the process and save the White Balance values in the system.

The Start Recording Command-Button

The final item to discuss with regards to the **Main Screen – Scan View Mode** page, is the ***Start Recording*** command-button.

This is, in fact, a software reflection of the camera's **Power/Scan** button allowing activation of a scan act through the screen display.

Figure 197 – The Main Screen – Scan View Mode – Power/Scan command-button

Once selected, the scan act is activated, and the command-button turns red:

Figure 198 – Scan View Mode – Power/Scan command-button in Active State

The Main Menu

The **Main Menu** represents the third (3rd) purpose of the Echo™ software – control and static settings of the system and is activated by selecting the ***Menu*** command-button in the ***Main Menu*** bar:

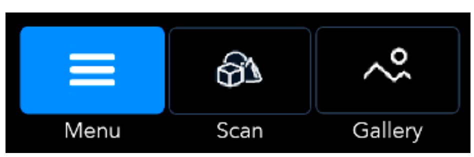


Figure 199 – The Main Menu Bar – Menu command-button

Synopsis of the Main Menu

Selection of the ***Main Menu*** command-button opens the ***Main Menu*** drop-down menu.

This menu has five (5) menu options:

- The ***About*** option – for retrieval of the details of the Echo™ software version as well as copyrights notice.
- The ***Settings*** option – for specifying details of the static settings.
- The ***Full-Screen*** option – for settings of the default display mode.

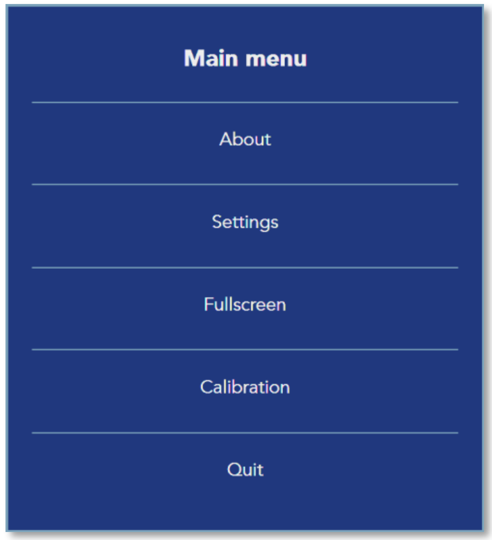


Figure 200 – The Main Menu drop-down menu

- The ***Calibration*** option – for activating the calibration procedure of the camera.
- The ***Quit*** option – for termination of the Echo™ software act.

NOTE:	The **Main Menu** drop-down menu is lengthened to include three (3) more options (on top of the above-mentioned five) when the Echo™ is in **Gallery View Mode – Edit Page** (both **Raws/ Editables** and **Spawns**) mode. Details of these extra three (3) options are provided in paragraph "Main Menu in Both Gallery View Mode's Edit Page" in page **186 below**.

The About Option

The ***About*** option of the **Main Menu** provides the Echo™ software version data.

Once this menu option is selected, the following message-window will open:

Figure 201 – Main Menu – About option

The Settings Menu Option

Selecting the ***Settings*** option of the **Main Menu** to open the ***Settings*** dialog-box:

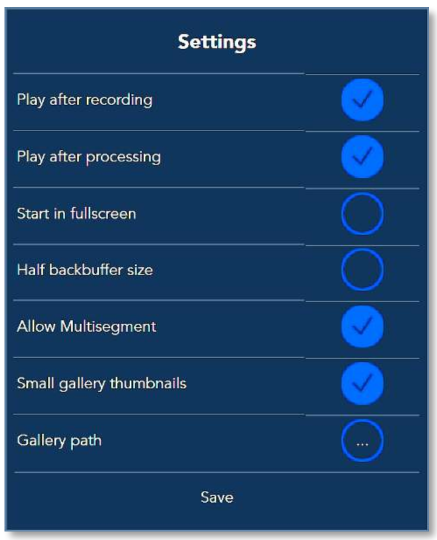


Figure 202 – Main Menu – Settings dialog-box

This dialog-box has seven (7) settings options:

- *Play After Recording* – which sets on-screen auto-play to be active concurrently with the scan recording session.

  Exploiting this option, the scan operation will be projected, in real-time, on the workstation's screen, concurrently with the scan operation, for monitoring by user purposes.

- *Play After Processing* – which sets on-screen auto-play to be active following any image process/edit for monitoring purposes.

- *Start in Full-Screen* – which sets the Echo™ software to start its operation in full-screen mode of view.

Full-screen view mode is where the workstation's Windows™ operating system's **Quick Access toolbar** (located at the top of the screen) and the **Task Bar** (located at the bottom of the screen) are not omitted from the displayed data.

Employing the Full-screen view mode and the screen will display as much as possible of the Echo™ data.

The ***Full-Screen*** option is identical to the ***Switch to Full Screen*** command-button explained the section "The Switch to Full Screen Command-Button" in page 149 **above**.

- ***Half Back-Buffer Size*** – which enhances the speed of screen refreshing rate by reducing the display resolution.
- Reducing the display resolution consumes much less system resources thus making the system responding faster.
- ***Allow Multi-Segment*** – which allow the Echo™ to scan in multi-segments mode.

The ***Allow Multi-Segment*** option sets the system to stop or continue the scan operation in case of loss of (non-successive) registration. If set (marked) the system will continue the scan operation even if the Echo™ software fails in the **Online Registration** process.

Pending the scanning circumstances, the online decoding process builds, among other things, connections between the decoded (converted from IR Video format to Point-Cloud format) **Frames** while attempting to have them connected to one another in order to create a single **Segment** right through the first scan operation (which will save editing resources later).

These **Segments** (slices of the scan) are single/multiple **Frames** that lack some data in the flow, therefore cannot succeed in connecting to the main scene. Such separated segments can be 'stitched' together, to create a complete model, on a later stage of the editing process.

NOTE:	Leaving the ***Allow Multi-Segment*** menu option unmarked will stop the scan operation every time a **Frame** (or a **Segment**) does not connect with the next one.

- ***Small Gallery Thumbnails*** – which sets the thumbnails of the **Gallery View** to a reduced size thus allowing more **Projects**/**Raws**/**Editable**/**Spawns** to be displayed on a single screen.

- *Gallery Path* – which defines the path to the Echo™ Database **Repository** (refer to paragraph “Setting the Database Repository” in page **37 above**).

  The ***Gallery Path*** option allows selection of a directory on the workstation’s hard-disk to be used as a repository for the Projects as well as their related data.

  Selecting the activation button opens the ***Select Folder*** window presented in Figure 203 **below**. Select the specific directory to be stated **Repository** and highlight it and then select the ***Select Folder*** command-button to set it as the **Gallery Path** of the Echo™.

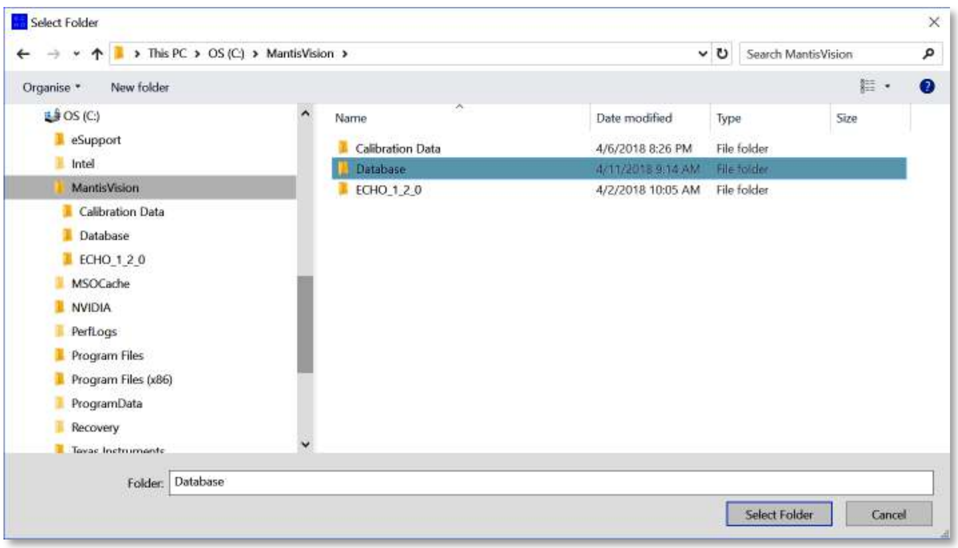


Figure 203 – Main Menu – Settings Option – Gallery Path – Select Folder window

The Full-screen Menu Option

The ***Full-screen*** view mode sets the Echo™ software to start its operation in full-screen mode (of the screen display).

Full-screen view mode is where the Windows™ operating system’s top **Quick Access** taskbar and bottom **Task Bar** are not included in the displayed data.

In the full-screen view mode case, the screen displays as much as possible of the Echo™ information. The ***Full-screen*** option is identical to the:

- ***Switch to Full Screen*** command-button explained the section “The Switch to Full Screen Command-Button” in page **149 above**, or

- **Main Menu – Settings** dialog-box' ***Start in Full-Screen*** menu option (see page **168 above**).

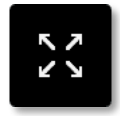


Figure 204 – The Full Screen command-button

The Calibration Menu Option

The camera is delivered subsequent to a comprehensive production-line calibration procedure. But, with time, conditions and workload, the calibration quality might deteriorate, and the camera might need to undergo a **Field Calibration** process.

Assessing the Need for Field Calibration

The method for judging whether the camera require **Field Calibration** or not begin by scanning a white, flat and smooth wall. The resulting **Point-Cloud** should display a smooth flat and clean surface. But, if the resulting **Point-Cloud** is of a ripped and torn surface (like the one presented in Figure 205 **below**), it clearly indicates that the camera require a **Field Calibration**.

Figure 205 – Ripped and Torn Surface Indicating the Need for Field Calibration

Components of the Field Calibration page

The process of **Field Calibration** is activated by selecting the **Calibration Menu option** from the **Main Menu** which open the **Field Calibration page** (see Figure 206 **below**).

The **Field Calibration page** consist of the following components (from top-left side of the screen, clockwise):

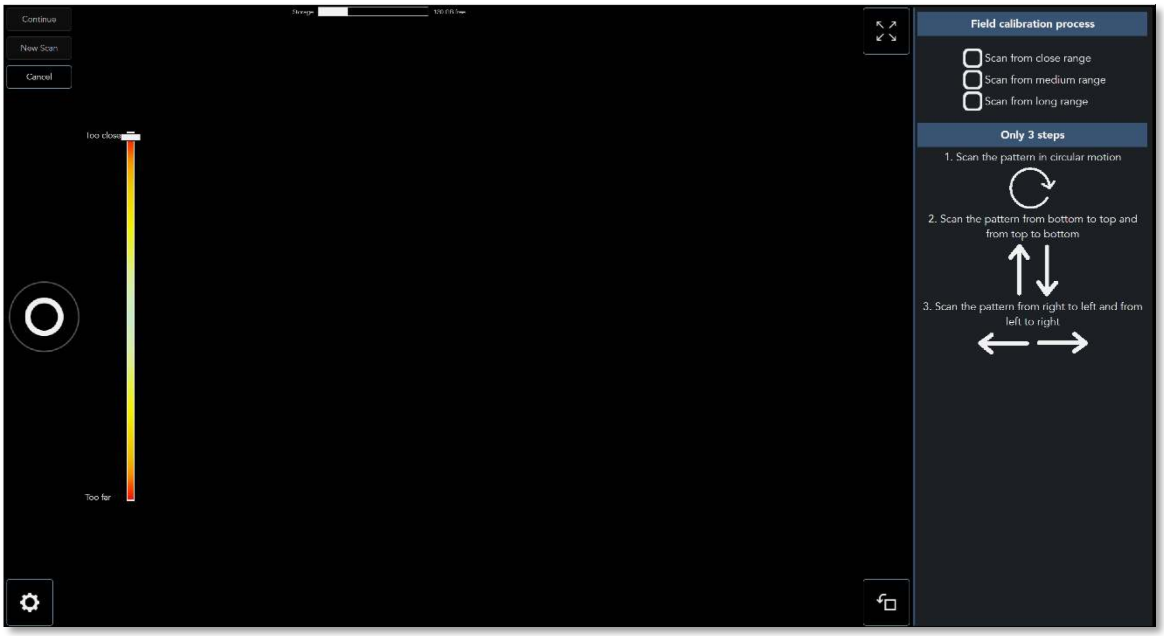


Figure 206 – Main Menu – Field Calibration page

- The **Calibration Scan Control** menu bar – used all through the calibration scan to continue a paused operation, start a new scan and cancel the calibration scan.

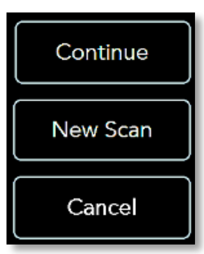


Figure 207 – The Main Menu – Calibration page – Control menu

The **Control menu** has three (3) command-buttons:

- The **Continue** command-button – some of the operations activated during the calibration scans are paused for the user's response.

The **Continue** command-button is used for re-activation of such operations.

- The **New Scan** command-button – is used for triggering a new calibration scan following completion of an entire calibration process. This is typically required when the calibration process fails.
- The **Cancel** command-button – is used for termination of the on-going scan operation.

- The **Storage Meter** – presents to the user the amount of free storage space left in the workstation's hard-disk for the next scanning sessions.

Figure 208 – The Main Menu – Calibration page – Storage meter

- The **Laptop Battery Gauge** – presents the amount of energy left in the workstation's batteries for the next scanning sessions.

Figure 209 – Main Screen – Scan View – The Laptop Battery Gauge

- The **Scanner Battery Gauge** – presents the amount of energy left in the camera's batteries for the next scanning sessions.

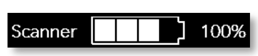


Figure 210 – Main Screen – Scan View – The Scanner Battery Gauge

The **Switch to Full Screen** command-button – enlarges the screen display to a full-screen view mode, where Windows™ operating system's top **Quick Access toolbar** and bottom **Task Bar** are not included thus enlarging the display realty as much as possible for the Echo™ data.

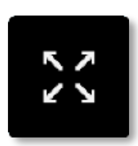


Figure 211 – The Main Menu – Calibration page – Full Screen command-button

In full-screen view mode, to return to normal mode, select the **Switch to Normal Screen** command-button which replaces the **Switch to Full Screen** command-button:

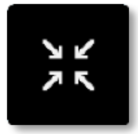


Figure 212 – Calibration page – Switch to Normal Screen command-button

- The **Calibration Support Billboard** – the right side of the screen is dedicated for support of the calibration process as a Help billboard.

  It is coaching the user about the three (3) steps to be executed in the calibration process and provide follow-up broadcasting of their execution.

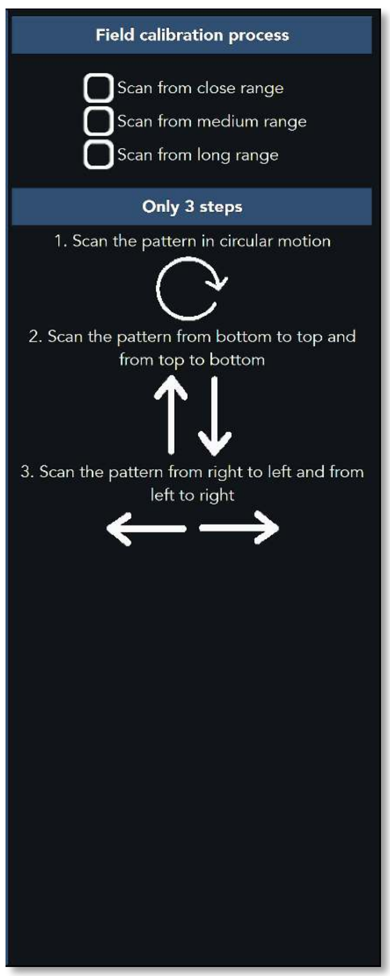


Figure 213 – The Main Menu – Calibration page – Calibration Support Billboard

The top end of the billboard is the calibration progress broadcasting section of the billboard reporting the completion of each of the three (3) steps of calibration scans (see details below) – whenever a step is accomplished, its status-box ( ) will be marked ( ).

The bottom part (below the "***Only 3 steps***" title) is the help section of the billboard, explaining the three (3) movements of the camera for calibration.

- The **Rotate View command-button** – enables rotation of the viewed scanning scene.

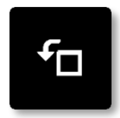


Figure 214 – The Main Menu – Calibration page – Rotate View command-button

NOTE:	Rotating the view only affects the displayed information, not the recorded data.

- The **Settings command-button** – reactivate the calibration process. Once selected, the **Camera Selection** dialog-box will re-open (see Figure 223 in page 179 below) and the process of calibration will restart from the below step (g) (see page 179). Reactivating the calibration process from the beginning might be required if the camera is different than the one defined for the calibration.

Figure 215 – The Main Menu – Calibration page – Settings command-button

- The **Scan On-Off Switch** – is the ON-OFF toggle switch for the scanning act:

Figure 216 – The Main Menu – Calibration page – Scan On/Off command-button

Once switched ON, the button changes its color to red to indicate that the scanner is active:

Figure 217 – Calibration page – Scan Switch in ON state

- The **Distance Meter** – the calibration process requires three (3) scanning sessions performed in three (3) distinctive distances from the **Field Calibration Pattern**.

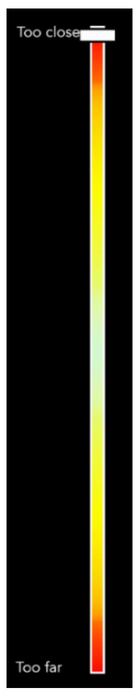


Figure 218 – The Main Menu – Calibration page – Distance Meter

Since these scans are done by hand, maintaining these distances, which need to be accurate, is pending the users' ability to measure the distance in real-time (during the scan).

The **Distance Meter** serves this exact purpose by utilizing the Echo™ ability to accurately measure distances (see section "The Measurement Toolbar in page 127 above).

The Field Calibration Procedure

1. **Preparations** for Field Calibration:

   a. Check to see that the Echo™ software version is 1.2.0 or higher.

      See section "The About Option" in page **167 above**.

   b. Download (https://www.mantis-vision.com/f6/f6-smart-field-calibration-2/) and print the **Field Calibration Pattern**.

      The **Field Calibration Pattern** should be printed on a white A3-size (297 x 420mm 11.7 x 16.5in.) paper.

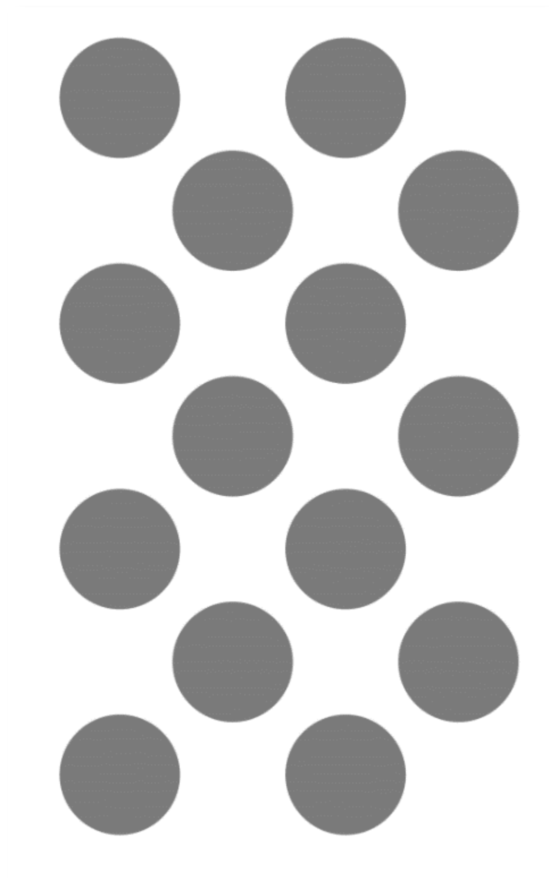


Figure 219 – The Field Calibration Pattern

   c. Check to see that the camera's battery is fully charged as well as the workstation's battery which need to be at least 50% charged.

   d. Check to see that the MVX Files' setup data is set to **8fps**. See section "*MVX* command-button" in page **154 above**.

e. Attach the **Field Calibration Pattern** page onto a vertical flat wall, at about 1.50m (~4ft 11”) from the floor (approximately at chin level).

   Check to see that there are no obstacles (i.e. furniture or other objects) that might interfere in the process.

2. **Launching the Field Calibration process**:

   a. Select the ***Calibration*** option in the **Main Menu**.

   b. A drop-down ***Calibration Menu*** will open for confirmation:

Figure 220 – The Main Menu – Calibration Menu

   c. Select the “***Start new calibration***” menu option to trigger the process.

   d. The **Calibration window** will open:

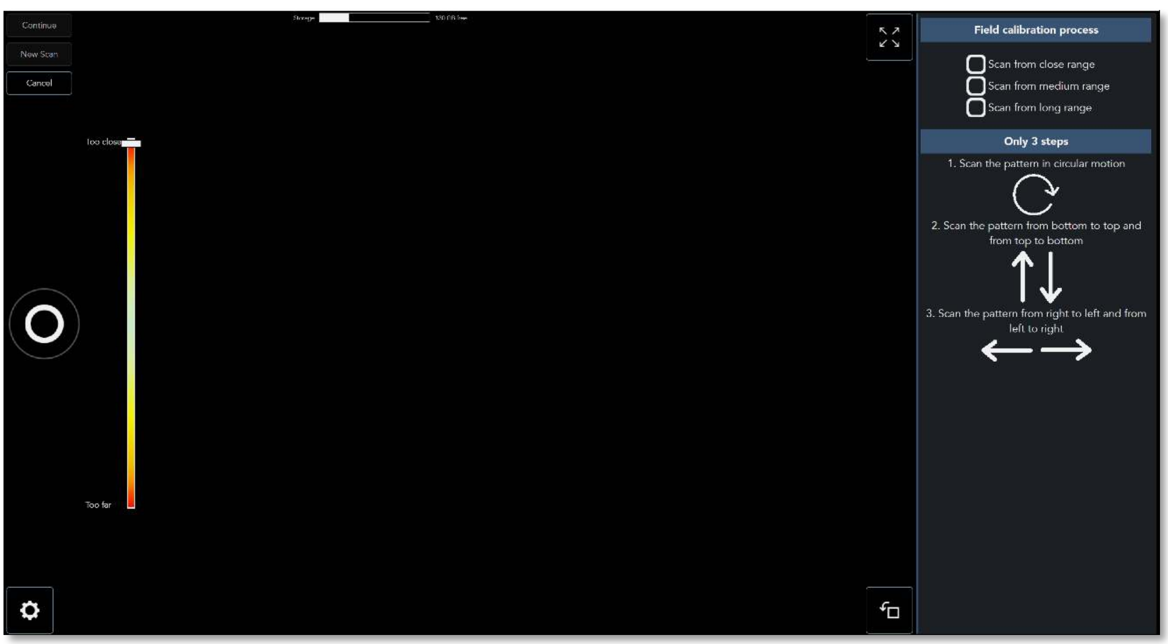


Figure 221 – The Main Menu – Calibration window

Description of the screen components is provided above and below.

e. The ***Are you sure?*** drop-down menu will open on top of the **Calibration window** for confirmation:

Figure 222 – The Main Menu – Calibration window – Are You Sure menu

f. Confirm the field calibration action by selecting the ***Yes*** option.

There is also an option to terminate the field calibration process by selecting the ***No*** option.

g. Once confirmed, the ***Camera*** selection dialog-box will open:

Figure 223 – The Main Menu – Calibration window – Camera selection dialog-box

This is an identical dialog-box to the one used in the Initial Setup of the (see page **42 above**) or in the Main Screen – Scan View Mode – The Settings Toolbar (see page **158 above**).

In this field-calibration procedure, it will be used for selecting the camera device to be calibrated.

h. Select the camera to be calibrated by highlighting its serial number and then select the ***Choose*** command-button to accept the selection.

i. An interim message-window will pop-up to inform about ***Starting calibration…*** and will disappear soon after:

Figure 224 – The Main Menu – Calibration window – Starting Calibration message-box

j. A procedural continuation message window will open to say –***Scan the calibration pattern following the guidelines specified in video tutorial***:

Figure 225 – The Main Menu – Calibration window – Message window

k. Select the ***OK*** command-button to activate the process.

The actual field calibration process commences at this point and its execution is being followed-up and broadcast on the **Field Calibration Support Billboard**'s top-end.

The process is constructed of three (3) distance-pending scanning rounds (phases), each of which is made up of three (3) scanner motion types.

All together there are nine (9) scanning steps.

l. Once the ***OK*** option is selected, the following short-term message window pops-up to initiate the first calibration phase – the **Close-Range Scan**:

Figure 226 – Calibration Scanning First Phase (Close Range) Message window

This phase is for calibrating at close range of ~70cm (~27.5in.).

II. Press the **Trigger Switch** (or activate the **Scan On-Off** command-button) and scan the **Field Calibration Pattern**, from a distance of ~70cm (~27.5in.), in a clockwise-circular motion 1-2 times:

Figure 227 – Clockwise Circular Scanning Motion

To support the distance-pending scanning, the system measures, online, these distances and present it on the **Distance Meter** (see Figure 228 **below**).

The **Distance Meter** is a ball-park meter type – when the measured distance is right, its needle will be at the center of the meter.

NOTE: There is no need to be extremely accurate about "holding the ball" at the very center.

Keeping the needle within the green range is good enough for accurate calibration.

Exercise this clockwise circular motion scan 1-2 times while paying attention to keep the **Field Calibration Pattern** at the center of the picture.

