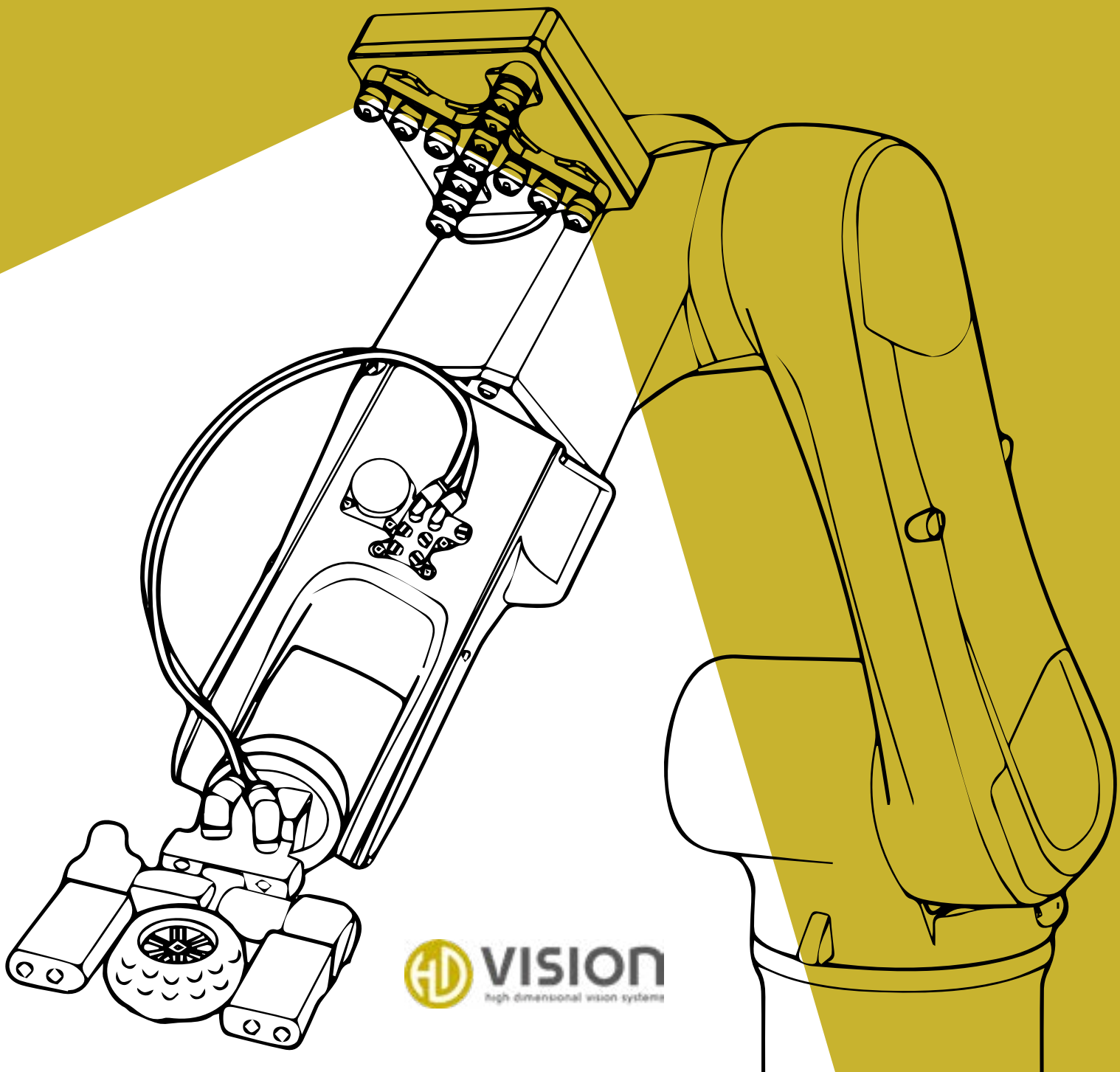
Manual

LumiScan VGR v1.8.4.0

HD Vision Systems GmbH



Imprint

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1 Introduction

1.1 About this Manual

This document contains important information about the installation and operation of the LumiScan VGR, LumiScan Annotation, LumiScan Training, LumiScan File Transfer, and LumiScan Hand-Eye Calibration applications.
Please read the manual carefully before using any of the above applications.

1.2 Formatting Convention

This guide uses special formatting to highlight certain words and phrases:

- Keywords/important information and buttons are highlighted in bold (e.g. Then click on **Install**).
- Links and references are highlighted in green (e.g. https://hdvisionsystems.com).
- File and path names are highlighted in a special font (e.g. `HDVAppData`)

1.3 Disclaimer

NOTE: By accessing or using these commercial software products, you expressly agree to the following terms and conditions.

Any attempt to use a debugger to examine, analyze, or tamper with the software provided by HD Vision Systems is strictly prohibited and may have immediate and irreversible consequences.