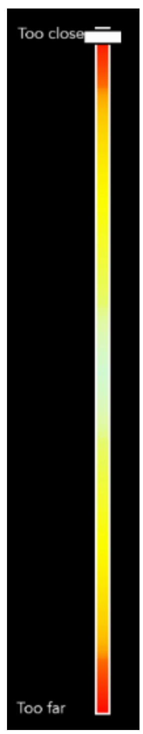


Figure 228 – The Main Menu – Calibration window – Distance Meter

III. Perform a vertical semi-circular motion scan as presented in Figure 229 below.

Pay attention to keep the **Distance Meter**'s needle at the center (green zone) and the **Field Calibration Pattern** at the center of the picture.

Exercise this vertical semi-circular motion once.

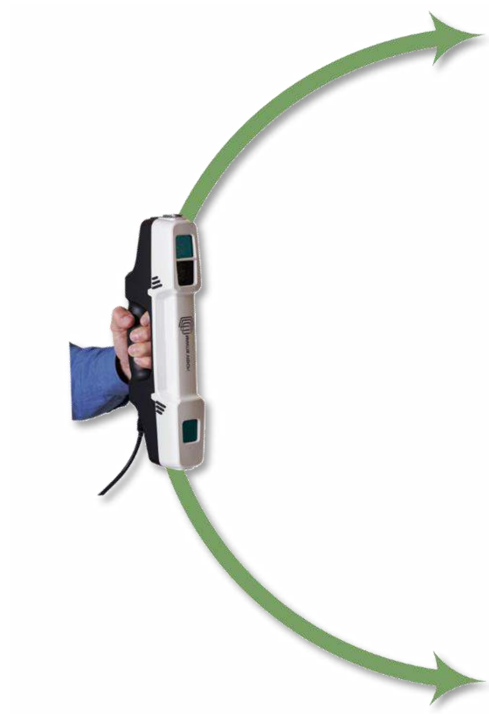


Figure 229 – Calibration window – Vertical Scanning Motion

IV. Perform horizontal semi-circular motion as demonstrated in Figure 230 below.

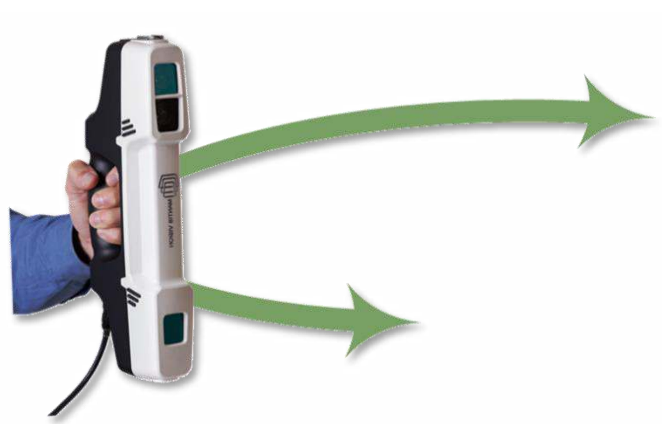


Figure 230 – Calibration window – Horizontal Scanning Motion

V. Press the scanner's **Triggering Switch** (or activate the Scan On-Off command-button) to inform the software that the first step is done.

VI. The calibration phase status in the **Calibration Support Billboard** will be updated:

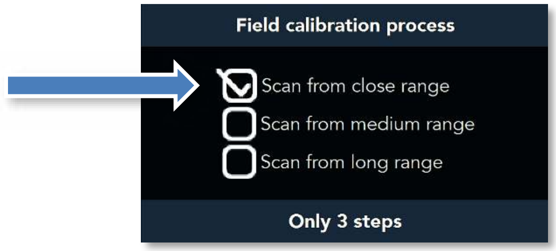


Figure 231 – Calibration window – Calibration Support Billboard – Status Update

VII. A new **Calibration Scanning Second Phase (Medium Range)** message window will open:

Figure 232 – Calibration Scanning Second Phase (Medium Range) Message window

VIII. Repeat the above steps **II-V** for medium range (1.25 meter).

IX. The calibration phase status in the **Calibration Support Billboard** will be updated:

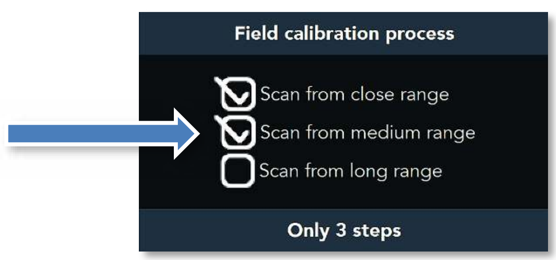


Figure 233 – Calibration window – Calibration Support Billboard – Status Update

X. A new **Calibration Scanning Second Phase (Long Range)** message window will open:

Figure 234 – Calibration Scanning Second Phase (Long Range) Message window

XI. Repeat the above steps **II-V** for long range (1.8 meter).

XII. The calibration phase status in the **Calibration Support Billboard** will be updated:

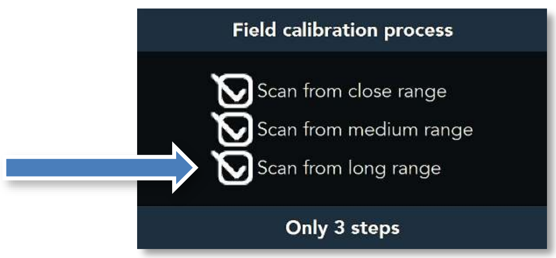


Figure 235 – Calibration window – Calibration Support Billboard – Status Update

l. Once all the above-described phases and steps are done, the Echo™ software will process the scanned data while displaying its progress:

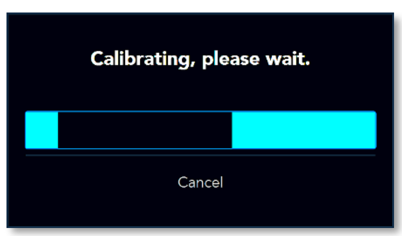


Figure 236 – Calibration window – Calibration Data Processing progress meter

m. The processing would normally end with new calibration data updating the **Calibration Files** (see paragraph "Uploading the Camera's Calibration Files" in page **40 above**) while presenting the following message window:

Figure 237 – Calibration window – Calibration Successful Termination message

Select the *OK* command-button to terminate the calibration process and return to the Gallery.

In case the calibration scanned data was insufficient or erroneous, the following message will be displayed:

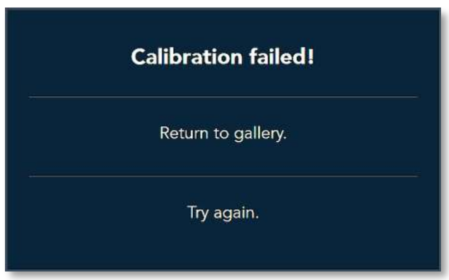


Figure 238 – Calibration window – Calibration Failure message

There are two (2) menu options to select from:

- Terminate the calibration process and ***Return to Gallery***, or
- Go back to the above phase **g** and ***Try again*** to calibrate the camera.

The Quit Menu Option

The ***Quit*** menu option terminates the Echo™ software application.

Main Menu in Both Gallery View Mode's Edit Pages

While in **Gallery View Mode – Edit (Third) Page** (both in The Edit Page for Raws and Editables page and The Edit Page for Spawns page), the **Main Menu** include three (3) more options:

- The ***Save*** menu option – saving the image in process,

- The ***Save As*** menu option – for saving under a different name, and
- The ***Export*** menu option – for exportation of the image into other file formats.

Figure 239 – Main Menu in Gallery View – Second Page

The Save Menu Option

The ***Save*** menu option is used throughout the entire process of editing the image, for the elementary reason of saving the work done.

Selecting this option will activate savior procedure which stores the file/data records into the workstation's hard-disk, while reporting its progress via a **Progress meter**:

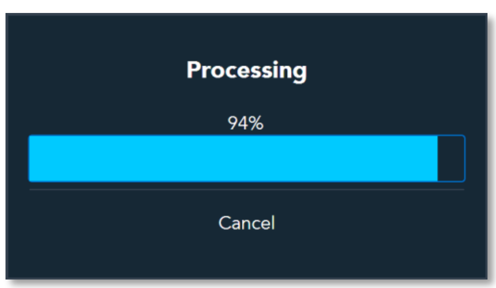


Figure 240 – Main Menu in Gallery View – Second Page – Save Progress meter

The time required for this procedure to complete is pending the complexity of the image and the performances of the workstation.

This procedure may be terminated by selecting the ***Cancel*** command-button.

The Save As Menu Option

The ***Save As*** menu option is used throughout the entire process of editing the image, for saving the work done under a different file/**Project** name.

Selecting this option will open the ***Enter a name*** dialog-box where, by default, the original **Project** name is displayed but can be over-written to reflect the new name required:

Figure 241 – Main Menu in Gallery View – Second Page – Enter a name dialog-box

Selecting the ***OK*** command-button will save the data to the workstation's hard-disk, while reporting its progress via a **Progress meter**:

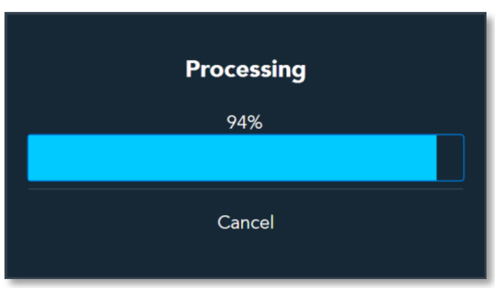


Figure 242 – Main Menu in Gallery View – Second Page – Save As Progress meter

There is also an option to cancel this operation by selecting the ***Cancel*** command-button.

The Export Menu Options

The ***Export*** menu option in the ***Main Menu*** allows exportation of all three (3) files/records data of the **Gallery View** mode's second page (***Raws***, ***Editables*** and ***Spawns***) into other market-accepted 3D and video formats detailed below.

Selecting the ***Export*** option of the ***Main Menu*** opens the ***Export*** Menu:

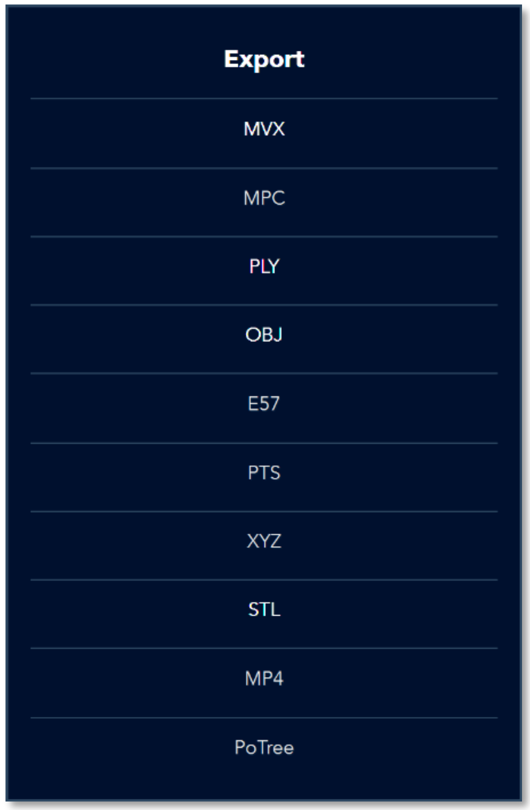


Figure 243 – Main Menu in Gallery View – Second Page – Export Menu

The exportation options provided in this menu are:

The MVX File Format Option

Mantis Vision's proprietary ***MVX*** file-format files are **Container** type files.

A container (or wrapper) file-format is a metafile format whose specification describes how different elements of data and metadata coexist in a computer file.

In other words – it is the image of the virtual drive stored in a big file.

The container file is used to identify and interleave different data types and it specifies only the wrapper (but not the coding).

The different elements constructing the container file are stored in the container in **Layers** each of which deals with another type of data.

By definition, a container format could wrap any kind of data (but not the decoding algorithms of the data).

Such containers are frequently used in multimedia applications. Since the container does not describe how the encompassed data or metadata is encoded, the program using this data must be able to identify and open/decode the container file.

Mantis Vision's MVX file is structured as a linear sequence of **Atoms** preceded by the MVX' header.

- **Atom**s are containers constructing the **MVX Files**.
- **Atom**s are usually used as frames for grouping some assortments of **DataLayers** which share the same **Timestamp** and **StreamID**.
- **DataLayers** – are blocks of data.
- **Stream** – are streams of **Atoms** sharing the same **StreamID**.
- **StreamID** – is a string identifying the **Stream**.

Only two (2) types of **Atoms** were defined by Mantis Vision so far:

NOTE: The format is flexible enough to support more than two.

- **FRAME**, and
- **LUT** (Lookup-Table).

The **LUT indicator** is optionally added at the very end of an MVX file and should only be added when the very last **Atom** of the MVX file is an **Atom** type **LUT**.

Atoms type **FRAME** are written throughout recording time.

Atom type **LUT** is recorded at the very end of the recording session since it contains aggregated information of all previously recorded **Atom**s.

Absolute offset to **Atom** type **LUT** cannot be foreseen by a file reader at read time or forecasted in advance by a file-writer.

For that reason, this information is added at the very end of the MVX file, giving file-readers the possibility to take advantage of the information in **Atom** type **LUT**.

On data-format level, **DataLayers** are divided into **Header** and **Body**. The **DataLayer Header** is completely type-agnostic in nature and serialized/deserialized on the level of the MVX framework (file readers/writes, network transmitters/receivers etc.).

The **DataLayer Body** is fully type-specific and therefore serialized/deserialized on the level of **DataLayer** classes, implemented by the corresponding C++ programmers.

Mantis Vision implemented many **DataLayers** by itself, gaining important insights on how to optimize performance and minimized memcopies on a C++ level.

The resulting mechanisms and patterns, on a C++ level, might look counter-intuitive at first glance and therefore not very 'beautiful', but they are simply effective in terms of performance and memory usage in typical and performance critical use-cases.

A core principle of MVX is – **DataLayers** never change, from the moment of formation until they get destroyed. While this is true for almost all cases, there are, meanwhile, some **DataLayers** related to configuration settings where changes happen at runtime.

This cases now look extra-complicated on a C++ level, since a change of any value of a **DataLayer** automatically results in a direct serialization of the entire **DataLayer**.

Selecting the ***Export*** to ***MVX*** file format will open the ***Export Settings*** dialog-box:

Figure 244 – Export Menu Options – MVX – Export Settings dialog-box

The ***Merge frames within groups*** option is not yet released. Do not change the default marking.

Select the ***Go!*** command-button to execute the exportation act.

A ***Save As*** window will open where the resulting file's storage repository (directory) can be set:

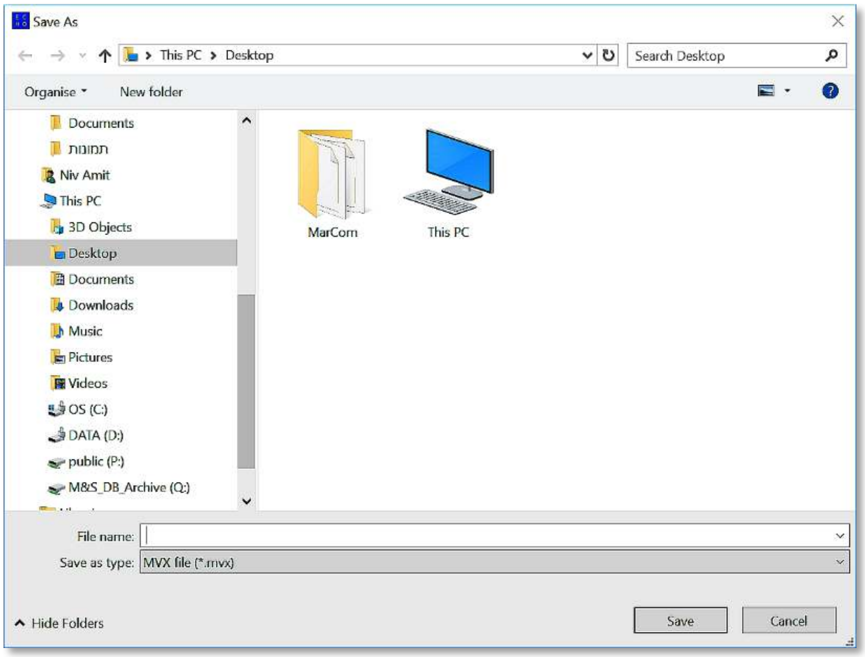


Figure 245 – Export Menu Options – MVX – Save As window

Type-in the file's name (the file extension is fixed to MVX) and select the ***Save*** command-button to execute the exportation.

Selecting the ***Cancel*** command-button will cancel the operation and terminate the export process.

The progress of exportation will be presented by a ***Processing*** progress meter:

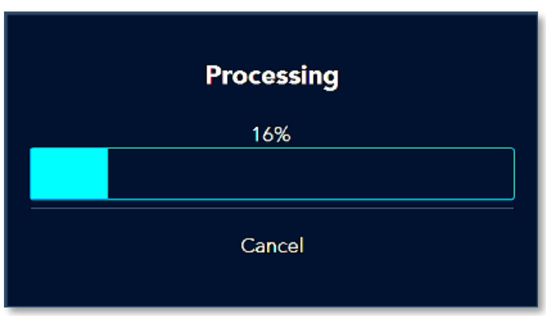


Figure 246 – Export Menu Options – MVX – Export Progress meter

The MPC Format Option

The **MPC** is Mantis Vision's legacy data file format developed and used in its previous 3D software products.

Unlike the above-described **MVX** file format, the **MPC** is not a container file allowing coexistence of different data types in the same file, but a unified file format storing:

- Point-Clouds of single Frames only.
- Each Point of the Point-Cloud is described with:
  - XYZ Cartesian coordinates of the Point,
  - Color (RGB) data of the Point, and
  - Normal of the Point (direction vector for the polygon that will be created from the Point and its neighbors).

The **MPC** file format DOES NOT include data regarding the physical relations between the Frames (description of how the scanner moved from one scanned Frame to the next).

For that purpose, there is an associated file, with the extension of *.TOC*, that must always accompany the **MPC** files.

Selecting the ***Export*** to ***MPC*** file format will open the ***Export Settings*** dialog-box:

Figure 247 – Export Menu Options – MPC – MPC Export Settings dialog-box

There are three (3) options of settings available in the ***MPC Export Settings*** dialog-box:

- ***Export Colors*** – selecting this option will add colors to the mesh (the original MPC file format did not include color information). The colors are derived from the color video stream recorded during the scan operation.
- ***Text Labels*** – this option is a parameter affecting MPC file-format only.

  Select the default option of ***Version 6***.
- ***Merge Frames within Groups*** – this option is not yet released.

  Do not change the default marking!

Once the options are set (or not), select the ***Go!*** command-button to execute the exportation act.

A ***Save As*** window will open where the resulting file's storage repository (directory) can be set:

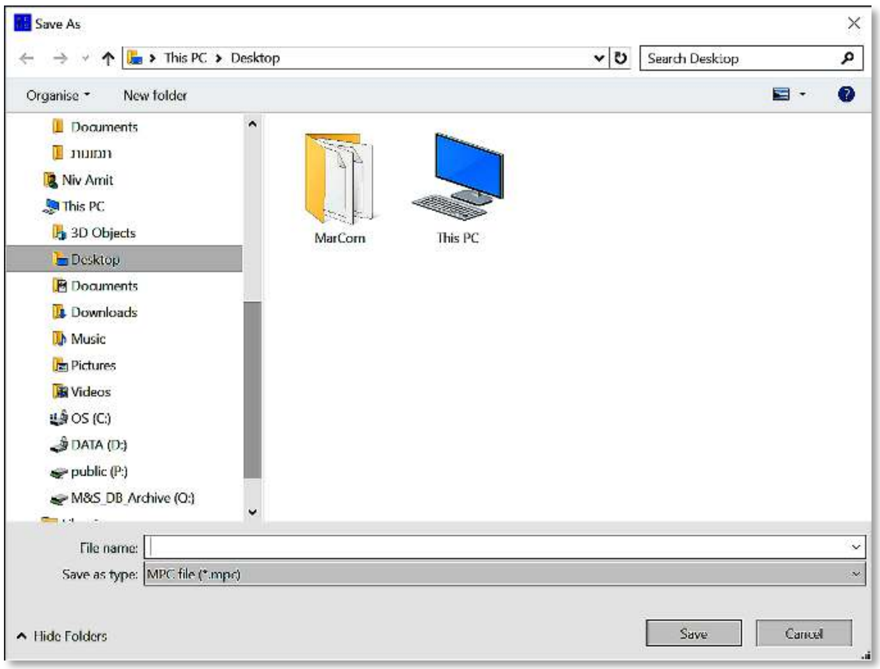


Figure 248 – Export Menu Options – MPC – Save As window

Type-in the file's name (file extension is fixed to MPC) and select the ***Save*** command-button to execute or ***Cancel*** – to cancel the operation and terminate the export process.

The progress of exportation will be presented by a ***Processing*** progress meter:

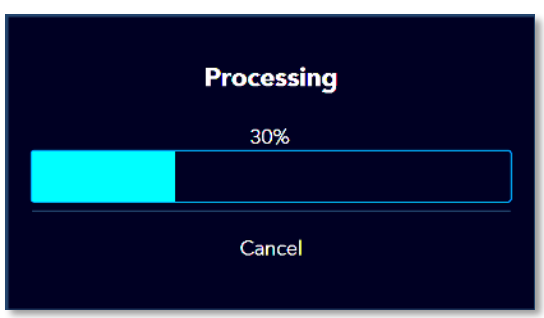


Figure 249 – Export Menu Options – MPC – Export Progress meter

The PLY File Format Option

PLY is a computer file format known as the **Polygon File Format** or the **Stanford Triangle Format** primarily designed to store 3D data from 3D scanners.

The design of this format was inspired by the Wavefront Technologies' **OBJ** format (see below).

This format support relatively simple description of a single object as a list of nominally flat polygons.

A variety of properties can be stored, including: color and transparency, surface normals, texture coordinates and data confidence values.

The format permits different properties for the front and back of a polygon.

There are two versions of the file format – ASCII and binary. In the ASCII version, the vertices and faces are each described one-to-a-line with the numbers separated by white space.

In the binary version, the data is simply packed together at the 'endianness' specified in the header and with the data types given in the 'property' records.

For the common "property list..." representation for polygons, the first number for that element is the number of vertices that the polygon has, and the remaining numbers are the indices of those vertices in the preceding vertex list.

PLY files are organized as a header, that specifies the elements of a mesh and their types, followed by the list of elements itself.

The elements would normally be vertices and faces, but may include other entities such as edges, samples of range maps, and triangle strips.

Selecting the ***Export*** to ***PLY*** file format will open the ***Export Settings*** dialog-box:

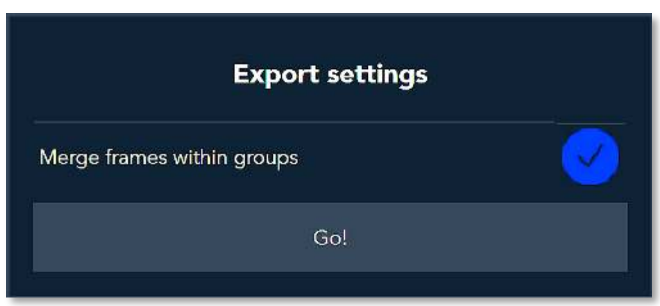


Figure 250 – Export Menu Options – PLY – Export Settings dialog-box

The ***Merge frames within groups*** option is not yet released.

NOTE: Do not change the default marking!

Once the option is selected (or not), select the ***Go!*** command-button to execute the exportation act.

A ***Save As*** window will open where the resulting file's storage repository (directory) can be set:

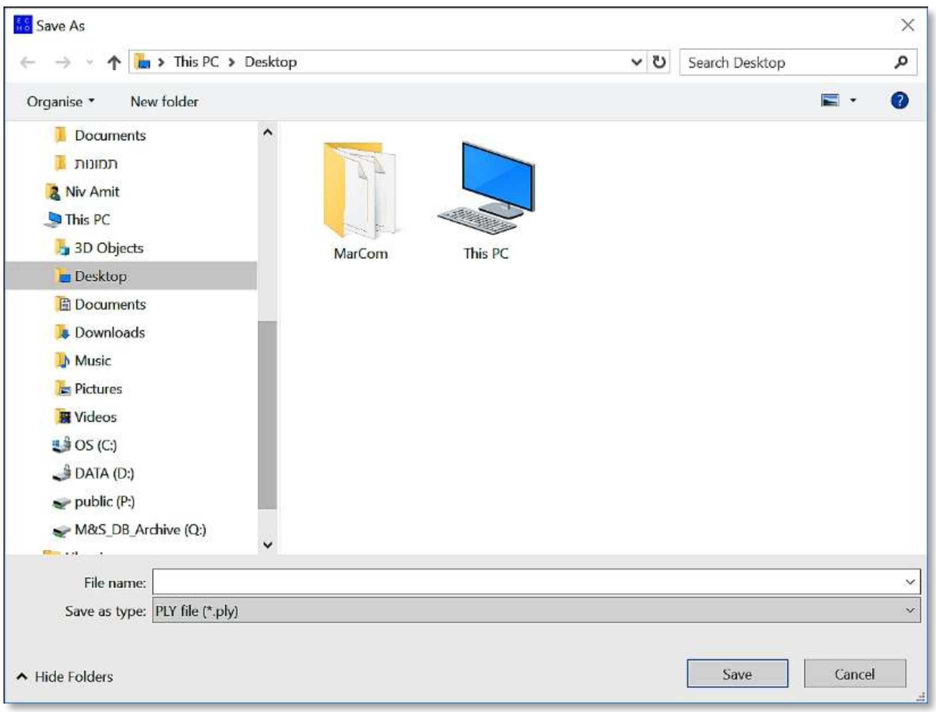


Figure 251 – Export Menu Options – PLY – Save As window

Type-in the file's name (file extension is fixed – PLY) and select the ***Save*** command-button to execute the exportation or ***Cancel*** – to cancel the operation and terminate the export process.

The progress of exportation will be presented by a ***Processing*** progress meter:

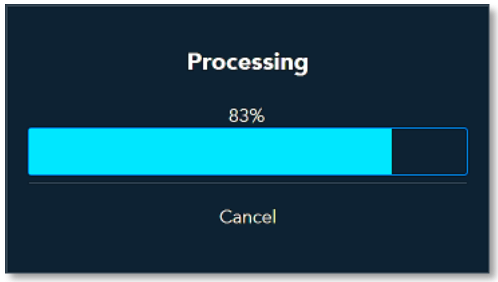


Figure 252 – Export Menu Options – PLY – Export Progress meter

The OBJ File Format Option

OBJ is a geometry definition file format initially developed by Wavefront Technologies™ for its animation package.

The standard has widespread support among different computer software packages, making it a useful format for interchange of materials.

The OBJ file format is a simple data-format representing 3D geometry alone — the position of each vertex, the UV position of each texture coordinate vertex, vertex normals, and the faces that make each polygon defined as a list of vertices, and texture vertices.

Vertices are stored in a counter-clockwise order by default, making explicit declaration of face normals unnecessary.

OBJ coordinates have no units, but OBJ files can contain scale information in a human readable comment line.

OBJ files references one or more Material Template Library format (MTL) files that describes surface shading (material) properties of objects within one or more OBJ files.

MTL files are ASCII text that define the light reflecting properties of a surface for the purposes of computer rendering, and according to the Phong reflection model.

Selecting the ***Export*** to ***OBJ*** file format will open the ***Export Settings*** menu:

The ***Merge frames within groups*** option is not yet released.

Do not change the default marking.

Figure 253 – Export Menu Options – OBJ – Export Settings dialog-box

Select the ***Go!*** command-button to execute the exportation act. A ***Save As*** window will open where the resulting file's storage repository (directory) can be set:

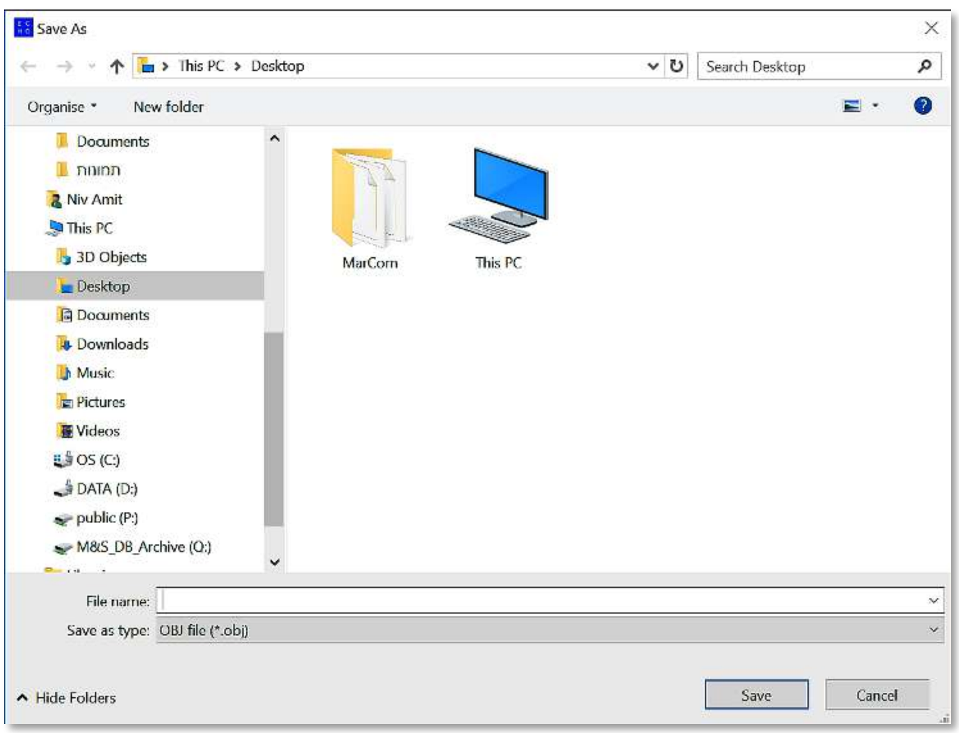


Figure 254 – Export Menu Options – OBJ – Save As window

Type-in the file's name (file extension is fixed to OBJ) and select the ***Save*** command-button to execute the exportation or ***Cancel*** – to cancel the operation and terminate the export process.

The progress will be presented by a ***Processing*** progress meter:

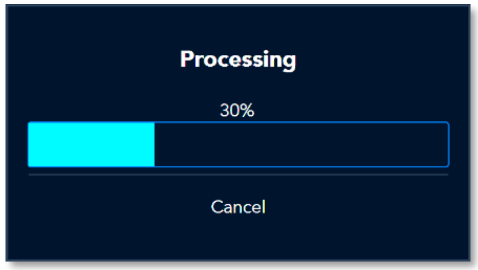


Figure 255 – Export Menu Options – OBJ – Export Progress meter

The E57 File Format Option

The **E57** is a **LIDAR** (light detection and ranging) Point-Cloud data file format.

Their file format is normally used for storing data captured by 3D imaging systems.

3D image file created in ASTM's (voluntary standards developing organization) **E57** 3D format saves LIDAR data captured by 3D range cameras.

It also enables remote sensing data to be saved in a vendor-neutral format.

E57 files can be used for rendering images of real-world objects, such as buildings, atmospheric entities (e.g. clouds), and geological surfaces which is useful for construction, surveying, engineering and research applications.

NOTE: The **E57** file format uses a combination of binary and XML data.

Selecting the ***Export*** to ***E57*** file format will open the ***Export Settings*** dialog-box:

Figure 256 – Export Menu Options – E57 – Export Settings dialog-box

The *Merge frames within groups* option is not yet released. Do not change the default marking!!!

Select the *Go!* command-button to execute the exportation act.

A *Save As* window will open where the resulting file's storage repository (directory) can be set:

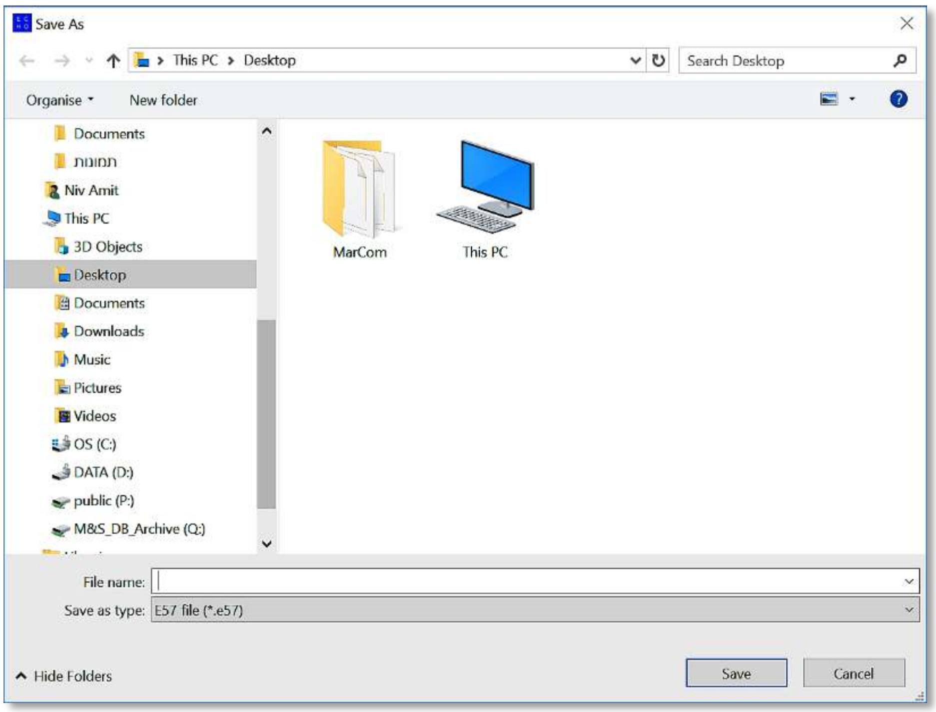


Figure 257 – Export Menu Options – E57 – Save As window

Select the *Save* command-button to execute the exportation or *Cancel* – to cancel the operation and terminate the export process.

The progress of exportation will be presented by a *Processing* progress meter:

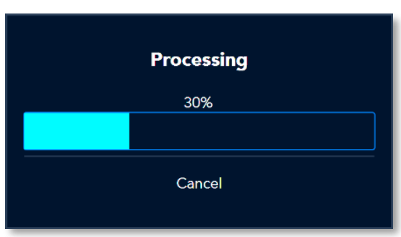


Figure 258 – Export Menu Options – E57 – Export Progress meter

The PTS File Format Option

PTS file is an ENVI (ENvironment for Visualizing Images) Ground Control Point file.

ENVI (ENvironment for Visualizing Images) is a software application used to process and analyze geospatial imagery.

Ground Control Point file used in image processing of remote sensing data.

The **PTS** format is often described as a "dumb format" because it does not retain any original scan or registration information.

In this regard, it is very similar to the ASCII file format.

The **PTS** format is often used when exporting final registered Point-Clouds that have been unified in Cyclone.

Also, the **PTS** format is often used in place of the PTX format for import into software that do not directly support PTX files.

Selecting the ***Export*** to ***PTS*** file format will open the ***Export Settings*** menu:

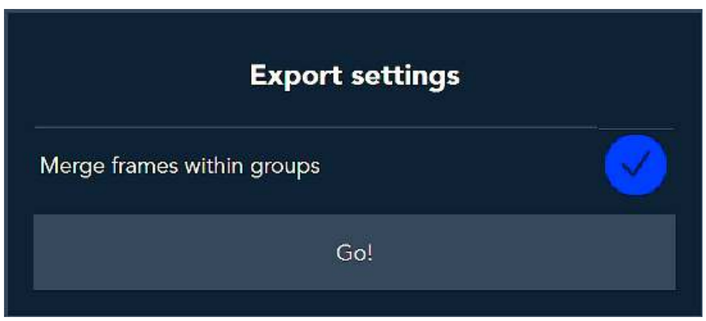


Figure 259 – Export Menu Options – PTS – Export Settings dialog-box

The ***Merge frames within groups*** option is not yet released. Do not change the default marking. Select the ***Go!*** command-button to execute the exportation act.

A ***Save As*** window will open where the resulting file's storage repository (directory) can be set:

Select the ***Save*** command-button to execute the exportation or ***Cancel*** – to cancel the operation and terminate the export process.

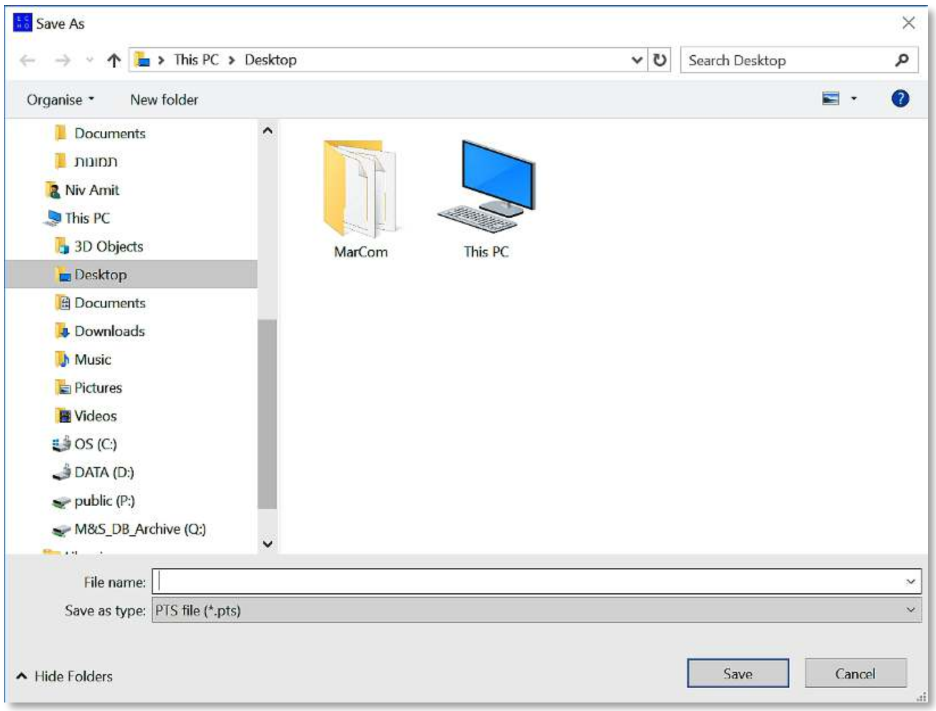


Figure 260 – Export Menu Options – PTS – Save As window

The progress of exportation will be presented by a ***Processing*** progress meter:

Figure 261 – Export Menu Options – PTS – Export Progress meter

The XYZ File Format Option

The XYZ file format is a file format created for chemistry applications.

There is no formal standard and several variations exist, but a typical XYZ format specifies the molecule geometry by giving the number of atoms with Cartesian coordinates that will be read on the first line, a comment on the second, and the lines of atomic coordinates in the following lines.

The file format is used in computational chemistry programs for importing and exporting geometries. The units are generally in angstroms.

Some variations include using atomic numbers instead of atomic symbols or skipping the comment line.

XYZ file formats are probably the simplest of the 3D structure files, since they contain little more than the x, y and z coordinates of each atom in the molecule.

Other information, such as bond order or charge is not specified.

Despite their simplicity, XYZ files are very useful since many XYZ files can be joined together into one long file, which when interpreted by an appropriate graphics package, appear as animation in the browser.

Because the graphics package decides if there is a bond between atoms based only on their proximity, atoms which move closer together and then further apart will appear to form a bond and then break it again.

Selecting the ***Export*** to ***XYZ*** file format will open the ***Export Settings*** dialog-box:

Figure 262 – Export Menu Options – XYZ – Export Settings dialog-box

The ***Merge frames within groups*** option is not yet released. Do not change the default marking. Select the ***Go!*** command-button to execute the exportation act.

A ***Save As*** window will open where the resulting file's storage repository (directory) can be set.

Select the ***Save*** command-button to execute the exportation or ***Cancel*** – to cancel the operation and terminate the export process:

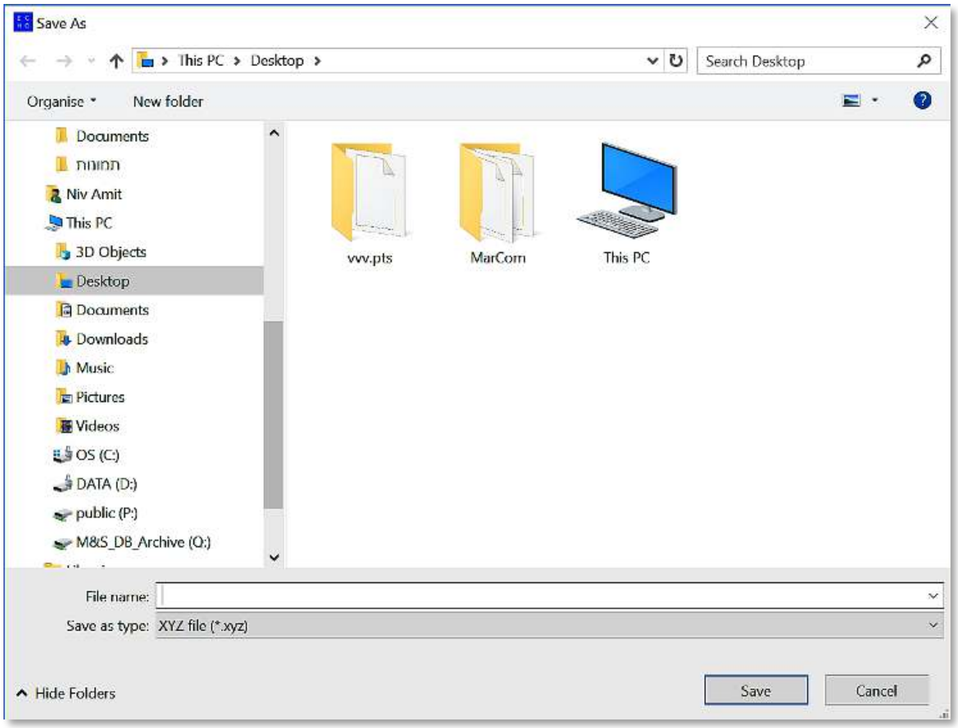


Figure 263 – Export Menu Options – XYZ – Save As window

The progress of exportation will be presented by a ***Processing*** progress meter:

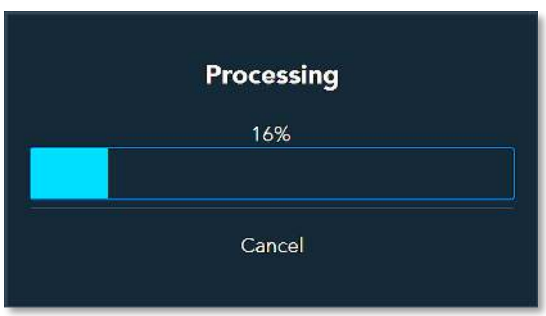


Figure 264 – Export Menu Options – XYZ – Export Progress meter

The STL File Format Option

The **STL** (STereoLithography) is a file format native to the stereolithography CAD software created by 3D Systems.

Invented by the Albert Consulting Group for 3D Systems in 1987, for 3D Systems' first commercial 3D printers.

The format is supported by many other software packages and is widely used for rapid prototyping, 3D printing and CAM.

STL files describe only the surface geometry of a 3D object without any representation of color, texture or other common CAD model attributes.

It specifies both ASCII and binary representations. Binary files are more common since they are more compact.

An STL file describes a raw, unstructured triangulated surface by the unit normal and vertices (ordered by the right-hand rule) of the triangles using a 3D cartesian coordinate system.

STL files contain no scale information, and the units are arbitrary.

STL file format is simple and easy to output. Consequently, many CAD systems can output the STL file format.

Although the output is simple to produce, some connectivity information is discarded.

Many CAM systems requires triangulated models.

STL format is not the most memory- and computationally efficient method for transferring this data, but STL is often used to import the triangulated geometry into the CAM system.

In order to use the data, the CAM system may have to reconstruct the connectivity.

STL can also be used for interchanging data between CAD/CAM systems and computational environments such as Mathematica.

The ***Export*** to ***STL*** format is not yet released.

The MP4 File Format Option

MPEG-4 Part 14 (formally ISO/IEC 14496-14:2003, also known as MP4, a standard specified as a part of MPEG-4) is a digital multimedia container format most commonly used for storage of video and audio.

It can also be used to store other data such as subtitles and still images. Like most modern container formats, it allows streaming over the Internet.

The MPEG-4 file format specification is based on the QuickTime format specification published in 2001.

Selecting the ***Export*** to ***MP4*** file format will open the ***Export Settings*** dialog-box:

Figure 265 – Export Menu Options – MP4 – Export Settings dialog-box

The ***Merge frames within groups*** option is not yet released. Do not change the default marking.

Select the ***Go!*** command-button to execute the exportation act.

A ***Save As*** window will open where the resulting file's storage repository (directory) can be set:

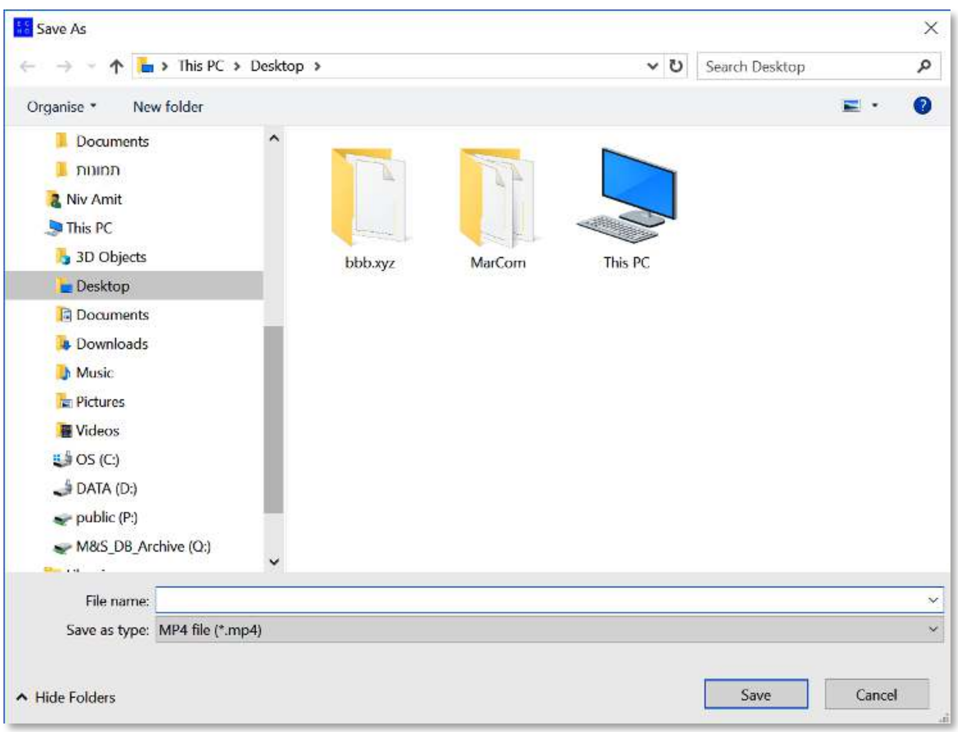


Figure 266 – Export Menu Options – MP4 – Save As window

Select the ***Save*** command-button to execute the exportation or ***Cancel*** – to cancel the operation and terminate the export process.

The progress of exportation will be presented by a ***Processing*** progress meter:

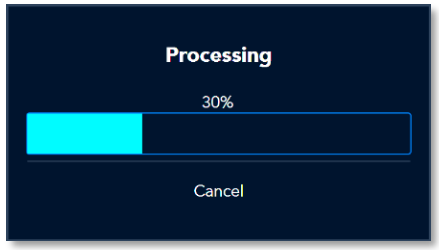


Figure 267 – Export Menu Options – MP4 – Export Progress meter

The Potree File Format Option

Unlike all the above described export procedures of 3D models from Echo™ to other file formats, exporting to Potree does not require any preliminary settings.

Therefore, when export to ***Potree*** option is selected from the ***Export*** drop-down menu:

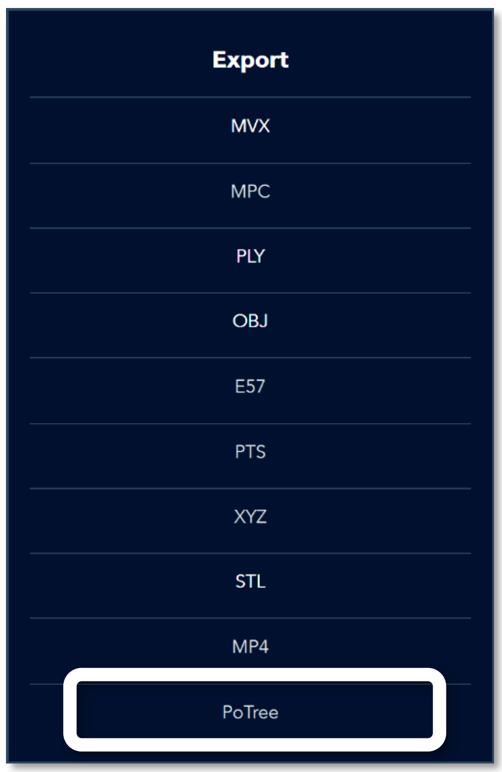


Figure 268 – Export Menu Options – Potree

The ***Save As*** window will open to prompt the user to indicate where the resulting file should be stored:

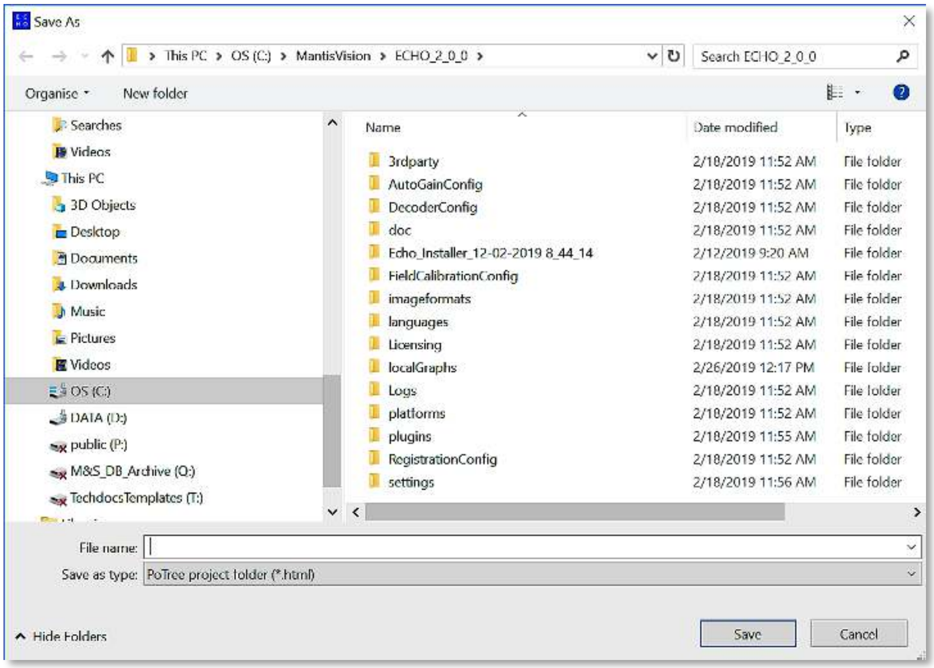


Figure 269 – Export Menu Options – Save As Window for Storage

Select the folder (directory) where the resulting file should be stored and select the ***Save*** command-button.

The export process starts as soon as the ***Save*** command-button is selected and its progress is reported by an ***Exporting*** progress-meter:

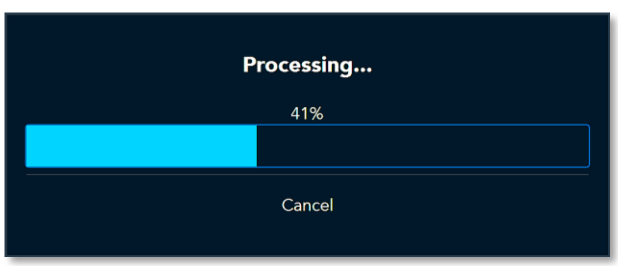


Figure 270 – Export Menu Options – Potree – Export Progress-meter

This export procedure engages Potree's format conversion program (***PotreeConvert.exe***) which uses both a progress-meter (see Figure 271 **below**) and a monitoring window (see Figure 272 **below**):

Figure 271 – Export Menu Options – Potree – External Process Message

The exportation process is complete as soon as both the above **Message** and **Monitor Window** are turned off, and the resulting *.HTML* file is stored in the directory selected.

This resulting *.HTML* file can be read by all popular web browser applications.

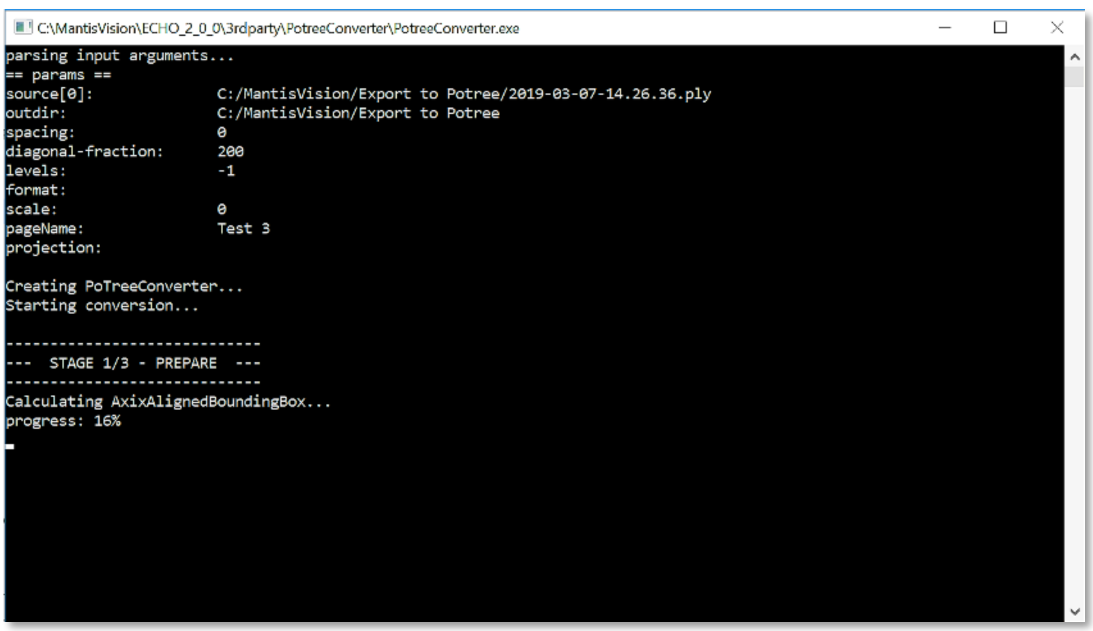


Figure 272 – Export Menu Options – Potree – External Process Monitor Window

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Chapter 6 The 3D Scanning Process

The Grand Finale of this User Guide is the following 3D Scanning Process flowchart concluding the elements described above.

Introduction to the Scanning Process

The scanning process is a procedural process with flowchart characteristics described in detailed steps below.

The ultimate goal of the scanning process is to produce a complete and accurate 3D model of the scanned object.

Prior to the actual scan, there is a need to perform some setup and verification steps to ensure best results.

Setups and Verifications for Scanning

To guarantee best results of the scanning act, the following items need to be set-up and/or verified prior to the execution of the scan act:

1. Verification of charging status of both the camera and the workstation.

   If not fully charged – connect to charger and verify full-charge status. This could be done by utilizing the **Laptop Battery Gauge** and the **Scanner Battery Gauge** described on page **149 above**.

2. Connect the camera to the workstation utilizing the USB cable as described in paragraph "Connecting the Camera to the Workstation" on page **39 above**.
3. Turn the camera ON.
4. Start the Echo™ software.
5. Select the ***Gallery*** command-button from the **Main Menu** bar:

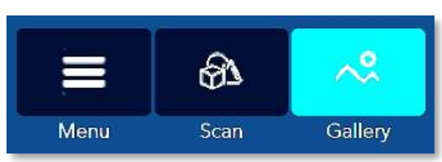


Figure 273 – Select Gallery from the Main Menu Bar

6. Initiate a new **Project** as described in paragraph "Gallery View Mode – First Page – The Actions Window – Creating a New Project" on page **60 above**.
7. Verify that the camera is correctly set as the active (***Current***) scanner as follows:
   a. Select the ***Scan*** command-button from the **Main Menu** bar:

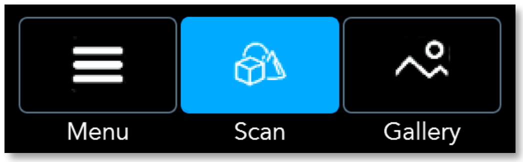


Figure 274 – Select Scan from Main Menu Bar

   b. Once the ***Start Recorder…*** message is turned off;

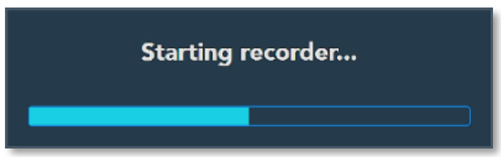


Figure 275 – Start Recorder… Message

Select the ***Camera*** command-button from the ***Settings*** menu:

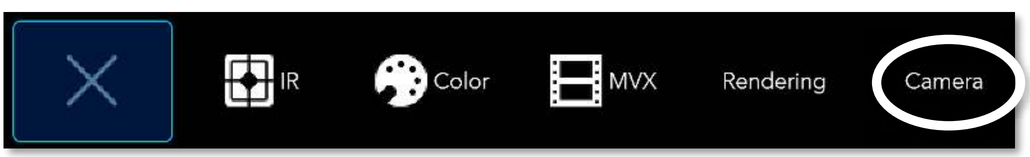


Figure 276 – Camera Command-Button in Settings Menu

In the Cameras' window that opens (see Figure 277 **below**), verify that the connected camera appears in the ***Cameras*** window and marked as the default ***(current)*** scanner.

If the connected camera is not properly defined in the system, follow the camera installation and setup procedure described in Chapter 4 – Initial Setup of the System – Connecting the Camera to the Workstation on page **39 above**.

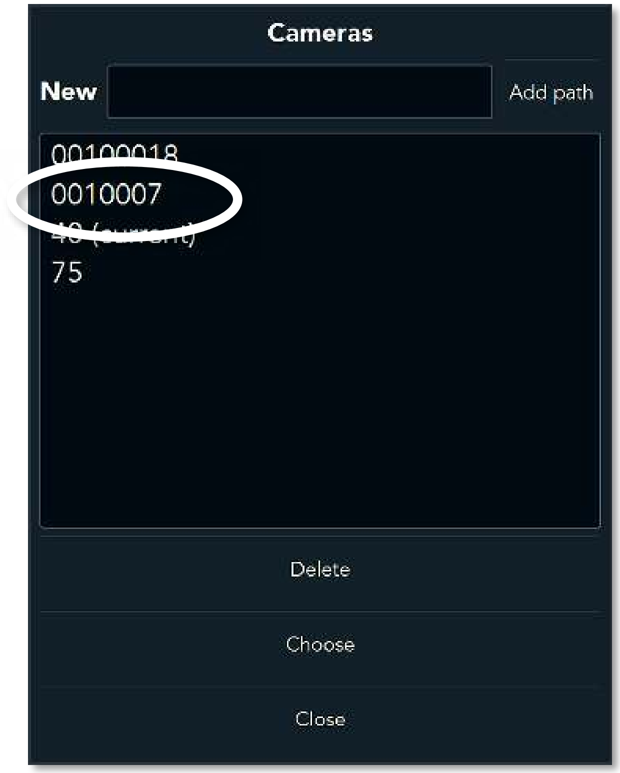


Figure 277 – Cameras' Window

8. Check to see that the camera is properly calibrated by following The Main Menu – The Calibration Menu Option paragraph's instructions (see page **171 above**).

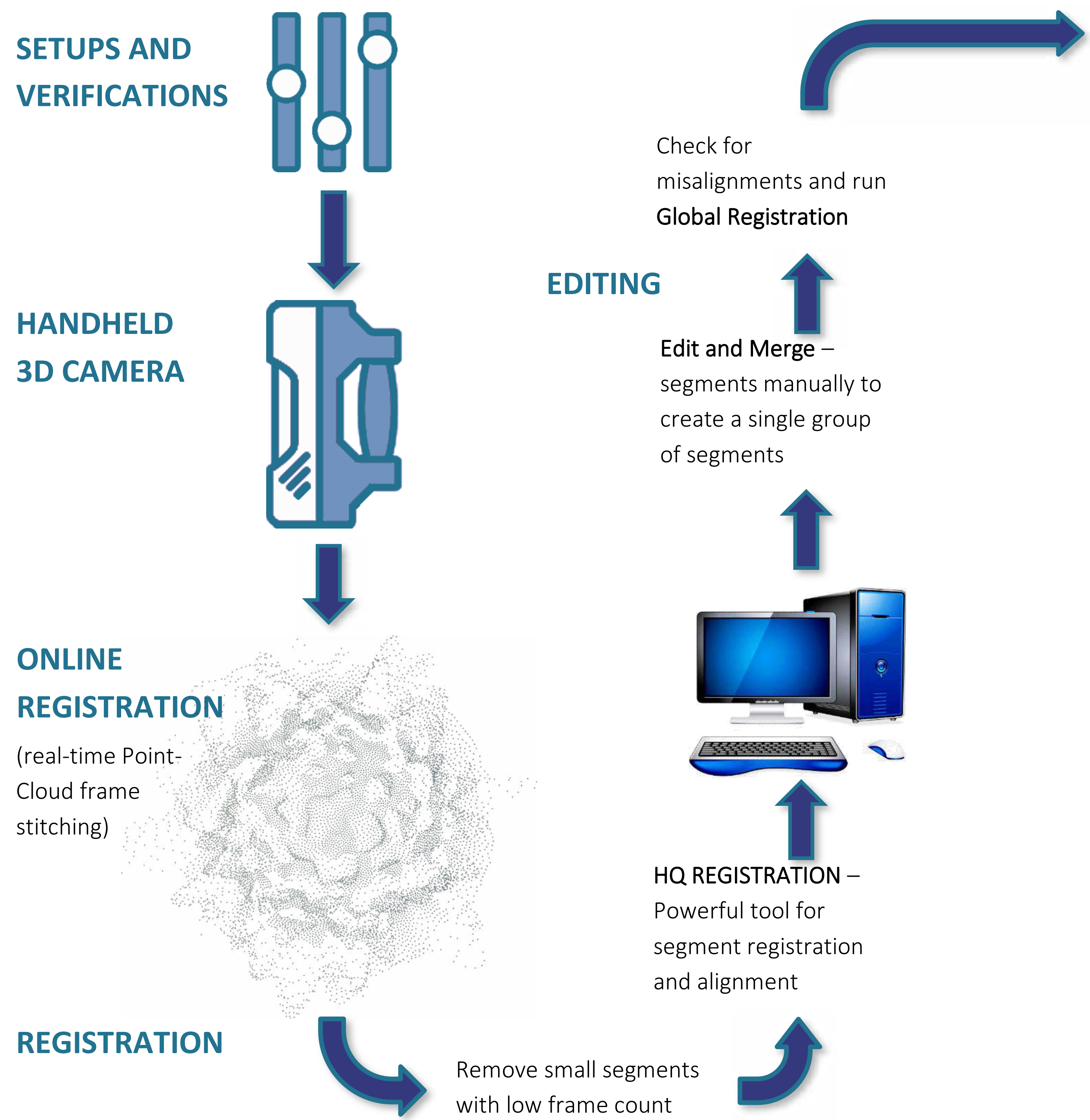
9. Set the data layers required for the **Raw** file (*.MVX*) of the scan act as described in paragraph Main Screen – Scan View Mode – The Settings Toolbar – ***MVX*** command-button on page **154 above**.

10. Execute **White Balance** and **Exposure** setup as described in section Setting the Color (RGB) Camera in 2D View Mode on page **163 above**.

NOTE:	It is recommended to run this step of ***White Balance*** and ***Exposure*** setup before ANY new scan act.

11. The system (the camera and the Echo™ software) is ready for the scan act.

The Scanning Process Flowchart



DENOISE

MLS – Smoothing algorithm

SOR – Cleaning algorithm

MESH

Mesh Preset –
Low
Medium
High

Custom Mesh – Image projection/ color vertex mesh based on Poisson Depth algorithm

EXPORT POINT-CLOUD

PLY | OBJ | E57 | PTS | XYZ

EXPORT MESH

VR / AR

PLY | OBJ | STL

The Scanning Act

12. Inspect the object to be scanned and verify that it is well illuminated all around and that there are no “blind spots”.
13. Plan the scanning path to conform with the geometry of the object within the hemisphere (half-sphere) volume around it.
14. Initiate the scan act by pressing the **Power/Scan** Button on the camera or selecting the on-screen **Power/Scan** command-button (see Figure 197 – The Main Screen – Scan View Mode – Power/Scan command-button on page **166 above**).

    The **Power/Scan** command-button will turn red to indicate the beginning of the scan act and recording of its data.

15. Move the camera on the hemisphere’s veneer surrounding the scanned object, as demonstrated in Figure 278 **below**:

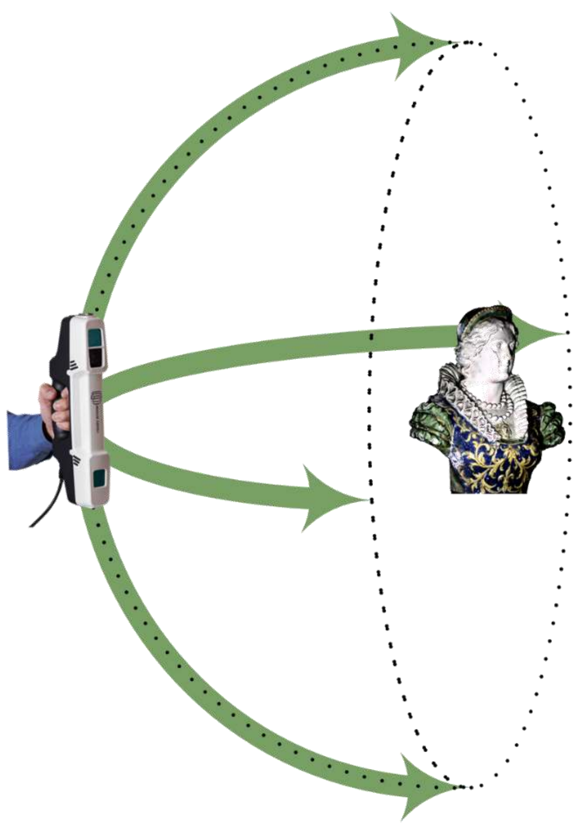


Figure 278 – Scanning Movements of the Camera Around the Object

NOTE:	Limit the scanning range (see section "The Scanning Range Limiter on page **150 above**) to block superfluous data capturing.

The Online Registration Step

During the scan act, the decoder part of the Echo™ converts, online and in real-time, the IR video data, frame-by-frame, into Point-Cloud frames and register between them, to create a 3D model, based on overlapping geometries found in the captured image.

If the ***Allow Multi-Segment*** option (see page **169 above**) was marked (in **Settings Menu** option of the **Main menu**) and the Echo™ software does not detect overlapping geometries for registration, a new segment will be opened in every such case but will not stop the scan act.

Same will happened in the following cases:

- Deviation from the camera's scanning range (0.6÷4 meters), or
- Deviation from limited scanning range (by "The Scanning Range Limiter" see page **150 above**), or
- Low camera's battery, or
- Direct sun light (over 25LUX), or
- Too fast scanning movements.

These segments will be "stitched" to the 3D model in the next step of the process – The Registration Act. If the ***Allow Multi-Segment*** option was not marked, the **Scanning Act** will stop.

The Registration Act

If the above-described **Scanning Act** was executed properly, an ***.MVX*** file (the **Raws** file) is created and stored on the workstation's hard-disk. It will include all the layers marked for recording in the **MVX Settings – Data Layers** menu (see section "***MVX*** command-button" on page **154 above**).

The most important layer for continuation of the process (of building a 3D model) is the **3D Point-Cloud** layer – the layer that include the decoded Point-Cloud data (including the above-described initial **Online Registration** data).

The following paragraph will deal with the processing of this layer only. All data gathered during the following steps will be registered in a ***.db*** (SQL database) file (not in the original raw ***.MVX*** file). The first step of processing the **3D Point-Cloud** layer is to "complete" the process of registering the segments of the 3D Point-Cloud model. There are two (2) action steps possible for this purpose:

- Removal of small segments, and/or
- High Quality (HQ) registration.

Their execution (and order of execution) is pending the quality of the **3D Point-Cloud** layer created to this point, with special attention to the number of segments included in these small segments.

The Removal of Small Segments Step

Sometimes the initial **3D Point-Cloud** layer include some small segments combining small amounts of frames and/or number of points, which do not contribute important information to the creation of the 3D model. These need to be removed from the model as they might create the need for extensive processing power, memory and time for registration, stitching, etc. The process of removing these small segments is explained in details in section "Delete Small Segments" on page **93 above**.

The High Quality (HQ) Registration Step

For the purpose of carrying out a high-quality 3D model, the resulting Point-Cloud need a rerun of the registration process.

This rerun step is called **High Quality (HQ) Registration** and differs from the above-mentioned **Online Registration** by the fact that it is a comprehensive registration process where the Echo™ software processes ALL of the scanned object's Frames, Segments and Groups together (unlike the **Online Registration** which register frame-to-frame) attempting to have them all matched and registered properly.

This registration process is further detailed in section "The Extra Functions Toolbar" in page **98 above**.

NOTE:	There is no compelling order for performing the removal of small segments step or the HQ registration step and it is up to the user to decide which step to perform.

The Editing Act

NOTE:	All previously mentioned acts could be carried-out with the scanning workstation. The following steps are recommended for execution on a high-performances desktop workstation.

The 3D model created to this point will, most probably, need an extra step of editing to bring it up to a higher level of perfection.

This act is made of two (2) steps:

- An Edit and Merge Step – manual corrections of registration issues not resolved by previous acts and steps, and
- A Global Registration Step – overall smoothing registration step required following the above-mentioned manual editing step.

NOTE:	The Edit Act is an optional procedure which should be run only in these cases where the 3D model is not made of a single group. The reason this Act should be performed at this stage of the 3D scan process is that the next step (“The Denoise Act” see below) can execute on a single-group model only.

The Edit and Merge Step

It is quite common, especially when the user is inexperienced, that the 3D model created to this point is fragmented to several unregistered (misaligned) groups/frames like demonstrated in Figure 279 below.

It is usually caused by the software’s inability to find overlapping geometries to be registered to one another and it need to be manually rectified.

The process of registering such groups/frames is detailed in Chapter 5 – User Interface (UI) of the Echo™ Software – Gallery View Mode – Edit (Third) Page on page 82 above.

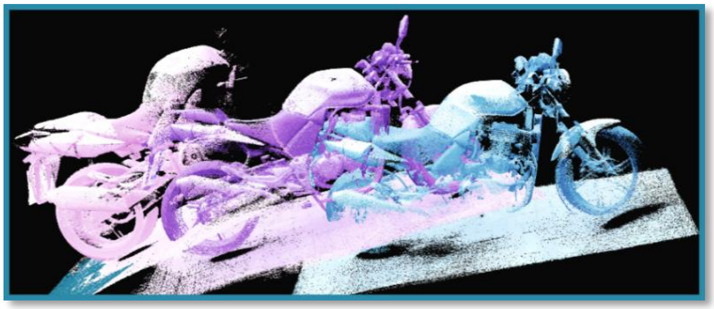


Figure 279 – Unregistered Groups

The Edit and Merge Step is a manual process done interactively with the specific model and aiming towards minimization of the number of groups in the model into one.

The first step is The Edit and Merge Step where the user needs to manually shift/rotate/ move every two (2) groups/frames until they are as close as possible (overlap) and then merge them together to resolve the misalignments between them.

Once all these fragmented groups/frames are merge into a single-group model, the user need to manually activate another registration process ("The Global Registration Step" see **below**) which converts all 3D frames into a single-coordinates model using the information of frames' positions to achieve fine-tuned registration of the 3D model.

NOTE: The Edit and Merge step may require several iterations to reach the stage where all groups/segments/frames are merge into a single-group model. The process of Edit and Merge may also require breaking segments/groups down into smaller fragments.

The Global Registration Step

Global Registration is a complementary registration process aiming at rectifying special registration issues like cumulative registration errors, bitty misalignments and alike, which cannot be accomplished prior to the state where all frames, groups and segments were already registered and form together a single-segment model.

A practical example of such registration errors is demonstrated in the following Figure 280.

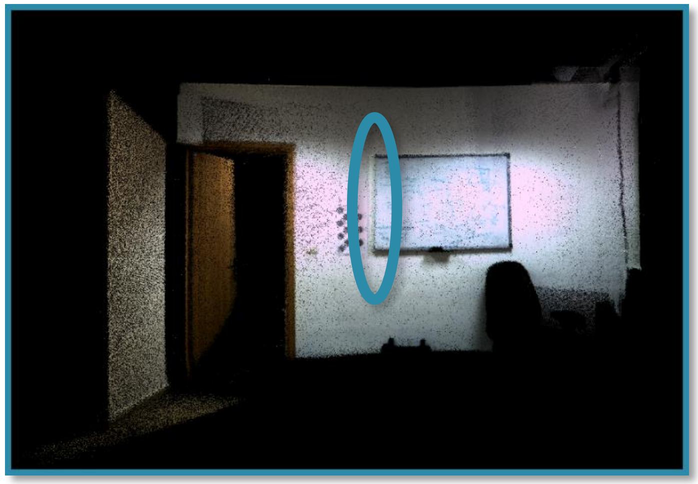


Figure 280 – A Practical Example of Registration Errors/Misalignments

The Global Registration algorithm converts all 3D frames into a single-coordinates model using the information of frames' positions (each frame is registered in the global coordinate system) relative to each other.

The algorithm uses both geometry and texture data of the object to find the optimal position of each frame to ensure highest accuracy of positioning and to fix misalignment that are hard to spot.

The Denoise Act

The next step in the process of building the 3D model would be to clean up the model from all acquired (during the Scan Act) noise particles.

There are two methods for denoising a 3D model:

- Statistical Outlier Removal (SOR) Cleaning Algorithm and
- Moving Least Squares (MLS) Smoothing Algorithm.

These are detailed below as well as in Chapter 5 – User Interface (UI) of the Echo™ Software – Gallery View Mode – Edit (Third) Page – The Noise Removal (Denoise) Act on page 97 above.

Following the Denoise Act, the 3D model is ready and can be:

- Exported in Point-Cloud formats to other editing software tools, or

- Covered with a Mesh and exported to 3D applications such as VR/AR, 3D printing, etc.

The Exporting Point-Clouds Step

The 3D model developed to this point of the above-described process, may be exported, in Point-Cloud formats, to the following file formats:

- **PLY file format** – A computer file format known as the Polygon File Format or the Stanford Triangle Format primarily designed to store 3D data from 3D scanners.

  This format support relatively simple description of a single object as a list of nominally flat polygons.

  A variety of properties can be stored, including: color and transparency, surface normals, texture coordinates and data confidence values.

  The format permits different properties for the front and back of a polygon.

  The PLY files are organized as a header, that specifies the elements of a mesh and their types, followed by the list of elements itself.

  The elements would normally be vertices and faces, but may include other entities such as edges, samples of range maps, and triangle strips.

- **OBJ file format** – OBJ is a geometry definition file format.

  The OBJ file format is a simple data-format representing 3D geometry alone — the position of each vertex, the UV position of each texture coordinate vertex, vertex normals, and the faces that make each polygon defined as a list of vertices, and texture vertices.

  Vertices are stored in a counter-clockwise order by default, making explicit declaration of face normals unnecessary.

  OBJ coordinates have no units, but OBJ files can contain scale information in a human readable comment line.

  OBJ files references one or more Material Template Library format (MTL) files that describes surface shading (material) properties.

  MTL files are ASCII text that define the light reflecting properties of a surface for the purposes of computer rendering, and according to the Phong reflection model.

- **E57 file format** – The E57 is a LIDAR (light detection and ranging) Point-Cloud data file format. It enables remote sensing data to be saved in a vendor-neutral format.

E57 files can be used for rendering images of real-world objects, such as buildings, atmospheric entities (e.g. clouds), and geological surfaces which is useful for construction, surveying, engineering and research applications.

- PTS file format – PTS file is an ENVI (ENvironment for Visualizing Images) Ground Control Point file. ENVI (ENvironment for Visualizing Images) is a software application used to process and analyze geospatial imagery.

  The PTS format is often described as a “dumb format” since it does not retain any original scan or registration information, similar to the ASCII file format.

  The PTS format is often used when exporting final registered Point-Clouds that have been unified in Cyclone.

  Also, the PTS format is often used in place of the PTX format for import into software that do not directly support PTX files.

- XYZ file format – XYZ file format is a file format created for chemistry applications.

  There is no formal standard and several variations exist, but a typical XYZ format specifies the molecule geometry by giving the number of atoms with Cartesian coordinates that will be read on the first line, a comment on the second, and the lines of atomic coordinates in the following lines.

  The file format is used in computational chemistry programs for importing and exporting geometries.

  XYZ file formats are probably the simplest of the 3D structure files, since they contain little more than the x, y and z coordinates of each atom in the molecule.

  Other information, such as bond order or charge is not specified.

  Despite their simplicity, XYZ files are very useful since many XYZ files can be joined together into one long file, which when interpreted by an appropriate graphics package, appear as animation in the browser.

These file formats and their usage are further detailed in Chapter 5 – User Interface (UI) of the Echo™ Software – The Main Menu – Main Menu in Both Gallery View Mode's Edit Pages – The Export Menu Option on page 189 above.

NOTE:	Regarding the Export Act – please also refer to Chapter 7 – Interfacing with Other 3D Software Tools on page 228 below.

The Mesh Act

Following the above-described Scan and Editing Acts and in order to give the model life-like appearance with solid continuous surfaces, as well as preparation of the models for their ultimate usage (e.g. export to VR/AR applications, 3D printing, etc.) together with a major reduction of the data's file size, there is a need to wrap-up the model and cover it with solid surfaces before transferring it to the next step of usage.

One approach to compress the scanned information is to represent the model surfaces by means of mathematical descriptions or primitive shapes (i.e. Polygons).

Most commonly, model's surfaces are approximated by polygonal meshes, particularly – Triangle Meshes, a standard data structure in computer graphics to represent 3D objects.

The algorithms for the creation of these triangle-meshes generate highly accurate polygonal models whose appearance must be as close as possible to the original object, require some major computing power.

Such algorithms take points in 3D space, called Vertices, and connect them by line segments to form polygon meshes.

Most 3D models are built as Textured Polygonal models since they are flexible and since computers can render them quickly.

The Echo™ allow selection between two (2) quality-related Mesh processes:

- The Preset Mesh Option – utilizing three (3) optional preset quality levels, or
- The Custom Mesh Option – allowing the user to manipulate all quality related factors of the Mesh process.

The Preset Mesh Option

Three (3) preset Mesh quality schemes where defined in the Mesh drop-down menu:

- Low quality
- Medium quality
- High quality

The selection of the desired Mesh preset quality is selected via The Extra Functions Toolbar detailed in User Interface (UI) of the Echo™ Software – Gallery View Mode – Edit (Third) Page – The Extra Functions Toolbar on page 98 above.

The Custom Mesh Option

The other quality-related Mesh option is activated by the selection of the ***Custom*** option in the ***Quality Preset*** drop-down menu (from within the ***Mesh*** menu).

Once selected, the ***Mesh*** menu's window will grow to accommodate all possible details of the Mesh process which can be controlled by the user.

Custom Mesh option is detailed in Chapter 5 – Gallery View Mode – Edit (Third) Page – The Extra Functions Toolbar – Creation of Custom Quality Mesh Spawns page 105 above.

The 3D Mesh Model

Once the model passes the Mesh process it becomes a 3D Mesh Model and can be exported to 3D applications like VR/AR, 3D printing, etc.

The Export Mesh Step

Exportation to Mesh models is similar to The Exporting Point-Clouds Step explained above.

NOTE: Regarding the Export Mesh Act – please also refer to Chapter 7 – Interfacing with Other 3D Software Tools on page 228 below.

The Export Mesh Formats

- **PLY file format** – A computer file format known as the Polygon File Format or the Stanford Triangle Format primarily designed to store 3D data from 3D scanners.

  This format support relatively simple description of a single object as a list of nominally flat polygons.

  A variety of properties can be stored, including: color and transparency, surface normals, texture coordinates and data confidence values.

  The format permits different properties for the front and back of a polygon.

  The PLY files are organized as a header, that specifies the elements of a mesh and their types, followed by the list of elements itself.

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  Vertices are stored in a counter-clockwise order by default, making explicit declaration of face normals unnecessary.

  OBJ coordinates have no units, but OBJ files can contain scale information in a human readable comment line.

  OBJ files references one or more Material Template Library format (MTL) files that describes surface shading (material) properties.

  MTL files are ASCII text that define the light reflecting properties of a surface for the purposes of computer rendering, and according to the Phong reflection model.

- STL file format – STL (STereoLithography) is a file format native to the stereolithography CAD software created by 3D Systems for commercial 3D printers.

  The format is supported by many other software packages and is widely used for rapid prototyping, 3D printing and CAM.

  STL files describe only the surface geometry of a 3D object without any representation of color, texture or other common CAD model attributes.

  It specifies both ASCII and binary representations. Binary files are more common since they are more compact.

  An STL file describes a raw, unstructured triangulated surface by the unit normal and vertices (ordered by the right-hand rule) of the triangles using a 3D cartesian coordinate system.

  STL files contain no scale information, and the units are arbitrary.

  STL file format is simple and easy to output, therefore many CAD systems can output the STL file format.

  Although the output is simple to produce, some connectivity information is discarded.

  Many CAM systems requires triangulated models.

STL format is not the most memory- and computationally efficient method for transferring this data, but **STL** is often used to import the triangulated geometry into the CAM system.

In order to use the data, the CAM system may have to reconstruct the connectivity. **STL** can also be used for interchanging data between CAD/CAM systems and computational environments such as Mathematica.

NOTE: Regarding the Export Mesh Act – please also refer to Chapter 7 – Interfacing with Other 3D Software Tools on page 228 below.

Chapter 7 Interfacing with Other 3D Software Tools

Introduction

Mantis Vision enhances its capabilities and provisions by collaborating with 3rd-party leading 3D processing software tools' manufacturers to provide value-added solutions for their applications.

These solutions are in fact, exporting tools added to The Export Menu Option in Main Menu in Both Gallery View Mode's Edit Pages (see page 189 above).

Interfacing to Potree

Overview

Potree is a free open-source WebGL-based point-cloud rendering software application for large Point-Clouds, developed at the Institute of Computer Graphics and Algorithms in Wien and aimed for visualization of Point-Clouds in websites.

WebGL (Web Graphics Library) is a JavaScript API for rendering interactive 3D graphics within any browser with no plug-in added software and is fully integrated with other web standards.

WebGL allow usage of GPU-accelerated physics and image processing and effects as part of the web page canvas.

WebGL elements can be mixed with other HTML elements and composited with other parts of the page or page background.

One of the main advantages of Point-Cloud visualization in web browser is that it allows users to share their data sets with clients (or the public in general) without the need to install 3rd-party applications.

Focusing on large Point-Clouds and a variety of measuring tools allows usage of Potree to look at, analyze and validate raw Point-Cloud data, without the need for a time-intensive and potentially costly meshing step.

Interfacing Mantis Vision generated Point-Clouds to Potree allow presentation of Mantis Vision generated 3D images in web pages/sites.

Mandatory Software Installation

Potree's software is intended to run on an HTTP Server (i.e. Apache) – a free and open-source cross-platform web-server software developed as a collaborative effort and aiming at creating a robust, commercial-grade, feature-rich and freely available source code implementation of an HTTP (Web) server.

The Apache HTTP Server is available for Linux distributions, as well as Windows and a wide variety of Unix-like systems.

Mantis Vision's 3D models exported to Potree's software application and presented on such Apache HTTP Server require no special support.

But, since Potree's software is a PHP-based server program, for testing the exported models on a workstation, there is a need to install Bitnami's XAMPP server stack to enable proper operation of the Potree's application by emulating a web-server over Windows Operating System.

Download the Bitnami's XAMPP server stack native installer from https://www.apachefriends.org/download.html and install it on the workstation used for emulating the Apache HTTP Server by double-clicking on the downloaded program and following the instructions provided throughout the process.

A Windows Frequently Asked Questions document is provided by Potree to support the users in this installation process as well as Community pages.

Setting up the Bitnami's XAMPP Server Stack

Following the above-mentioned installation, the **Bitnami's XAMPP server stack** need to be set up for proper operation.

The setup procedure is activated from Window's main menu's **XAMPP Control Panel** option (see Figure 281 **below**).

Activating the **XAMPP Control Panel** opens its window (see Figure 282 **below**) where the **Apache**, **MySQL** and **FileZilla** options need to be marked.

Marking these options can be done:

- Either temporary – by selecting the **Actions**' column proper option command-buttons (marked in Figure 282 **below**) or,
- Lastingly – by selecting the 

command-button (marked in Figure 282 **below**), which will open the **Configuration of Control Panel window** (see Figure 283 **below**), where the same options can be marked permanently as ***Autostart***ers.

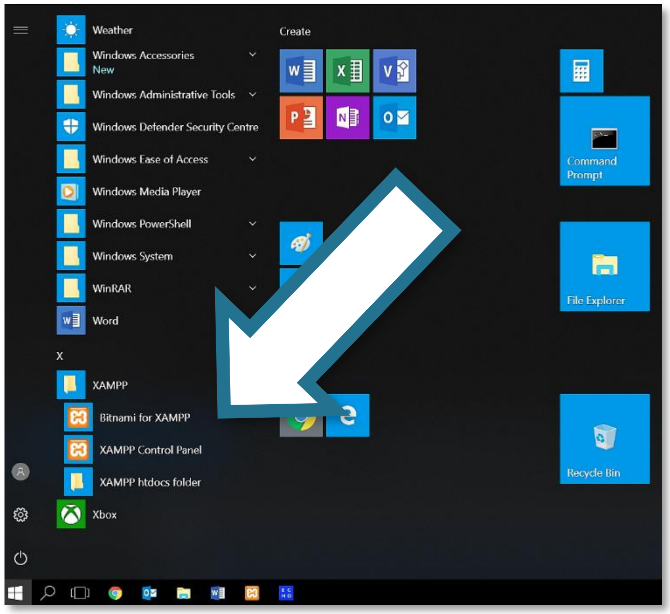


Figure 281 – Windows Main Menu – XAMPP Control Panel Menu Option

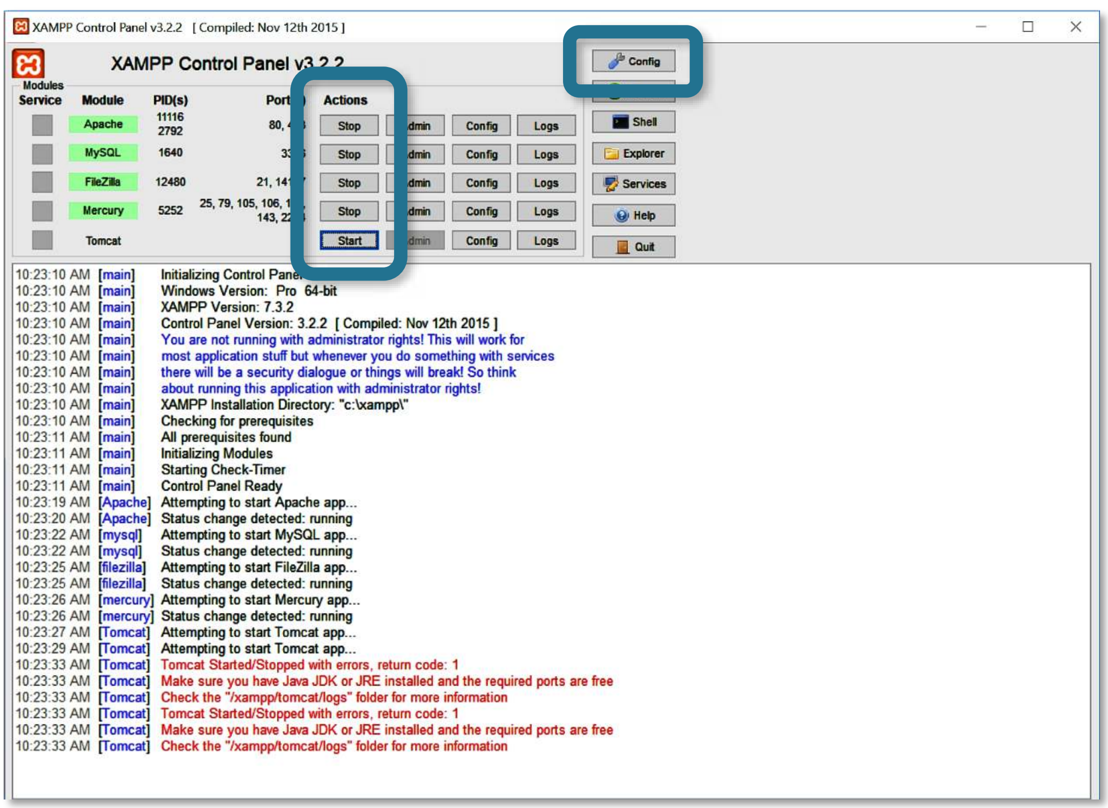


Figure 282 – XAMPP Control Panel Window

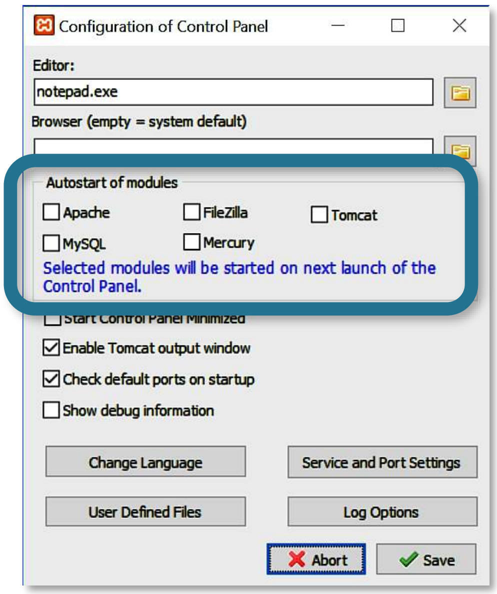


Figure 283 – XAMPP Control Panel – Configuration Window

Once all the above installation and setup procedures are complete, the **Bitnami's XAMPP server stack** is set for action and can be used to emulate the Apache HTTP Server on the workstation.

Repository for the Exported 3D Models

The above installation of the **Bitnami's XAMPP server stack** creates, among other things, an `\xampp\htdocs` directory which should become the **default repository** for the exported models.

The `\libs` and the `\pointclouds` directories, as well as the `.HTML` files created during the exportation should be saved onto this repository.

Directing these directories and files to be saved in the `\xampp\htdocs` directory is done during the ***Save As*** step of the **Export to Potree** procedure as explained in page 207 above.

Interfacing an Echo™ 3D Point-Cloud to Potree

The process of interfacing a 3D model from Echo™ to Potree is made of the following three (3) consecutive steps:

1. Export the Point-Cloud model to Potree from Echo™.

The process of exporting to Potree is detailed in section “The Potree File Format Option” on page 207 above.

2. Upload the exported data to the website for distribution.

3. Provide a link to the *.HTML* file.

   In case of employing XAMPP for emulation of an Apache HTTP Server should be called upon with the link: http://localhost/<file_name.html>.

Following is an example of a room scanned and processed with F6 SMART™ System, exported to Potree utilizing the above-described procedure and presented via Google’s Chrome™ browser:

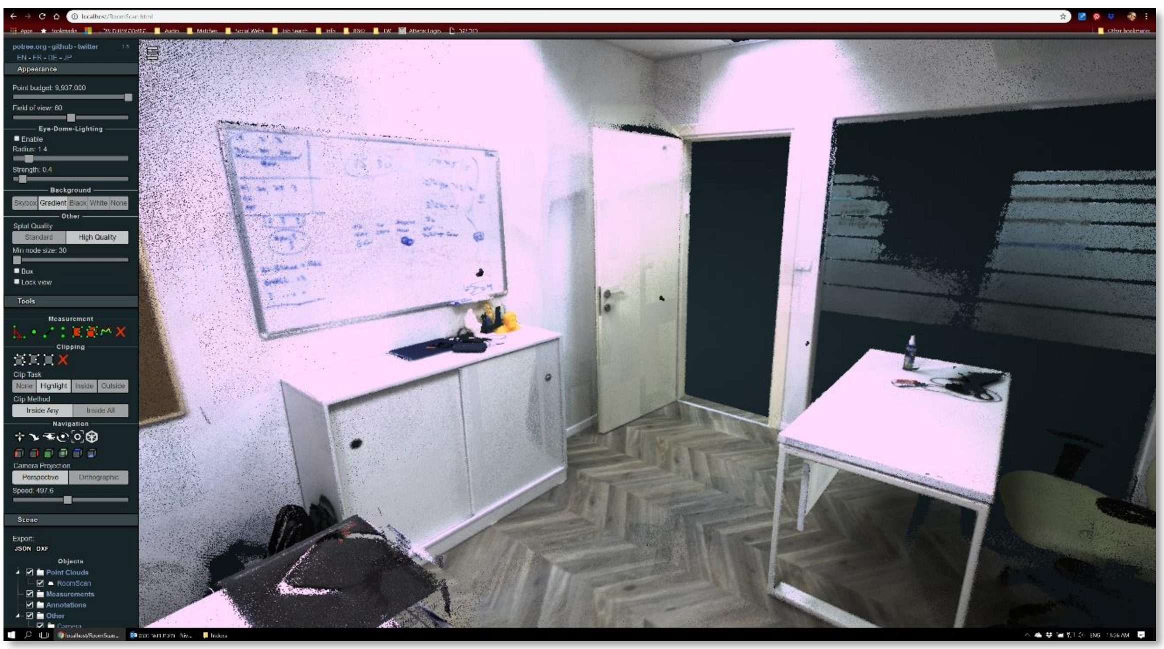


Figure 284 – Presentation of an Exported Model to Potree

Appendix 1 Errata, Comments and Book Support

We hope you found this User Guide informative and clear. Mantis Vision made every effort to ensure the accuracy of this book and its companion content.

Our customers' comments are most valuable asset for us!

Mantis Vision Ltd. Ltd. wants its User Guides to be as helpful as possible. Please send your comments about this User Guide to docs@Mantis-Vision.com.

Appendix 2 Glossary of Terms, Acronyms and Abbreviations

The following terms and abbreviations are used in Mantis Vision's documents:

1-sided	When a polygon is created, unless otherwise set up, it will have only one side. Looking at a playing card, it has a front and a back. A 1-sided polygon only has a front, and therefore only one surface normal.
2D	Two Dimensional.
2D map	Two dimensional map consisting of either a bitmap or a procedural map. An object using a 2D map needs texture coordinates. See: UV-grid.
2-sided	Like a playing card. A polygon that has a front, and a back, is 2 sided. A 2-sided polygon will have two surface normals, facing opposite directions.
3D	Three Dimensional.
3D Accelerator Card	A graphics card specifically designed for 3D graphics.
3D map	Three-dimensional map built up from multiple layers of bitmaps or, more often, generated in three dimensions with a procedural texture. These are algorithms that can generate 3D maps resembling marble or wood, and when applied to an object, the grains of the marble, and the fibers of the wood, will be correctly mapped to the surface in all three dimensions. Spliting a 3D-mapped cube in two halves will result with the cross section surface matching the neighboring faces. A 3D map does not require texture coordinates.
3D Modeling	The process of developing a mathematical representation of any 3D surface of an object (either inanimate or living) via specialized software.

3D object	Anything with a position and a representation in 3D space. Some objects have a special role, for instance a camera or a light, while others serve as controls for other objects, for instance splines or manipulators. The most common 3D objects are geometric objects, which can be classified according to whether they are polygon meshes, surfaces, curves, implicit objects, or nulls.
3D Printer	Also known as Modeler. An additive fabrication machine that is designed to join materials to make objects from 3D model data through depositing of material usually layer upon layer also known as 3D printing.
3D Printing	A process of fabricating objects from 3D model data through depositing of material usually layer upon layer. See also: Additive Fabrication.
3D Shutter Glasses	3D glasses made with electronic liquid crystal shutters. They are powered by the computer they are attached to and use this power to turn on and off the liquid crystal in each of the lenses creating a 3D effect, instead of the usual 2D display a computer monitor can offer.
3DS	Old Autodesk® 3D Studio™ file format used by for 3D scenes. It contains geometry, textures, lights and cameras as well as animation data.

A

Absolute Coordinates	The location of a point in terms of distances and/or angles from a fixed origin.
AC	Alternating Current. An electric current which periodically reverses direction.
ADC	Analog to Digital Conversion/Converter. Also referred to as digitization or quantization.

A-D A/D A2D A-to-D	The conversion of an analog signal into the digital data representation of that signal – normally for subsequent use in a digital machine. For TV, samples of audio and video are taken, the accuracy of the process depending on both the sampling frequency and the resolution of the analog amplitude information – how many bits are used to describe the analog levels. For TV pictures eight or 10-bits are normally used; for sound, 16 or 20-bits are common, and 24-bits are being introduced. The ITU-R 601 standard defines the sampling of video components based on 13.5 MHz, and AES/EBU defines sampling of 44.1 and 48 kHz for audio. For pictures, the samples are called pixels, each containing data for brightness and color.
Additive Fabrication	Also known as: 3D Printing, Rapid Manufacturing, Additive Manufacturing, Layer Manufacturing. An automated method to build models, prototypes, tools and manufactured parts directly from CAD data, that constructs these parts by depositing and bonding materials on a layer-by-layer basis.
Additive Mixing of Colored Light	There are two sorts of mixing of colors: One is called additive, or sometimes transmissive and refers to the fact that the more red, green and blue added together, the nearer to white the final color will be. This is the normal light scene for most graphics packages with output mainly through the medium of a screen. Subtractive mixing indicates that the fewer colors mixed, the nearer to white the result will be and is used for reflective color, such as printed material.
ADC A-D A/D A2D	Analog to Digital Conversion/Converter. Also referred to as digitization or quantization. The conversion of an analog signal into the digital data representation of that signal, normally for subsequent use in a digital machine.

A-to-D

AGC	Automatic Gain Control. Automatically controlling the signal's gain to maintain a constant output with a varying input signal within a predetermined range of input-to-output variation.
Aggregate Object	An object that is made up of a number of other objects. A normal aggregate object will be made up of primitives. A more complex aggregate object may be made up of primitives, other aggregate objects, or both.
Algorithm	A formula or set of steps used to simplify, modify, or predict data. A problem-solving method that involves using a multi-step process.
Aliasing	Defects or distortion in a television picture. In analog video, aliasing is typically caused by interference between two frequencies such as the luminance and chrominance frequencies or the chrominance and field scanning frequencies. It appears as Moiré or herringbone patterns, straight lines that become wavy, or rainbow colors. In digital video, aliasing is caused by insufficient sampling or poor filtering of the digital video. Defects are typically seen as jagged edges on diagonal lines and twinkling or brightening (beating) in picture detail.
Alpha Channel	Top byte of a 32-bit pixel used for data other than color. Alpha channel usually contains mask data which enables an image to be separated from its background for use in compositing.
Ambient Light	An artificial all-directional illumination level representing infinite diffuse reflections from all surfaces within a 3D scene, ensuring that even surfaces without direct illumination become visible to the user.
Analog	An adjective describing any signal that varies continuously with time as opposed to a digital signal, which is built from discrete values.

Appendix 2 – Glossary of Terms, Acronyms and Abbreviations

Angle of Incidence	The relative angle between a lit surface and the light source. The more the surface is turned away from the light source, the less light it receives and the darker it becomes. When the angle of incidence is 90 degrees, the light shines directly on the surface and it is illuminated with maximum intensity.
Animate, Animation	The movement of elements through time and space. Also, the process of creating and recording images that change over time. Everything in a scene is represented by numeric values and, as such, animation is also the process of changing these values – position, color, or any other property, over time. A method of creating illusion of life or movement in inanimate objects or drawings. Through animation the artist’s drawing comes to life. The most well known works are cartoon comedies.
Anti-Aliasing	Over-sampling methods for smoothing and removing of aliasing effects or artefacts caused by limited display resolution by filtering and other techniques. These aliasing effects include ‘jaggies’ (stair-casing along diagonal lines), Moiré effects, and temporal aliasing (strobing) in animated scenes.
Aperture	Effective diameter of the lens that controls the amount of light reaching the image capture sensor.
API	Application Program Interface. A set of subroutine definitions, protocols, and tools for building application software.
AR	Augmented Reality. A direct or indirect live view of a physical, real-world environment whose elements are "augmented" by computer-generated perceptual information, ideally across multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory.
Arc	Regularly curved open element that has a constant radius around a single center point. A section of a circle.

Array	A set of elements put together into a single entity. A pixel array is an ordered set of colored elements used for display purposes. In a 3D program, the array tool is usually used to create ordered copies of an object within 3D space. This tool is so named because it creates arrays of objects (creates an ordered set consisting of multiple copies of the same object).
Artifact	Undesirable elements or defects in a video picture. These may occur naturally in the video process and must be eliminated in order to achieve a high-quality picture. Most common in analog are cross color and cross luminance. Most common in digital are macroblocks, which resemble pixilation of the video image.
ASCII	American Standard Code for Information Interchange. A character encoding standard for electronic communication from the American Standard Code for Information Interchange.
Aspect Ratio	The proportions of an image expressed as the ratio between horizontal and vertical dimensions. Because pixels are not necessarily proportional, the aspect ratio is independent of the number of pixels in the X and Y directions. For example, both NTSC and PAL television screens are 4 x 3 (aspect ratio 1.33). However, a CCIR601 NTSC image is 720 x 486 pixels, while a PAL image is 720 x 576 pixels.
Atmosphere	In rendering, the environment that surrounds the objects in a scene. For example, the simulation of fine particles (fog, smoke, or dust) in the air. When an object is photographed in the real world, it is usually within an atmosphere (for example, air) and can be surrounded by other background objects.
Attenuation	When light travels through air its strength diminishes with the distance.

	The further the light travels, the dimmer the light. In real life, the light attenuates by the inverse square of the distance. This means that if attenuation is turned on for a light only the geometry in its proximity will be lit. Not only is this more realistic for renderings, it also helps speed up rendering time since only the geometry close enough to be affected by the light needs calculation time. See: Decay.
Atom	A data-container within MVX Files. Usually used as a frame, grouping a collection of Data Layers that share the same time-stamp and StreamID.
Auto Balance	System detecting errors in color balance in white and black areas of the picture and automatically adjusting the white and black levels of both the red and blue signals as needed for correction.
AVI	Audio Video Interleaving. The Microsoft™ Video for Windows™ file format for combining video and audio into a single block in time such as a 1/30th second video frame. In this file format, blocks of audio data are woven into a stream of video frames. ASF is intended to supersede AVI.
Axis	One of three vectors (X, Y, and Z) that define the three dimensions of a scene. Often defined as local space, object space, origin axis or world space. Relating to digital picture manipulation, the X axis is a horizontal line across the center of the screen, the Y axis is a vertical line, and the Z axis is in the third dimension, perpendicular to the X and Y axes, and indicates depth and distance.
Axis of Motion	In 3D space – line that an object follows during movement.
Axis of Rotation	In 3D space – line that an object rotates around.

B

Binary	A base-2 numbering system using the digits 0 and 1 (unlike 10 digits [0 ÷ 9] in the decimal system).

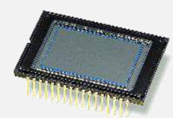
	In computer systems, the binary digits are represented by two different voltages or currents, one corresponding to 0 and the other corresponding to 1. Computer programs are executed in binary form.
Bit	Binary Digit. The smallest piece of binary digital data and is represented by a value of either “0” or “1”.
Bit Budget	The total amount of bits available on the media being used. In DVD, the bit budget of a single sided/single layer DVD5 disk is actually 4.7 GBytes.
Bit Depth	The number of bits used to define the shade or color of each pixel in an image, a ‘bit’ being the smallest unit of memory or storage on a computer. A 1-bit image is black and white. An 8-bit image provides a 256-colour palette. A 24-bit image provides 16.7 million possible colors: a palette sometimes known as “True Color”. A 32-bit image provides the same palette, plus an 8-bit greyscale alpha channel.
Bitmap	Image comprising pixels (as opposed to vector artwork such as EPS). 2D array of pixels representing video and graphics.
Bit Stream	A continuous series of bits transmitted on a line (i.e. USB cable).
Blinn	See: Shading.
BLOB	Binary Large OBject. A collection of binary data stored as a single entity in a database management system. BLOBs are typically images, audio or other multimedia objects, though sometimes binary executable code is stored as a BLOB. The data type and definition was introduced to describe data not originally defined in traditional computer database systems, particularly because it was too large to store practically at the time the field of database systems was first being defined in the 1970s and 1980s.

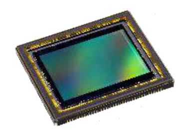
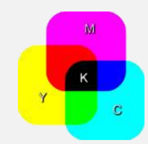
	The data type became practical when disk space became cheap. This definition gained popularity with IBM's DB2. The name "BLOB" is further borrowed by the deep learning software Caffe to represent multi-dimensional arrays.
Blooming	This effect is sometimes called whiter-than-white. Blooming occurs when the white voltage level is exceeded and screen objects become fuzzy and large. The defocusing of regions of a picture where Brightness is excessive.
Bluescreen Footage	Live footage shot in front of a single uniform colour (usually blue or green) background targeted for compositing it into a computer generated (CG) background. Every pixel with the same colour value as the backdrop is replaced by the CG image.
Brightness	The attribute of visual perception in accordance with which an area appears to emit more of less light. Luminance is the recommended name for the photo-electric quantity which has also been called brightness.
Bounding Box	The smallest box-shaped container that encloses a 3D object, usually rectangular in shape.
Byte	A group of data bits that are processed together. Typically, a byte consists of 8 bits.

C

CAD	Computer Aided Design (and Drafting).
CADD	The use of computer systems to aid in the creation, modification, analysis, or optimization of 2D-3D designs.
CAGD	Computer Aided Geometric Design. Software component providing solid/surface modeling features to CAD applications.
CAM	Computer Aided Manufacturing. The use of software to control machine tools and related ones in the manufacturing of workpieces.
Camera	A virtual viewpoint in 3D space that possesses both position and direction.

	In a 3D scene, the camera represents the viewer's eye. When the scene is rendered at final quality, it is the camera view that is used, rather than the one seen in the software's workspace. This enables the artist to move around the workspace without disturbing the camera view.
Camera Mapping	A technique by which geometry matching the size and perspective of objects shown within a still image is constructed, and the original image mapped back onto those objects. This permits limited camera movement around the picture, giving the illusion of a 3D environment from a 2D image.
Camera Move	A movement of the virtual camera within a 3D software package analogous to one in real-world cinematography. Common camera moves include dollying, in which the camera angle remains fixed, but the camera moves towards or away from the subject; panning, in which the camera position remains fixed, but the camera tilts or swivels in any direction to follow the action; and tracking, in which the camera moves in a single plane at right angles to the area of interest.
Camera Path	The path in virtual space along which the camera moves during the course of an animation.
Camera Tracking	Also known as match moving, camera tracking is the process of 'extracting' the motion of the camera in space from a piece of live-action footage. This motion data can then be imported into a 3D software package and used to animate the virtual camera, in order to better match the rendered output to that of the source footage during the compositing process.
Cartesian Coordinates	A mathematical representation of Euclidean space. Every point can be described by three coordinates (X,Y,Z) representing the position along the orthogonal X, Y, and Z axes. The point (0, 0, 0) is called the origin, which is the global centre of the 3D world.

Cartesian Space	A space in which positions are denoted by a three-coordinate system (x, y, and z coordinates) relating to a central origin (0,0,0).
Cache	Local or temporary storage.
Caustics	Patches of intense illumination caused by the refraction of light through a transparent object or the reflection of light from a reflective surface. One common example would be the shifting patterns of light and shade cast on the floor of a swimming pool on a sunny day.
CCD	Charged Couple Device. A semiconductor device that converts optical images to electronic signals. CCDs are the most commonly found type of sensor in camcorders and video cameras. 
Center of Projection	The point in perspective projection where all projectors intersect.
Center of the World	The absolute center of a 3D space, represented by X, Y, and Z points (0, 0, 0). Also referred to as the Origin.
Center Point	A point that represents the center of an object. This point is used in some programs for a point of reference for rotation and position. The center point of a polygon is where the line representing the normal comes out from.
CG	Computer Generated. Design output via a computer.
CGI	Computer Generated Imagery. Design output via a computer.
Channel	For a 2D image, a channel is a sub-image composed only of the values for a single component of a given pixel. A greyscale image has one color channel, an RGB image has three, and a CMYK image has four. When applied to materials, the term refers to one particular subset of the properties which determine the way in which a surface reacts to light, including color, reflectivity, transparency, diffusion, specularity and bump.
Child	An object whose movements are influenced by another object, called the "parent". See: Hierarchy.

Chrominance	The color component of a video signal that includes information about hue and saturation.
Clone	An exact copy, indistinguishable from the original. As in copying recorded material, for example a copy of a non-compressed recording to another non-compressed recording.
CMB	Chromeleon Backup Archive. File format supported by Stratasys FDM printers.
CMOS	Complementary Metal-Oxide-Semiconductor. A technology for constructing integrated circuits. CMOS technology is used in microprocessors, microcontrollers, static RAM, as well as analog and digital image sensors and other digital logic circuits. 
CMYK	Cyan, Magenta, Yellow, Key. A subtractive color model referencing four ink colors (Cyan, Magenta, Yellow and Key [black]) used in 4-color process printing. The CMYK model works by partially or entirely masking colors on a lighter, usually white, background. 
CODEC	COmpressor/DECompressor. The term used to reference the way that software programs handle different movie files, such as Quick Time, AVI, etc. CODEC can control image quality, and can assign the amount of space given to the movie file.
Color (Colour)	A visual perception that humans correspond to the categories called red, green, blue and others.
Color Bleeding	Physical phenomenon where color of one object is seemingly transferred to a neighbouring object by light bouncing from one surface to the other. Like caustics, color bleeding is a complex real-world lighting effect, and one that rendering software has only recently become able to simulate accurately.
Color Depth	The number of bits used to represent a color. For example; an 8-bit image uses 2^8=256 colors, a 32-bit image uses 2^{32}=4.3 billion colors, etc. The bits build up the three primary colors.
Color Model	A system used to specify colors.

	Examples: RGB (Red, Green, Blue), HLS (Hue, Lightness, Saturation), HSV (Hue, Saturation, Value).
Color Space	A mathematical method for defining the way in which color is represented within an image. Common color spaces include RGB (Red, Green, Blue), which has a bit depth of 24, and is commonly used in broadcast applications, and CMYK (Cyan, Magenta, Yellow, Key [black]), which has a bit depth of 32, and is used for print illustration work.
Color Space Conversion	The translation of color value form one color space to another. Since different media types, like video and computer graphics, use different color spaces, color space is often performed on the fly by graphics hardware.
Compositing (Comping)	The process of combining multiple images into a single image. This is often performed in films to make a live actor appear on a computer-generated background, or vice versa. It can also be used following multi-pass rendering to combine the various render passes in different ways to control the look of a scene.
Compression	Reduction of volume of data from any given process. Pictures are analyzed looking for redundancy and repetition and so discard unnecessary data. The techniques were primarily developed for digital transmission (also known as Bit Rate Reduction [BRR]) but have been adopted as a means of handling digital video in computers and reducing the storage demands for digital VTRs. Compression can be at either a set rate or a variable rate. There are a variety of compression schemes that can be applied to data of which MPEG-1 and MPEG-2 are called lossy since the data produced by compression is not totally recoverable.
Concept Model	The parts that are used early in the design process when alternatives are being conceived.

	The primary use is for product visualization and design communication.
Concentric	Having a common center or origin point with varying radii.
Constraints	Values in a geometric model that define relationships, i.e. a line is tangent to a circle. Constraints are often used to drive parametric or variational geometry-based systems. The algorithms used to work with constraints are known as constraint management.
Container	A container or wrapper format is a metafile format whose specification describes how different elements of data and metadata coexist in a computer file.
Contrast	The range of light to dark values in a picture or the ratio between the maximum and minimum brightness values.
Contour	Toolpaths that follow the outline of a region. Regions are defined by contours and then filled with rasters.
Co-ordinate System	A set of numerical values used to denote a location in 3D space. In the Cartesian co-ordinate system, three orthogonal 'world axes' (the X, Y and Z axes) are used to define the position of a point relative to the intersection of these axes, or origin. Other co-ordinate systems can be used for modelling and texture projection.
Coplanar	Refers to two or more entities that lie on the same plane. Two planar surfaces, for example, that lie on the same 3-dimensional plane are considered coplanar. If these coplanar surfaces share a common edge, it is recommended that they be joined into a single surface.
CPU	Central Processing Unit. The electronic circuitry within a computer that carries out the instructions of a computer program.
Cross Product	Using two vectors to calculate a normal of those two.
Cross-Section	A view of the interior of an object as it is sliced along a plane.

CSL	Coded Structured Light. Coded Structured Light is considered one of the most reliable techniques for recovering the surface of objects. This technique is based on projecting a light pattern and imaging the illuminated scene from one or more points of view. Since the pattern is coded, correspondences between image points and points of the projected pattern can be easily found. The decoded points can be triangulated and 3D information is recovered.
Curve	A generic term used to describe any of the planar paths (contained in x-y plane) that are present in the software at every z-layer. Curves are the result of slicing, support generation and toolpath generation.
CV	Control Vertex. A control point used to manipulate the shape of a NURBS curve. Also: Computer Vision.
CVA	Compiled Vertex Array. An OpenGL interface which allows static vertex array data to be cached or pre-compiled for more efficient rendering.

D

DAC D-A D/A D2A D-to-A	Digital-to-Analog Converter. A component that converts a digital signal into an analog signal. An analog-to-digital converter (ADC) performs the reverse function.
DAR	Device Aspect Ratio. The aspect ratio of the display device on which the user views the rendered image. The device aspect ratio represents the image aspect ratio multiplied by the pixel aspect ratio.
Data Compression	A technique that provides for the transmission or storage, without noticeable information loss, of

	fewer data bits than were originally used when the data was created.
Data Layer	A block of data.
DC	Direct Current. A unidirectional flow of electric charge.
DDM	Direct Digital Manufacturing. The process of going directly from a digital representation of a part to the final product (finished goods) via additive fabrication technologies.
Decay	Phenomenon where the light intensity decreases with the distance. The further away from the light source, the less intense are its rays. In the real world the decay is proportional to the inversed square of the distance (quadric decay), but there is also directional (one-dimensional) decay (slower than in real life) as well as cubic decay (faster than in real life). See: Attenuation.
Decompression	Returning a compressed file to its full size.
Default Unit	The Default Unit is the unit of measure (e.g. meter, feet, etc.) that is assumed when no unit of measure is entered with the numeric data.
Depth Channel	The distance of objects from the camera. Also known as Z-depth or Z-buffer channel.
Depth Cueing	The process of reducing the apparent sharpness of an object the farther away it is from the viewer or camera. This often enhances the perception of depth.
DoF	Depth of Field. The total distance, on either side of the point of focus, which, when viewed from an appropriate distance, appears sharp in the final print.
Depth Sorting	Sorting all triangles in the world depending on diminishing depth (lower and lower z-value) so that when they are rendered, the triangle closest to the viewer is obscures those behind it.
Deskew	Process used to remove skew or distortion through a small angle rotation.

Desktop Video	Video editing and production done using standard desktop computing platforms running add-on video hardware and software.
Device Aspect Ratio	The aspect ratio of the display device on which the rendered image is viewed. The device aspect ratio represents the image aspect ratio multiplied by the pixel aspect ratio.
Diagnostics	Tests to check the correct operation of hardware and software. As digital systems continue to become more complex, built-in automated testing becomes an essential part of the equipment. Some extra hardware and software has to be added to make the tests operate. Digital systems with such provisions can often be quickly assessed by a trained service engineer, so speeding repair.
Diffuse	Surfaces reflect (or scatter) light, and colour in many angles. This type of surface causes light and colour to spread freely.
Digital	Circuitry in which data carrying signals are restricted to either of two voltage levels, corresponding to logic 1 or 0. A circuit that has two stable states: high or low, on or off.
Digital Word	The number of bits treated as a single entity by the system.
Dimension	A measure of spatial extent, especially width, height, or length.
Directional Light	Another name for a distant light.
Displacement Map	Can be used to modify the actual mesh (as opposed to the bump map) to create wrinkles, creases, crumples etc. The displacement map will need a more complex mesh to create the same effect as bump mapping, but has the advantage of allowing more thorough close-ups, since the surface is actually deformed and not just simulated as being so.
Distant Light	A light with color, intensity and direction. All rays emitted from a distant light are parallel, and therefore it has no obvious source.

	Distant lights can be used to simulate point lights from a great distance (whose rays can be approximated to be parallel) like the sun. The intensity from a distant light does not decay.
DLL	Dynamic Link Library. Microsoft's implementation of the shared library concept in the Windows™ and OS/2™ operating systems.
DoF DOF	Depth of Field. The in-focus range of a lens or optical system around an item of interest measured from the distance behind the object to the distance in front of the object when the viewing lens is specifically focused on the object. Depth of field depends on subject-to-camera distance, focal length of the lens, and f-stop.
Dpi DPI	Dots per Inch. In a bitmapped image, the number of dots that exist within each inch of the image. This number remains constant therefore enlargering the image decreases the quality.

E

E57	Point-Cloud format. A format used for storing data captured by 3D imaging systems. 3D image file created in the ASTM E57 format, saves LIDAR data captured by 3D range cameras; enables remote sensing data to be saved in a vendor-neutral format. The E57 format uses a combination of binary and XML data.
EaC	Engineering and Construction.
Edge	A straight line connecting between two vertices of a polygon.
Encoding	The process of converting uncompressed image/s to a new format, usually compressed. e.g. MPEG, MP4, QuickTime, WMV, H264 etc.
EULA	End User License Agreement. In proprietary software, a EULA (or software license agreement [SLA]) is the contract between the licensor and purchaser, establishing the purchaser's right to use the software.

EV	Exposure Value. See: Exposure
Exposure	In photography, exposure is the amount of light per unit area (the image plane illuminance times the exposure time) reaching a photographic film or electronic image sensor. This value is determined by shutter speed, lens aperture and scene luminance. Exposure is measured in lux seconds and can be computed from the EV and scene luminance in a specified region.
External Attributes	The position of the camera and the direction it's pointing.
Extrude	Creating a three-dimensional object from a two-dimensional shape by adding a third dimension to it.

F

F6 SMART™ Camera	Mantis Vision’s 3D Handheld Scanner. 
Face	The shape made up by the bounding point making a polygon. Faces can have as many vertices as wanted, but only polygons having a shape of three or four vertices can be made into sub division surfaces.
Face Normal	Also just known as the normal, this is a line perpendicular to the face that also describes which way the face is pointing in a one-sided polygon.
Fall-off	The way in which the intensity of a light diminishes with the distance from its source. In the real world, the fall-off of light is governed by the inverse square law, which states that the intensity is inversely proportional to the square of the distance. However, in 3D software packages, it is possible to use a variety of different mathematical formulae to describe the relationship.

File Format	The format in which the data making up a particular 3D object or scene is stored. File formats come in two types: object formats, such as the LWO format in LightWave or 3DS format in 3ds max, which contain only details of the geometry and surface properties of an object; and scene formats, such as their LWS and MAX equivalents, which contain such global information as lighting, animation or camera data. Other file formats supported by most major 3D software packages include the DXF and IGES formats for CAD and NURBS models, the OBJ object format, and the cross-platform FBX format developed by Kaydara for the interchange of motion data between 3D applications.
File Texture	A bitmap image that can be mapped to shading attributes.
Fill-rate	The amount of pixels from a texturemap (texels) that is rendered per time unit. Measured in texels/second.
Flatness	Flatness is used as a threshold in determining if a polygon is non-planar. A flatness of 0 percent means the polygon is absolutely flat. Flatness is computed as percentage deviation from a triangle (the “ideal plane”) formed from the first two and last vertices of a polygon. All of the other points are measured relative to this plane. The largest deviation is divided by the total size of the polygon to get a percentage that is the flatness value. For example, if a polygon is 1 meter wide, 5% flatness means that no point will be outside the ideal plane of the polygon by more than 5 millimeters.

Flat Shading	Shading technique where all individual faces in a mesh are assigned a single color value based on the orientation of their face normals.
FP	Floating Point. In computing, Floating-Point arithmetic is arithmetic using formulaic representation of real numbers as an approximation so as to support a trade-off between range and precision.
Floating Point (FP) Images	Refers to images that do not use standard color depth models to represent the colors contained in them, but rather an expression of the floating point value of a color changing from 0 for black up to 1 for the brightest point in the image. Mid-gray in such an image would be represented by R: 0.5, G: 0.5, B: 0.5.
Focal Length	of a lens is the distance along the optical axis from the lens to the focus (or focal point). The inverse of a lens' focal length is called its power.
Focus	of a lens is the point onto which collimated light parallel to the axis is focused.
Foreground Image	The image closest to the camera.
Format Conversion	The process of both encoding/decoding and re-sampling digital rates to change a digital signal from one format to another.
Formula-defined Shapes	Refers to shapes that are defined by using one or more equations. This includes complex shapes such as aesthetic bottles or simple shapes such hyperbolic paraboloids, oblate spheroids, prolate spheroids, or ellipsoids.
FoV FOV	Field of View. The maximum angle of view that can be seen through a lens. The wider the FOV, the more of the scene that will be seen.

	Human eyes have a FOV of about 50 degrees, and normally virtual reality application use similar values to resemble real life.
fps	frames-per-second.
FPS	The number (rate) of single frames needed to be captured (or displayed) per second to achieve smooth animation (usually 20-30 fps).
Fractal	A 3D random function with a particular frequency distribution. Fractal textures are useful for simulating many natural phenomena, such as rock surfaces, clouds, or flames.
Frame	In filmmaking, video production, 3D scaning, animation, and related fields, a frame is one of the many still 2D images which compose the complete moving picture. The term is derived from the fact that, from the beginning of modern filmmaking up until today, single images were recorded on a strip of photographic film that quickly increased in length, where each image looks like a framed picture when examined individually. In computer animation, the term “frames per second” (fps) is a measurement of the number of still frames displayed in one second to give the impression of a moving image. For film work, this value is usually 24fps; for the European PAL broadcast format – 25fps; and for the US NTSC broadcast format – 30 fps. In the 3D scanning products; the Point-Cloud, a frame is a 2D model equal to the original video frame it was decoded from.
Frame-rate	The speed at which a frame of animation is shown, usually expressed in frames per second (fps).
Frustum	A volume of space that includes everything that is currently visible from a given camera viewpoint.

	A frustum is defined by planes arranged in the shape of a 4-sided cone with dimensions that correspond to the film aspect ratio.
F-Stop	See: Aperture.

G

Gauge	Any device for measuring or checking the dimensions of an object.
Generic Primitive	Simple 3D objects that most 3D programs can create easily. These objects typically consist of spheres, cylinders, cubes and cones.
Geometry	The points of an object. These points are usually seen with objects that can be rendered. For example, a cube's geometry is composed of eight points. By this definition, a curve has geometry since it is also composed of one or more points, whereas nulls have no geometry. Geometry refers to the positional layout of points and polygons for an object. The mathematics of the properties, measurement, and relationships of points, lines, angles, surfaces, and solids. See also: Mesh.
Global Illumination	A superset of the radiosity and raytracing rendering techniques. The target of Global Illumination rendering is to compute all of the possible light interactions between surfaces, in a given scene to obtain a truly photorealistic image. All combinations of diffuse and specular reflections as well as transmissions must be accounted for. Effects like color bleeding and caustics must also be included in a global illumination simulation.

Global Shutter (camera)	A method of image capturing in which a still picture (or each frame of a video) is captured by taking a snapshot of the entire scene at a single instant in time, thus all parts of the image of the scene are recorded at exactly the same instant. This is in contrast with Rolling Shutter in which the picture/frame is captured by scanning across the scene rapidly, either vertically or horizontally. The advantage of this method is minimization of Motion Blur and Motion Skew effects on the captured image.
Gouraud Shading	Developed by Henri Gouraud in 1971, this is a fast incremental shading technique using bilinear intensity calculation to create smooth transitions between the vertices in a triangle. Most often used for lighting purposes by computing the vertex normals in the polygon, calculating the light values for each vertex, and then Gouraud shading the polygon. Even though it has obvious advantages over flat shading, the facets in the mesh can still be discerned. The placement of the highlight depends on the underlying polygons.
GPU	Graphics Processing Unit. A specialized electronic circuit designed to rapidly manipulate and alter memory to accelerate the creation of images in a frame buffer intended for output to a display device. Their highly parallel structure makes them more efficient than general-purpose CPUs for algorithms that process large blocks of data in parallel.
Group	A set of sub-objects within a model or scene that move and behave as a single entity, yet can still be split apart (ungrouped), if necessary.

		Most complicated models are constructed from several less complex parts that need to maintain the same spacing and orientation; grouping provides a way of locking the relative positions of the objects without joining them permanently.
	GUI	Graphical User Interface. The graphical interpreter between man and computer allows a more intuitive interaction with the computer. The window maker in UNIX, and Windows for the PC are both GUIs. This way the user does not have to be computer literate to the same extent as if he should have to type all commands needed for the computer to perform. Although the GUI varies from program to program, there are certain basic conventions governing the layout of the main professional 3D applications.
H		
	H.264	Also known as MPEG-4 AVC (Advanced Video Coding), one of the most commonly used recording formats for high definition video. It offers significantly greater compression than previous formats.
	Hardware Rendering	Also known as display rendering. Hardware rendering previews a 3D scene within the viewports on a 3D software package, providing real-time on-screen feedback about the effects of changes made to that scene, but omitting certain processor-intensive effects such as volumetrics, shadowing and realistic refraction.
	HDRI	High Dynamic Range Imaging. An HDRI image has an extra floating point value associated with each pixel that is used to define the persistence of light at that point.

	Until recently, a high-dynamic range image was be created from several digital photographs with different exposures combined to show the full range of light. Nowadays, specialised cameras have the capability to capture a large dynamic range of exposure which can even exceed the natural human range of vision.
Hidden	Any element that is not shown in the current rendering of the scene but still exists.
Hidden Surface Removal	Algorithm for removing obscured polygons in a three-dimensional view space. As opposed to the faster algorithm backface culling, the hidden surface removal algorithm is able to sort out those polygons that are obscured by another object. Another way of finding an obscured polygon is the z-buffer.
Hierarchy	The relationship of the sub-objects within a model or a scene to one another. Sub-objects may exist as parents, children or independents. A parent object controls the motion of all child objects linked to it, although the motion of a child object does not affect that of the parent.
History	A record of the previous values of the attributes of a 3D scene, enabling an artist to revert immediately to a specific earlier state. The history is especially valuable during the modelling process.
HLS	**Hue, Lightness, Saturation**. The three components of the HLS color model. Hue refers to the position of the color in the spectrum, such as red, yellow, or green. Lightness is the amount of white mixed in a color, such as the difference between a pure red and pink.

	Saturation is the purity of the color, such as the difference between a pure red and a dusty rose – low saturation means that there is grayer in the color.
HQ	High Quality.
HSV (HIS)	Hue, Saturation (Intensity), and Value (Illuminance). The three components of the HSV color model. This color model defines the hue and saturation similar to the HLS model. Value is similar to lightness, as in HLS; however, a value of 1 represents a pure color when saturation is 1, while a lightness of 1 yields white no matter what the saturation. In both systems, 0 is black.
Hue	The position of the color in the spectrum that describes the tone or tint of a color, such as red, yellow, or blue.
Hull	A series of straight lines connecting the CVs of a NURBS surface.
HW	Hardware.

I

IBL	Image Based Lighting. The simulation of light emitted from an infinitely distant (environment) sphere to create photo-realistic images. With image-based lighting, an environment texture (an image file, ideally HDRI) is needed to illuminate the scene and provide the necessary environment reflections
Icon	In desktop computing and editing, a graphic symbol that represents a file, a tool, or a function.
ID	Identification.

Image-Based Lighting	A technique in which a photographic reference image is used as an environment map to control the surface illumination of a 3D object, in order to create subtle real-world lighting effects.
Incident Light	The direct light that falls on an object.
Intensity	The strength at which the light source illuminate objects in the scene.
Interference Checking	The process of identifying if and where two or more pieces of geometry (usually solids) intersect.
Internal Attributes	The properties of the camera such as depth of field and line-of-sight.
Interpolation	The mathematical procedure by which a 3D software package calculates the in-between positions between two keyframes.
I/O	Input/output. Typically refers to sending information or data signals to and from devices.
IP	Internet Protocol. The principal communications protocol in the Internet protocol suite for relaying datagrams across network boundaries. Its routing function enables internetworking, and essentially establishes the Internet.
IR	Infra-Red. Electromagnetic radiation with longer wavelengths than those of visible light, and is therefore generally invisible to the human eye.
Isometric View	Standard view in a 3D design where the top, front, and right side faces of a cube are equally inclined to the screen surface.

J

K

kHz	Symbol for kilohertz.

		A unit of frequency. One kilohertz is equal to 1,000 hertz or 1,000 cycles per second.
L		
	Layer	A portion of a scene. A level of an image that can be edited independently of the rest of the image.
	Latent Surfaces	Surfaces that are no longer visible after a Boolean or intersection operation because they lie inside or outside the solid.
	LCD	Liquid Crystal Display. A flat-panel display optical device that uses the light-modulating properties of liquid crystals.
	LCS	Local Coordinate System. As opposed to the world coordinate system the LCS is tied to a specific object. LCS are used, among other reasons, to simplify the representation of complex objects by using several, different LCSes as reference points for the object's vertices. It is also easier to transform the object if the object can be rotated around its own "center of gravity" instead of the origin of the World Coordinate System.
	LED	Light Emitting Diode. A semiconductor light source that emits light when current flows through it.
	Lens	In a real camera, a lens is a curved piece of glass or other transparent material that focuses light onto the film. Modern 3D software is capable of simulating a variety of optical distortions created by imperfections in real-world lenses, adding realism to the rendered output.
	Lens Flare	A bright pattern on a captured image caused by the reflection and refraction of light within a camera.

	Although lens flares are actually artefacts of the photographic process, many 3D software packages offer artists the opportunity to add them deliberately in order to increase the realism of rendered output.
LIDAR	**Light Detection and Ranging**. A surveying method that measures distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a laser-sensitive sensor.
Light	A point or volume that emits light onto a 3D object. Types of light supported within 3D packages include Point lights, which emit light in all directions from a single point; Spot lights, which emit light in a cone; Distant or Directional lights, which emit light rays in parallel, illuminating all surfaces within a scene; and Area lights, which emit light from two-dimensional surfaces.
Light Source	In rendering, an object that provides illumination to a scene. In the real world, the surfaces of objects are illuminated by light rays emitted from various light sources (for example, light bulbs, torches, the sun).
Light Probe	A tool used to create custom HDRI environment maps.
Live-streaming	Streaming media that is broadcast to many people at a set time.
Local Coordinates	Every object has its own origin, which is subordinate to the world coordinate system (or other objects that are higher in the hierarchy). Local coordinates are useful for determining positions of subordinate objects.
LoD LOD	**Level of Details**. A term reffering to varying the amount of detail in an object depending on the distance from the object to the camera.

	Example: A car for a close-up would need to have every little detail modeled into it; Chrome, bumpers, body seams, door handles, etc. Same car, as seen from an helicopter flying over the highway, would possibly be a simple cube with an image map applied to it.
Low-Poly Modelling	The process of creating simplified models with low polygon counts, usually for use in videogames, where scenes must be rendered in real time, by software with a limited ability to handle complex models.
LSS	**Laser and Synchronization Subsystem**. An electronic module that has a micro-controller and an FPGA to generate synchronized signals to all VoCAM's parts (IR and RGB cameras Exposure and Power to Laser).
Luminance	The component of a video signal that includes information about its brightness. The black and white information (brightness, sharpness, and contrast) encoded in a color.
Luminosity	Much like glow, luminosity is a measure of how much light a surface gives off before any light strikes it.
LUT	**Look Up Table**. An array that replaces runtime computation with a simpler array indexing operation.

M

Mask	An area that can be protected and isolated from changes applied to the rest of the image.
Match Moving	The process of matching the camera or object movement from live action footage with a computer-generated (CG) scene. See: Camera Tracking.
Mbps	**Mega-bits-per-second**. One megabit is equal to one million bits or 1,000 kilobits.

Metadata (side information)	Informational data about the data itself. Typically information about the audio and video data included in the signal's data stream.
Mesh	The surface geometry of a 3D model, made up of a series of linked geometry elements such as polygons, patches, etc. The actual vertex (a point in space with additional attributes) data that results in a visible 3D object. A way to represent solid objects through polygon division.
Mesh Complexity	Term for describing the amount of information (amount of vertices, normals, triangles etc) used to create an object. A higher mesh complexity needs more memory and is slower to process.
MIS	Mantis Vision's legacy file format.
MLS	**Moving Least Squares**. A method of reconstructing continuous functions from a set of unorganized point samples via the calculation of a weighted least squares measure biased towards the region around the point at which the reconstructed value is requested. In computer graphics, the moving least squares method is useful for reconstructing a surface from a set of points. Often used to create a 3D surface from a Point-Cloud through either downsampling or upsampling.
Model	A computer-based description and representation of a 3D object; self-contained 3D representation of a scene, potentially including other assets (i.e. textures, and scripts). Even when importing or exporting single objects the formats dictate that a scene exists at the "root" of the node hierarchy. Also see Geometry.
Modeler	An additive fabrication machine that manufactures parts.

	The process forms three-dimensional objects from 3D model data (CAD generated solid, surface models or Voxel-based models). The designed object emerges as a solid 3D part through the deposition of material, layer-by-layer, also known as 3D Printing. See also 3D Printer.
Modeling	The process of creating a 3D scene consisting of objects and the applying of mapping to those objects or of posing before a camera, sometimes with no clothes on.
Motion Blur	An artefact of real-world cinematography in which the camera's target object is moving too quickly for the camera to record accurately, and therefore appears blurred. Many 3D software packages simulate motion blur as a rendering effect, in order to increase the realism of 3D images or animation.
Motion Capture	Often abbreviated to mo-cap, motion capture is the process of recording the movements of a live actor, and converting them to a 3D data format which can then be applied to a virtual character.
Motion Skew	The image "bends" diagonally in one direction or another as the camera or subject moves from one side to another, exposing different parts of the image at different times. This is an effect caused by using rolling shutter camera.
MPC	Mantis Vision's legacy Point-Cloud file format.
MPE	Maximum Permissible Exposure.
MR	Mixed Reality.
Multicast	Data flow from single source to multiple destinations. A multicast may be distinguished from a broadcast in that number of destinations may be limited.
MV	Mantis Vision.

MVC	Mantis Vision's F6 SMART™ Camera.
MVX	Mantis Vision's Point-Cloud file format. Mantis Vision eXtended Point-Cloud format that also may include: ● The source video stream/s ● The decoded Point-Cloud ● Calibration data

N

Negative Light	A light within a 3D scene that decreases the illumination on a surface instead of adding to it. Negative lights can be used to remove "overspill" in brightly lit scenes.
NIR	Near-Infra-Red.
Node	A node is a container within a scene. Nodes have position, angle, and a few other properties.
NOHD	Nominal Ocular Hazard Distance.
NOHA	Nominal Ocular Hazard Area.
Normal	In modelling, a directional line perpendicular to a surface indicating orientation of polygonal faces.
NTSC	National Television Standard Committee. Common video standard in USA and Japan. It has a frame-rate of 30 fps. 60 times per second every other scan line is changed, resulting with smoother transitions. Pixel resolution is 720x486 and pixel aspect is 0.9.
NULL	Non-renderable help-object used in modeling programs to simplify the manipulation of 3D-objects and texture mapping.
NUM	Numeric.
NURBS	Non-Uniform Rational B-Spline. A mathematical model (surfaces described by parametric curves) commonly used in computer graphics for generating and representing curves and surfaces.

	Offers great flexibility and high precision for handling both analytic and modeled shapes. NURBS are commonly used in **CAD**, CAM and CAE and are part of numerous industry wide standards, such as IGES, STEP, ACIS, and PHIGS. NURBS tools are also found in various 3D modeling and animation software packages.

O

Object	A generic term referring/describing to any item that can be inserted into and manipulated within a 3D scene. Models, lights, particle emitters and cameras are all objects.
Object file	See: File Format.
OEM	Original Equipment Manufacturer.
On-demand Streaming	Streaming media content that is transmitted to the client upon request.
OOG	**Object Oriented Graphics**. Different from bitmap format, this image type consists of objects that have definite mathematical formulas behind them. These images always print at the maximum quality specified by the printer, unlike bitmapped images that always print at the same quality level. They can also be referred to as “vector graphics”
Opacity	The opposite of transparency.
OpenGL	A 3D graphics API that includes capabilities for 2D imaging. Basically, OpenGL is a set of instructions that can be used by a program to interpret images and display them on the screen.
Orbit	To travel around a target – more commonly circular or elliptical.
Origin	See Co-ordinate System, Axis.

Orthogonal	A view that displays a parallel projection along one of the major axes. In an orthogonal view, the camera is oriented so it is perpendicular (orthogonal) to specific planes: ● The Top view faces the XZ plane, ● The Front view faces the XY plane, and ● The Right view faces the YZ plane. An orthogonal view eliminates the effect of distance from a viewpoint, which provides a useful means of locating points and objects in 3D space and is particularly helpful when modeling objects in wireframe mode. An orthogonal view is in contrast to a perspective view.
Orthogonal Direction	There are six different orthogonal directions in a 3D space: up, down, back, forward, left and right.
OS	Operating System. Base program that manages a computer and gives control of the functions designed for general purpose usage--not for specific applications.

P

PAL	Phase Alternate Line. The industry standard for color encoding for analogue television used in broadcast television systems in most countries broadcasting at 625-line / 50 field (25 fps), definition of composite video in most of Europe.
Pan	To rotate the camera horizontally. As opposed to the orbit movement, the pan rotates the camera around a single axis, as if it where mounted on a tripod.
Panel	In a 3D programs, a screen that serves many functions such as informing the user of errors, asking for user input, or informing the user of the state a program is currently in. Otherwise known as a Window or Requester.

	Also reffered to as Billboard.
Parent	An object that influences the motion of another object in a hierarchy, called the “child”. Also see: Hierarchy.
Parenting	The process of creating a hierarchical organization of objects in a scene. In parenting, an object (called the parent object) is "parented" to another object (called the child object). Parenting relationships can be nested to any degree, so that one or more objects are the children of another object, which is in turn the child of another.
Pattern	Physical representation of a design that is used to produce molds, dies or tools.
PC	Personal Computer.
PCI	Peripheral Component Interconnect. A local computer bus for attaching hardware devices in a computer.
Perspective	A traditional art method of creating the illusion of 3D form and distance on a two-dimensional surface. Perspective provides a 3D view of the scene that indicates depth. In a perspective view, objects appear to converge toward a central vanishing point, and objects closer to the camera appear larger than those farther away. A perspective view is in contrast to an orthogonal view.
Photogrammetry	Also known as image-based modelling. Photogrammetry is the process of generating a fully textured 3D model from a series of photographs of a real object. Although it was once an expensive high-end technique, there is now a range of increasingly inexpensive photogrammetry software packages on the market.

Photorealism	The process of generating computer images that mimic photographs.
Pitch	The amount that the camera or an object in the scene is tilted up or down.
Pivot Point	A single point, usually in the geo-center of an object that is used for many functions. It is the point that is addressed to locate an object's position in 3D space. It is also the point around which all rotational moves are made and is the reference point for transformations and scaling.
Pixel	A picture element/cell. Smallest controllable segment of computer or video display or image. Name given to one sample of picture information. Pixel can refer to an individual sample of RGB luminance or chrominance, or sometimes to a collection of such samples if they are co-sited and together produce one picture element.
Pixel Aspect Ratio	The aspect ratio of each pixel, which may be square (1.0) or non-square.
Plane	A 2D surface in Cartesian co-ordinate space. Essentially a flat sheet extending infinitely in all directions, a plane may be used to aid object manipulation, positioning and construction, and is not usually made visible in a final render.
Point	A 1D point in coordinate space. The point is a fundamental building element of an object in 3D space with an XYZ location. Point coordinates are the minimum information from which the geometry of an object can be calculated. Points can be linked up to form polygons, used as control vertices or employed as nulls to control lights or cameras, amongst other functions.
Point-Cloud Cloud of Points	A set of data points in some coordinate system in space.

	In a 3D coordinate system, these points are usually defined by X, Y, and Z coordinates, and intended to represent the external surface of an object.
Point-to-multipoint	An arrangement, either permanent or temporary, in which the same data flows or is transferred from a single origin to multiple destinations. The arrival of the data at all the destinations is expected to occur at the same time or nominally the same time.
Polygon	Cross-platform industry standard for constructing geometry. N-sided facet (figure) defined by three (3) or more vertices in space. A polygonal object can be closed, open, or made up of shells, which are disjointed pieces of geometry. Often referred to as a mesh.
Polygon Geometry	Polygons are the most commonly used geometry type in 3D. While polygons are commonly used for all types of objects, in order to create very smooth surfaces with polygons means that users need to add a lot more geometry than with either NURBS or subdivision surfaces.
Post Processing	The manipulation of a rendered image, either to improve the quality of that image, or to create effects that cannot easily be achieved directly within the 3D software itself. Some 3D software packages can be set to automatically apply post-processing effects, such as motion blur or Depth of Field, after a frame is rendered.
PoV POV	Point of View.
Preset	A pre-generated list of settings for a particular 3D software package.

	Presets are usually used to control and customise properties such as rendering or lighting styles. Like plugins, they may either be commercial products, or freely downloadable from the Internet.
Preview	A time-saving method of checking the progress of a project by rendering it at a lower quality, resolution or frame rate than will be used for the final project.
Primary Colors	There are three (3) primary colors of light: Red, Green and Blue (RGB). Light colors are additive, which means that if these three colors are combined equally, the result is a white light. Black is thus absence of light.
Primitive	Basic geometric shape used in modeling. Some primitives consist of a combination of different primitives. Cone, box, sphere, tube, torus, and disc are common primitives.
Procedural Texture	A texture that is calculated based on some algorithm or mathematical formula.
Projection	The process by which a two-dimensional texture map is applied over the surface of a three-dimensional object, as if it were an image projected from a slide projector. There are several common projection types, including Planar, Cubic, Spherical and Cylindrical. Which one is most appropriate depends on the type of map being projected, and the shape of the object it is being projected upon.
Projection Map	A technique of projecting a 2D image onto 3D geometry, useful for creating textures or icons on a rendered object.
Protocol	Set of syntax rules defining exchange of data including items such as timing, format, sequencing, error checking, etc.

PTS	Leica's 3D Point-Cloud format. ASCII-based interchange format utilizing the concept of separate scans, each with points defined in their own coordinate system and a registration of all those Point-Clouds into a single coordinate system. Point data for each cloud is stored in its original coordinate system and a matrix of transforms for each Point-Cloud are provided as header information.

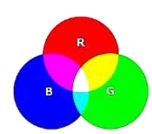
Q

Quad	Short for quadrilateral – a polygon with four sides.
Quantization	The process of sampling an analog waveform to convert its voltage levels into digital data.

R

RAM	Random access memory. A temporary, volatile memory into which data can be written or from which data can be read by specifying an address.
Rasterization	The process of, on a per pixel basis, determining what value to assign to the pixels on the screen from a vector based image.
Raytracing Ray tracing	A technique for rendering 3D scenes. Raytracing traces the path of every ray of light from its source until it either leaves the scene or becomes too weak to have an effect. The term is also sometimes applied to the reverse method: tracing the path of every ray of light from the camera backwards to the light source.
Realtime Real-Time RT	Computation or processing done in the present to control physical events occurring in the present.

	For example, when a digital effects system operator moves a joystick and the video images on the monitor appear to move simultaneously, the computations required to make the images move are said to have occurred in realtime.
Reflection	Light that bounces off a surface. A mirror is highly reflective, whereas the reflection of a matte rubber surface is insignificant.
Reflection Map	An environment map used for simulatation of real-world reflection effects on the surface of a 3D object. Reflection maps render more quickly than methods that generate true surface reflections, such as raytracing.
Rendering	Creating a 2D image from a 3D scene is a process known as rendering. To create a rendered image, the scene must first be constructed within the dedicated 3D graphics software on the computer workstation; this software allows the artist to describe geometry, lighting, surface properties, special effects and animation (time based changes). 3D rendering is a creative process similar to photography or cinematography. The camera is defined at a location in 3D coordinate space, pointing in a given direction. Unlike traditional photography, everything appearing in a 3D rendering needs to be created in the 3D space before it can be rendered – allowing an almost infinite amount of creative control over what appears in the scene and how it is depicted. Artists need to create this scene before the rendering can commence. The rendering output can be setup for photo-realism or be designed to appear stylised.

	As an animation requires as many as 30 images for every second, rendering time is an extremely important consideration in all 3D animation. Rendering time is a function not only of the power of the computer used, but also of the complexity of the scene, the lighting model, and the presence of computationally intensive elements (to mention only a few). The properties of rendered image files can be controlled according to post-production or presentation requirements. Also known as software rendering.
Resolution	The size of the final image in pixels when rendering out a scene. Higher resolution renders contain more detail, but take longer to complete.
Rolling Shutter (camera)	A method of image capturing in which a still picture (or each frame of a video) is captured not by taking a snapshot of the entire scene at a single instant in time but rather by scanning across the scene rapidly, either vertically or horizontally, thus not all parts of the image of the scene are recorded at exactly the same instant. This is in contrast with Global Shutter in which the entire frame is captured at the same instant. The advantage of this method is that the image sensor can continue to gather photons during the acquisition process, thus effectively increasing its sensitivity.
RGB	Red, Green, Blue. An additive color model based on the primary colors of light (and television). Cameras and telecines have red, blue and green receptors, the TV screen has red, green and blue phosphors illuminated by red, green and blue guns. Much of the picture monitoring in a production center is in RGB. 

S

Scalar	A quantity, such as mass, length, or speed, that is completely specified by its magnitude and has no direction, a one dimensional value.
Scanner	Device for reading images into the computer. This is useful for creating realistic textures. With a 3D scanner it is even possible to capture three-dimensional objects and convert them into models.
Scene	Most 3D software uses a scene as the primary element to contain objects. Scenes may include environment settings like ambient light and fog. Scenes include an object graph with all the data in the scene.
Script	A small piece of code created in a 3D software package's own internal programming language, and used to automate common or complex tasks.
Scrub	The process of manually dragging the frame advance control slider on the timeline to see or hear its effect on video/audio.
SDK	Software Development Kit. A set of software development tools that allows the creation of applications for a certain software package, software framework, hardware platform, computer system, video game console, APIs, operating system, or similar development platform.
Segment	A section/division/group of Frames, distincted from the other (either eccidentaly or for a purpose).
Shading	The mathematical process of calculating how a model's surfaces react to light. A variety of alternative algorithms can be used for the task, including Phong, Lambert, and Blinn shading models.

	Shaders are often built up as node-based shading trees, with each node controlling a specific aspect of the process.
Skew	Modifying an object by tilting it.
SL	**Structured Light**. The process of projecting a known pattern (often grids or horizontal bars) on to a scene. The way that these deform when striking surfaces allows vision systems to calculate the depth and surface information of the objects in the scene, as used in structured light 3D scanners.
Smoothing	Technique that, when rendering or shading, smoothes out the edges between segments making objects appear smoother than their geometry really are.
S/N	**Serial Number**.
Snapping	The automatic alignment of one object to another or to a reference grid, intended to aid the precise placement of objects within a scene or modelling hierarchy.
SOR	**Statistical Outlier Removal**. Laser scans typically generate point-cloud datasets of varying point densities. Additionally, measurement errors lead to sparse outliers which corrupt the results even more. This complicates the estimation of local point-cloud characteristics such as surface normals or curvature changes, leading to erroneous values, which in turn might cause Point-Cloud registration failures. Some of these irregularities can be solved by performing a statistical analysis on each point's neighborhood, and trimming those which do not meet a certain criteria.
Specularity	A surface property of an object that determines the way in which highlights appear on that surface.

SSD	**Solid-State Drive** or **Solid-State Disk**. A solid-state storage device that uses integrated circuit assemblies as memory to store data persistently.
Standard Deviation	Standard deviation is the measure of dispersion of a set of data from its mean. It measures the absolute variability of a distribution; the higher the dispersion or variability, the greater is the standard deviation and greater will be the magnitude of the deviation of the value from their mean.
Stereoscopic 3D	Two separate photographs taken from slightly different angles that, when compiled, appear three-dimensional.
Stitching	Image stitching is the process of combining multiple images with overlapping fields of view to produce a segmented panorama or high-resolution image.
STL	STereoLithography file format.
Stream	A stream of Atoms sharing the same StreamId.
StreamID	A field of data identifying the Stream.
Surface	The outer part of an object. The surface attributes can be changed using the Surface panel. Such attributes as name, color, and many other features affect the appearance of an object.
SW	**Software.**

T

Take	A take is a single continuous recorded performance. The term is used in film and music to denote and track the stages of production.
Target	In aiming the camera, the target is the object that is selected for the camera to point toward.

	The target is in the center of the scene.
Tessellation	Increasing the detail level of a polygonal 3D model by increasing its number of polygons, usually triangles. The more triangles, the smoother the shape and subsequently the larger the model. The tessellation can be performed by dividing one triangle into two (or more) smaller ones. The new, more faceted model can be modified without losing too much of its smoothness.
Texture	A bitmap image that is applied to the surface of 3D object to give it detail. Texture maps may be either photographic images or procedural textures, and may be applied in each of the material channels of an object using a variety of mapping or projection methods.
Texture Coordinates	Coordinates used to describe how to map a texturemap onto an object. There are different kinds of techniques to apply the texture: planar, box, cylindrical, spherical and shrink map. Their names indicate how the texture is projected onto the object the mapping coordinates are applied to. The shrink map projection differs from the spherical projection in the way it only has one pole where all seams meets. The modeler can manipulate the texture coordinates to or mirror the texture. The procedural maps do not need texture coordinates.
Texture Mapping	The process of projecting a 2D image onto a 3D surface.
Tiling	The process of duplicating a texture across the surface of an object. Tiling textures must be created so that the edge of one aligns perfectly with that of its neighbour, otherwise the result is a series of ugly seams.

		High frequency textures are those in which patterns repeat at short intervals over an object's surface; low-frequency textures are those in which the intervals are larger.
	Timeline	A fundamental element of the graphical user interface of most modern 3D software packages which shows the timing of the keyframes in a sequence of animation. Playback of the animation may be controlled either by a series of VCR-like controls, or by selecting and dragging with the mouse to 'scrub' a slider to and from along the timeline.
	Triangle	A triangle is the simplest polygon that is made up of three sides or edges connected by three vertices, making a three-sided face. When modeling, triangles are typically a polygon type often avoided. When creating complex meshes, triangles tend to pose a problem when subdividing geometry to increase resolution, and when a mesh will be deformed or animated.
	Truck	To move the camera in the viewing plane.
	Twist	Twisting a mesh by rotating its vertices non-uniformly along an axis.
U		
	UI	User Interface. The area where interactions between humans and machines, for effective operation and control of the machine (from the human end), occurs. To complement this purpose, the machine provides information back which supports the human's decision-making process.
	USB	Universal Serial Bus. An industry standard developed to define high speed serial communication's cables, connectors and protocols for connection, communication, and power supply between personal computers (PCs) and their peripherals.

UV-grid	A grid system for identifying points on a surface. The U-direction and V-direction are for the surface, what the X-axis and Y-axis are for the coordinate system.
UX	User Experience. Refers to a person's emotions and attitudes about using a particular product, system or service. It includes the practical, experiential, affective, meaningful and valuable aspects of human–computer interaction and product ownership.

V

VCD	Volumetric Capture Device. The VCD is attached to the VoCAM and controls and captures the VoCAM's images.
VCSEL	Vertical Cavity Surface Emitting Laser. A type of semiconductor laser diode with laser beam emission perpendicular from the top surface.
Vector	Entity with both magnitude and direction. A 3D vector is written as: V=(v1, v2, v3) where each component is a scalar.
Vertex	A position (usually in 3D space) along with other information such as color, normal vector and texture coordinates. The Vertex is the smallest component of a polygon model. By connecting multiple vertices together users can create a polygon model. Also see Point.
Vertex Count	The number of vertices in a scene. Remember, the higher the mesh complexity the longer the rendering time.
Vertex Normal	Even though it is a single point in 3D space, its normal can be calculated based on the normal of the face they are describing.

	The three vertex normals of a single triangle without any neighboring triangles are set to be the same as the polygon's normal. For triangles surrounded by other triangles, the vertex normals are the average of the surrounding face normals.
View Frustum	Representing the field of view of the camera, the view frustum is a pyramid volume with the top sheared off. The top of the pyramid represents the viewport of the camera (usually the screen), and is often called the near (or hither) plane, while the bottom is called the far (or yon) plane.
View Frustum Culling	Removing faces that lie outside the observer's view. Only the faces that is within the view frustum is kept for rendering – speeding up rendering time and helping to maintain a high framerate.
Viewport	The user's viewing window into the presented 3D space.
V-Maps	An abbreviation for vertex maps. V-Maps provide additional information associated with object points (vertices), like weight, UV and morph maps.
VoCAM™	Mantis Vision's Volumetric Camera. 
Volumetric Pixel Voxel	Volume element representing a value on a regular grid in 3D space.
Volumetrics	Volumetric lights are lights whose illumination can be observed throughout a volume of space, rather than simply where the light strikes a surface. In similar fashion, volumetric textures are textures applied throughout a volume of space, rather than to a surface.
VR	Virtual Reality.

	A computer technology that simulates a real or imagined environment so that the user can interact with it as if physically present.

W

WebGL	**Web Graphics Library** A JavaScript **API** for rendering interactive 2D and 3D graphics within any compatible web browser without the use of plug-ins. WebGL is fully integrated with other web standards, allowing GPU-accelerated usage of physics and image processing and effects as part of the web page canvas. WebGL elements can be mixed with other HTML elements and composited with other parts of the page or page background.
Wireframe	A shading method in which a simple grid of lines is used to represent the basic contours of the underlying model. For many 3D artists, this is a favoured mode to work in, since it permits them to see faces and surfaces that would otherwise be hidden by overlying geometry.
World Coordinate System	The coordinate system, normally in 3D, used to describe the location in space of a specific point called vertex.

X

XYZ	XYZ is a generic Point-Cloud file format. In this format, data is spatially represented using 3D coordinates. It is the most commonly accepted format for software in the Construction and Mining industries.

Y

	Yaw	To turn about the vertical axis, also known as heading.
Z		
	Zoom (in/out)	Decreasing or increasing the distance of the user's view towards whatever it is that the camera is facing.

Appendix 3 Release News for Echo™ Software Version 2.0.0

This appendix describes all updates made to the Echo™ software and, accordingly, to this User Guide.

New Features for Software Version 1.3.0

New Features for Software Version 2.0.0

Version 2.0.0 of Echo™ include many new and enhanced features, some of which are "under-the-hood" features (e.g. enhanced algorithms, etc.) not elaborated upon in this User Guide.

These new and enhanced features are:

- Auto Process – a short-cut new tool combining the frequently used Registrations, Denoising and Meshing acts into a single command-button.
- Export to Potree – a new export option to Potree's web presentation of Point-Cloud software for internet web browsers.

See paragraph "Modifications Made to this Document" below how these new and enhanced features affected the content of this User Guide.

Bugs Fixed in this Release

Modifications Made to this Document

- Auto Process – documented in section "View Control Toolbar – Auto Process Command-Button" on page 67.

Also affected are Appendix 6 – 3D Registration Types, Appendix 7 – 3D Noise Cleaning (Denoise) Types and Appendix 8 – 3D Meshing (Spawning) which were extracted from section Gallery View Mode – Edit (Third) Page – The Edit Page for Raws and Editables to form new theory background appendixes serving both the Auto Process and the Edit Page for Raws and Editables paragraphs.

- Export to Potree – documented in section Main Menu in Both Gallery View Mode's Edit Pages – The Export Menu Options – The Potree File Format Option, as well as in the new Chapter 7 – Interfacing with Other 3D Software Tools – Interfacing to Potree.

Appendix 4 Technical Specifications

Echo™ Software Specifications

Item	Data
Minimum free hard disk space for installation	90 Mb (without the Visual Studio™ and the FTDI Driver).
Recommended working disk space	
Output formats	PTS, ASCII, PLY, E57, STL
Operating System (OS) Supported	Microsoft™ Windows™ 7 Pro (64bit) or higher. Windows™ 10 Pro (64bit) recommended.

Table 5 – Echo™ Software Specifications

Workstation Specifications

Item	Data
Operating System (OS)	Microsoft™ Windows™ 7 Pro (64bit) or higher. Windows™ 10 Pro (64bit) recommended.
Processor	Intel™ i7-6650U quad core processor (2.2GHz to 3.4GHz, 4MB cache) or higher.
Memory	Minimum 16 GB RAM.
Hard Disk Drive	PCI Express SSD (from 128GB to 1TB).
Display	12.3” 2736 x 1824 PixelSense display with 3:2 aspect ratio or higher. Touch screen display is highly recommended.
USB port	Minimum two (2) USB 2.0 (or higher) ports with minimum power delivery capability of 500mA (as per USB Standard).

Table 6 – Echo™ Workstation Specifications

Appendix 5 Mantis Vision Data Files Content and Structure

The Mantis Vision Echo™ software uses a specially developed data file formats – the **MVX** data file format and its predecessor – the **MPC** data file formats, which are mentioned within this document.

The following paragraphs describes these file formats:

The .MPC Data Files

The **MPC** is Mantis Vision's legacy data file format developed and used in its previous 3D software products.

Unlike its current alternative, the **MVX** file format (see **below**), the **MPC** is not a container file (see section "Synopsis of Container File-Format" **below**) allowing coexistence of different data types in the same file, but a unified file format storing:

- Point-Clouds of single Frames only.
- Each Point of the Point-Cloud is described with its:
  - XYZ Cartesian coordinates of the Point,
  - Color (RGB) data of the Point, and
  - Normal of the Point (direction vector for the polygon that will be created from the Point and its neighbors).

The **MPC** file format DOES NOT include data regarding the physical relations between the Frames (description of how the scanner moved from one scanned Frame to the next) included in the file.

For that purpose, there is an additional/associated file, with the extension of *.TOC*, that must always accompany the **MPC** files.

The **TOC** file contains the Frames' registration data expressing the movement of the scanner during the scan act.

Only the combination of both **MPC** file with it associated **TOC** file (with the same file name) will allow the creation of 3D model out of the file's data.

The MVX Data Files

Synopsis of Container File-Format

Mantis Vision's proprietary **MVX** file-format files are **Container** type files.

A container (or wrapper) file-format is a metafile format whose specification describes how different elements of data and metadata coexist in a computer file.

In other words – it is the image of the virtual drive stored in a big file.

The container file is used to identify and interleave different data types and it specifies only the wrapper (but not the coding).

The different elements constructing the container file are stored in the container in **Layers** each of which deals with another type of data. By definition, a container format could wrap any kind of data (but not the decoding algorithms of the data).

Such containers are frequently used in multimedia applications.

Since the container does not describe how the encompassed data or metadata is encoded, the program using this data must be able to identify and open/decode the container file.

Mantis Vision's MVX Container File

Synopsis of MVX Container File

Mantis Vision's MVX file is structured as a linear sequence of **Atoms** preceded by the MVX' header.

Atoms are containers constructing the **MVX Files**.

Atoms are usually used as frames for grouping some assortments of **DataLayers** which share the same **Timestamp** and **StreamID**.

DataLayers – are blocks of data.

Stream – are streams of **Atoms** sharing the same **StreamID**.

StreamID – is a string identifying the **Stream**.

For example:

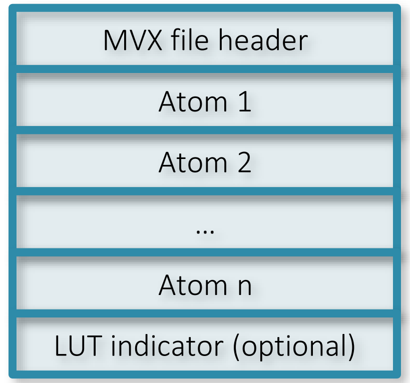


Figure 285 – Example of MVX Container File

The Atom Data Container

Only two (2) types of **Atoms** were defined by Mantis Vision so far:

NOTE: The format is flexible enough to support more than two.

- **FRAME** and
- **LUT** (Lookup-Table).

Structure of a Practical MVX File

Practically, an MVX File is typically structured as follows:

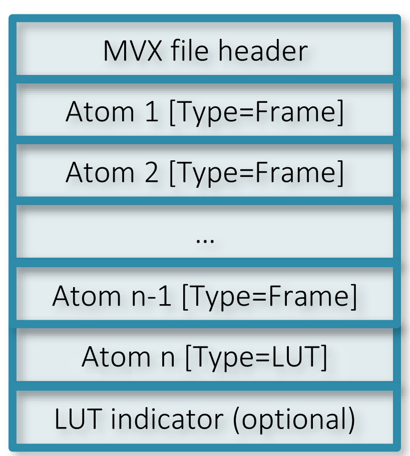


Figure 286 – Example of a Practical MVX Container File

Structure of an Atom Type FRAME

Atom's Body Data of an **Atom** Type **FRAME** is structured as a sequence of **DataLayers**:

DataLayer 1
DataLayer 2
…
DataLayer n

Figure 287 – Example of Atom's Body Data (Atom type FRAME)

Structure of the LUT

The **LUT** (Look-Up-Table) is a compact representation of many **Atoms**, structured as follows:

LUT-header
GUIDS section
Streams section

Figure 288 – Example of LUT's Structure

Structure of the GUIDS Section

The structure of the **GUIDS** section defines a **Guid Sequence**:

Num Guids
Guid #1
Guid #2
…
Guid #n

Figure 289 – Example of GUIDS Section's Structure

Structure of the Stream Section

The structure of the **Stream** section defines a **Stream Sequence**:

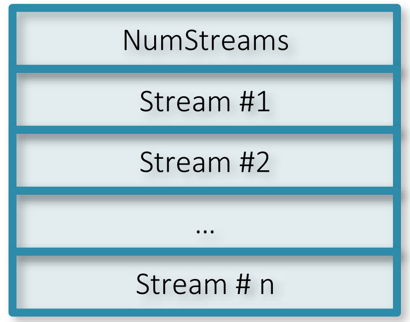


Figure 290 – Example of Streams Section's Structure

The Structure of Frame X Followed by Sequence of DataLayers

The structure of **Frame X** starts with some **Frame** information followed by a sequence of **DataLayers**:

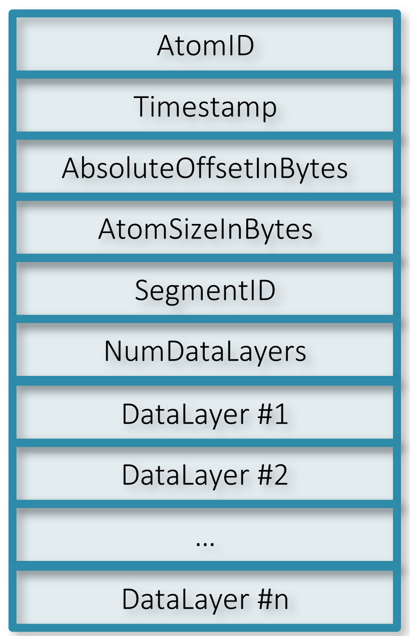


Figure 291 – Example of Frame X followed by a Sequence of DataLayers

The LUT Indicator

The **LUT indicator** is optionally added at the very end of an MVX file and should only be added when the very last **Atom** of the MVX file is an **Atom** type **LUT**.

Atoms type **FRAME** are written throughout recording time.

Atom type **LUT** is recorded at the very end of the recording session since it contains aggregated information of all previously recorded **Atom**s.

Absolute offset to **Atom** type **LUT** cannot be foreseen by a file reader at read time or forecasted in advance by a file-writer.

For that reason, this information is added at the very end of the MVX file, giving file-readers the possibility to take advantage of the information in **Atom** type **LUT**.

Background Information on Current Implementation

On data-format level, **DataLayers** are divided into **Header** and **Body**.

The **DataLayer Header** is completely type-agnostic in nature and serialized/deserialized on the level of the MVX framework (file readers/writes, network transmitters/receivers etc.).

The **DataLayer Body** is fully type-specific and therefore serialized/deserialized on the level of **DataLayer** classes, implemented by the corresponding C++ programmers.

Mantis Vision implemented many **DataLayers** by itself, gaining important insights on how to optimize performance and minimized memcopies on a C++ level.

The resulting mechanisms and patterns, on a C++ level, might look counter-intuitive at first glance and therefore not very 'beautiful', but they are simply effective in terms of performance and memory usage in typical and performance critical use-cases.

A core principle of MVX is the following – **DataLayers** never change, from the moment of formation until they get destroyed.

While this is true for almost all cases, there are meanwhile some **DataLayers** related to configuration settings where changes happen at runtime.

This cases now look extra-complicated on a C++ level, since a change of any value of a **DataLayer** automatically results in a direct serialization of the entire **DataLayer**.

Appendix 6 3D Registration Types

Throughout the course of assembling the 3D model, there are five (5) different types of registration processes made by the system, all targeting perfect registration between all **Frames** and **Segments** of the scanned object which will result with a complete model built around a **Single Segment**.

Online Registration

During the scan operation (**online**), the Echo™ Decoder process the IR video stream to create the 3D Point-Cloud, frame-by-frame.

Figure 292 – Scan View – Settings toolbar – MVX Settings toolbar

If the **3D Point-Cloud option** and the **Live Registration option** in the Main Screen – Scan View Mode (see details in section "The Settings Toolbar" in page **152 above**) were marked for both ***Active*** and ***Recorded***, this process will create the 3D Point-Cloud data off the IR video stream and save it as a layer in the emerging Raws' *.MVX* file.

This process also attempts to match (align/register) these emerging frames, each to its successive neighbor (frame-by-frame), to create a coherent 3D model utilizing for this purpose identified overlapping geometries which were included in the IR video stream.

This initial registration process is called **Online Registration** and is done automatically, throughout the scan, with no option for control (except for the initial setup).

High Quality (HQ) Registration

This is a general image improvement registration process, usually performed prior to all other registration processes (except for the **Online Registration**). The Echo™ software processes ALL of the scanned object's Frames, Segments and Groups together (and not frame-by-frame like the **Online Registration**) attempting to have them matched and registered properly. This registration process is further detailed in section "The Extra Functions Toolbar" in page **98 above**.

Manual Registration

The process of **Manual Registration** between every two(2) consecutive Frames (or Segments or Groups), where the user need to manually drag, tilt and rotate the objects until they are overlapping each other as best as possible and then transfer the control to the Echo™ software to complete the job. In cases where the Echo™ cannot complete the registration, a message window will pop-up to inform the user about it:

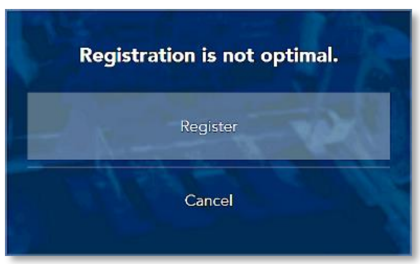


Figure 293 – Manual Registration – Registration not Optimal message window

The user has the option to retry the registration process by selecting the ***Register*** option or abort the process by selecting the ***Cancel*** option.

This is the primary tool used for registration in the editing phase of building a 3D model.

Automatic Registration

Unlike the **Online Registration** which processes the registration frame-by-frame or the **Manual Registration** which processes only two Segments at a time, the **Automatic Registration** takes ALL Segments/Groups/Frames into the registration process and attempt to match them all together.

TIP: It is recommended to run **Automatic Registration** prior to **Manual Registration** since most registration issues will be rectified in this process and save time of manual procedures.

Global Registration

Global Registration is a complementary registration process aiming at rectifying special registration issues like cumulative registration errors, which cannot be accomplished prior to the situation where all **Frames**, **Groups** and **Segments** were already registered and form a single-segment object.

The **Global Registration** algorithm converts all **3D Frames** into a single-coordinates model using the information of frames' positions (each **Frame** is registered in the global coordinate system) relative to each other.

The algorithm uses both geometry and texture data of the object to find the optimal position of each **Frame** to ensure highest accuracy of positioning and to fix misalignment that are hard to spot by the naked eye.

The **Global Registration** algorithm is one of the most resource-intensive operations in data processing of the Echo™ software.

NOTE: **Global Registration** can be performed on a single group of segments only, therefore alignment and registration of all segments into a single group is required prior to running the **Global Registration** command.

Appendix 7 3D Noise Cleaning (Denoise) Types

The **Noise Cleaning** is used to smooth or remove small sporadic particles (outliers, considered as "noise") acquired by the video sensors during the **Scan act**.

Such sporadic particles may interfere with the construction of the fully-registered, **Single Segment** Point-Cloud model.

Such undesirable particles may result from parasitic reflections of light or parasitic energy diffusion, as well as other environmental disturbances.

The idea is to distinct between points which represents the legitimate surfaces of the scanned object and the outlier points representing noise.

This way the Denoise Act screens (filters) outlier points out of the entire Point-Cloud.

A common strategy for denoising a Point-Cloud is to define a smooth surface function, based on the Point-Cloud, which will be used as reference for the Denoise Act.

For example; the following scan of a pillar shows an apparent surface which is an obvious physical part of the scanned object (marked with black points), with some diluted Point-Cloud around its edges representing noise picked-up during the scan operation (marked with pink points):

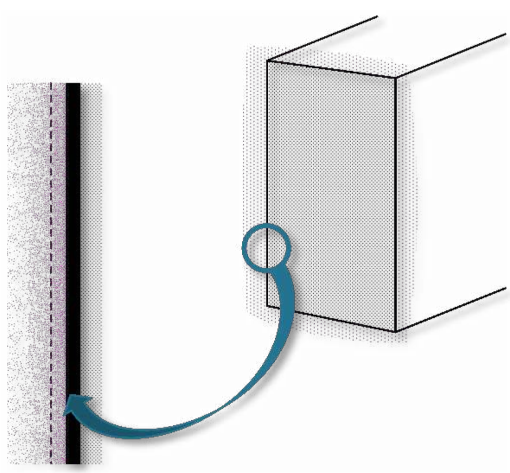


Figure 294 – Scanned Pillar with Some Noise

Statistical Outlier Removal (SOR) Cleaning Algorithm

Laser scans typically generate Point-Cloud datasets of varying point densities. Additionally, measurement errors lead to sparse outliers which corrupt the results even more.

This complicates the estimation of local Point-Cloud characteristics such as surface normals or curvature changes, leading to erroneous values, which in turn might cause Point-Cloud registration failures. Some of these irregularities can be solved by performing a statistical analysis on each point's neighborhood and trimming those which do not meet a certain criterion.

Sparse outlier removal is based on the computation of the distribution of point to neighbors' distances in the input dataset. For each point, the Echo™ software compute the mean distance from it to all its neighbors.

By assuming that the resulted distribution is Gaussian with a mean and a standard deviation, all points whose mean distances are outside an interval defined by the global distances mean and standard deviation can be considered as outliers and trimmed from the dataset.

Moving Least Squares (MLS) Smoothing Algorithm

Moving least squares (MLS) is a method of reconstructing continuous functions from a set of unorganized point samples via the calculation of a weighted least squares measure biased towards the region around the point at which the reconstructed value is requested.

In computer graphics, the moving least squares method is useful for reconstructing a surface from a set of points.

Often it is used to create a 3D surface from a Point-Cloud through either down-sampling or up-sampling.

Moving least squares (MLS) surfaces representation directly defines smooth surfaces from Point-Cloud data, on which the differential geometric properties of point set can be conveniently estimated.

As mentioned above, the initial step in the process is to define a temporary artificial threshold surface/plane, adjacent to the authentic surface (marked as a hatched line in Figure 294 **above**), which will be used as reference for the distinction between legitimate points and outlier/noise points.

Appendix 7 – 3D Noise Cleaning (Denoise) Types

Each of these algorithms utilizes a different mathematical method for the threshold calculation as well as executes the **Denoise Act** differently:

1. The **MLS** algorithm calculates the reference threshold plane utilizing weighted least squares measure biased towards the region around the point at which the reconstructed value is requested.

   The reference threshold plane may be first (1^{st}) or second (2^{nd}) order where first order creates flat surfaces (rough estimation) and the second order – curved surfaces (more accurate and closer to the authentic surface's points).

   It then **shifts points** (does not remove them) which are within a pre-defined radius from the artificial/reference surface to a closer position to the object's authentic surface.

2. The **SOR** algorithm first calculates the average distance of each point to its neighbors and then rejects (deletes) the points that were farther away from the calculated average distance plus (+) a pre-defined number of times the standard deviation (also calculated during the process).

   The SOR calculations are based on the **Outlier Coefficient**.

   SOR Outlier Coefficient assumes that the value of 1 is closer to the target and the value of 10 is distant from the target.

   The coefficient parameter removes outlier points based on the distance from the reference plane and does not change the position of existing points.

Appendix 8 3D Meshing (Spawning)

The resulting 3D models of the **Scan Act** of the camera are **Point-Cloud models**, representing the outer surfaces of the scanned objects.

NOTE: Note that Point-Clouds are not **Continuous Surfaces**.

In addition, the camera can produce several million data points per scan and the amount of collected data becomes enormous and difficult to handle.

Following the scan operation (and the different edit operations explained herein, all aimed towards building a fully-registered single-segment 3D Point-Cloud model) and in order to:

- Give this model life-like appearance with solid and continuous surfaces,
- Prepare the models for their ultimate usage (e.g. export to other 3D applications, 3D printing, etc.),
- Achieve major reduction in file size,

There is a need to wrap-up the model and cover it with solid surfaces before transferring it to the next step of usage.

One approach to compress the information scanned is to represent the model surfaces by means of mathematical descriptions or primitive shapes (i.e. **Polygons**).

Most commonly the model's surfaces will be approximated by polygonal meshes, particularly – **Triangle Meshes**, a standard data structure in computer graphics to represent 3D objects.

The algorithms for the creation of these triangle-meshes generate highly accurate polygonal models whose appearance must be as close as possible to the original object, require some major computing power.

Such algorithms take points in 3D space, called **Vertices**, and connect them by line segments to form polygon meshes.

Most 3D models are built as **Textured Polygonal models** since they are flexible and since computers can render them quickly.

Appendix 8 – 3D Meshing (Spawning)

Following is an example of the **Stanford Bunny**, converted from the originally-scanned Point-Cloud to a Polygon Mesh model:

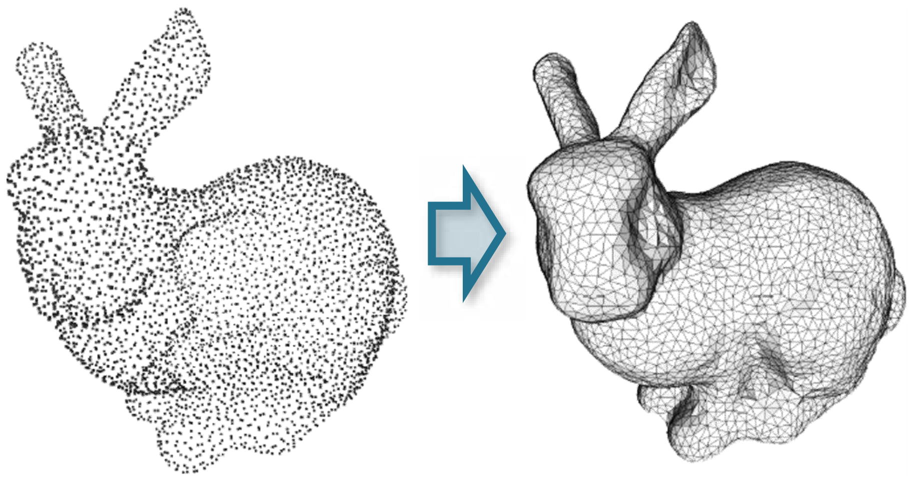


Figure 295 – Example of a Point-Cloud Model Converted to a Polygon Mesh Model

NOTE: The **Stanford Bunny** used for the example is a computer graphics 3D test model developed in Stanford University for testing various graphics algorithms, including polygonal simplification, compression, and surface smoothing.

The model is built of data characterizing some 69,451 triangles resulting from a 3D scan of a ceramic figurine of a rabbit.

This figurine and others (like the Stanford Dragon and the Stanford Happy Buddha, etc.) were scanned to test methods of range scanning physical objects and used as reference mainly for tutorials.

Although not **Continuous Surfaces**, meshed models can also be fashioned in Point-Cloud format.

This is done by creating, out of the fully-registered single **Segment** (following all edit actions required), a Point-Cloud mesh-look-alike model made of **Vertices** and colored by the RGB video stream data derivatives, to make it resemble real-life.

Spawns are Mantis Vision's pragmatic name for the two (2) types of the Echo™ resulting meshed model:

- The above-described **Polygon Mesh** type, and
- The above-described **Point-Cloud Mesh** type.

> **NOTE:** Spawns can be created only when the **Project** is fully aligned, merged and registered (comprised of a single **Segment**).

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Appendix 11 Warranty

Appendix 12 Eye Safety

Labelling

The system is class-1 eye safe. The source of emission is the H1 projector contained in the scanner device. The device Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019.

Two labels are attached to the device, the first is a system label, shown below:

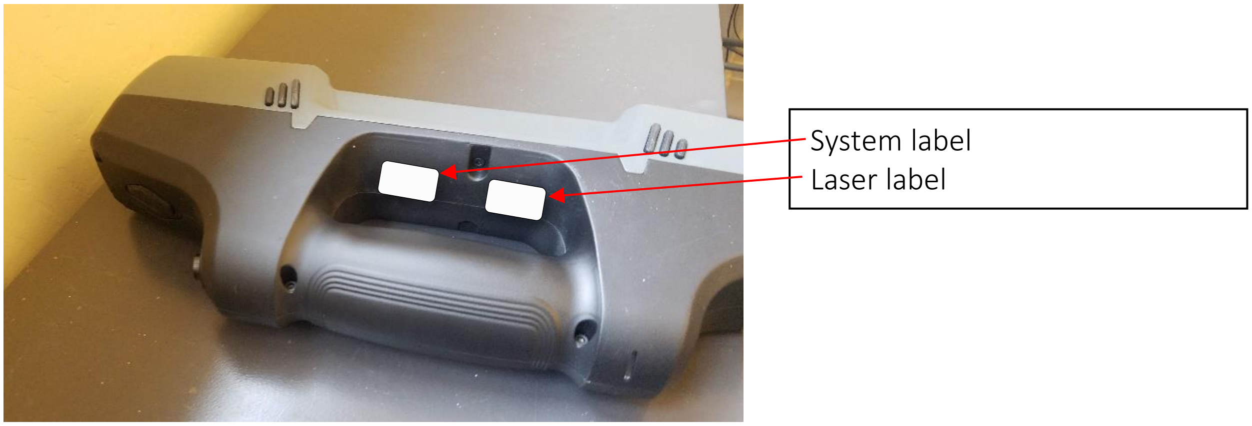
Additionally, a laser label will be added to devices that pass the outgoing optical test, but before product shipment. A copy of the label is shown below:

CLASS 1
LASER PRODUCT

94 Shlomo Shmeltzer Rd,
Petach Tikva, Israel 4970602
Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019

Manufactured on:
___________ (month/year)

The placement of each of these labels is behind the handle, as shown on the device:



The date of manufacture is shown on the label.

Critical Components for eye safety.

The following components are considered critical for eye safety. These components should not be altered or disassembled at any time. Any design change or replacement of these components would require recertification of the device laser eye safety.

- *Laser Driver*
- *H1 Projector module*

Caution – Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure

Maintenance and service

No Maintenance action needed for the product lifetime.
No regular service schedule is needed.