If the software detects the presence of a debugger, security protocols will be activated to protect the intellectual property, functionality and stability of the software. This may result in, among other things, immediate suspension of the associated Software license, loss of data, and, in extreme cases, forced termination of all instances of the Software operating under the same license, as well as legal consequences.

By using the Software, you acknowledge that you have read, understood and accepted the terms of this Disclaimer (see also General Disclaimer).

2 LumiScan VGR

2.1 Description

LumiScan VGR is software that can be used for a variety of applications, such as bin-picking or automated assembly.
The high quality data received from the camera is used to generate accurate point clouds for object localization.
Two approaches are used:

- The generated point cloud is compared to 3D models of the objects.
- Machine learning algorithms are used for more complex scenes.

This makes LumiScan VGR highly adaptable to different object textures.
The robot kinematics and collision network calculate the robot's path and allow collision-free movement.

2.2 System Requirements

- IPC
  - Windows10 or higher
  - NVIDIA GPU, which supports CUDA11.8, cuDNN 8.8.1
- Interface
  - PROFINET or
  - OPC UA
- Camera
  - LumiScanX with Ethernet connection

2.3 Functionality

The LumiScan VGR software is organized into modules that contain one or more cameras, pipelines, and robots (Fig. 1).

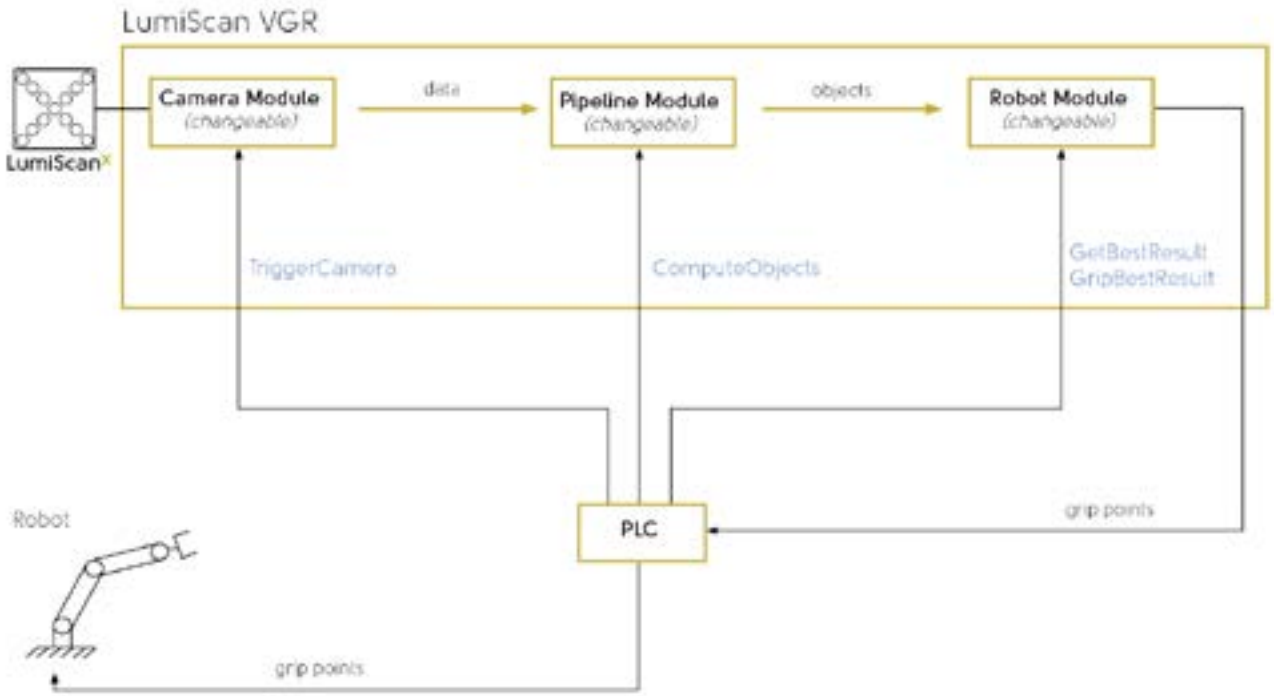


Fig. 1: LumiScan VGR: Functionality

At any given time, one set of modules is considered active and all functions refer to it. Modules can be swapped from both the user interface and the PLC.

The general workflow can be described as follows:

1. LumiScan^X camera is used to capture a new image and a point cloud is created.
2. Objects are detected in the captured image.
3. The 6DOF orientation in space is calculated from the point cloud for each detected object.
4. A set of possible grip points is calculated for each object.
5. The next best handle is transmitted to the PLC via Profinet.

Software is highly customizable via a JSON settings file.

2.4 JSON Settings

The JSON settings are the interface for all parameters. It contains information about cameras, robots, networks, objects, and pipelines (Fig. 2).
Exactly which parameters are needed depends on the application.

LumiScan VGR

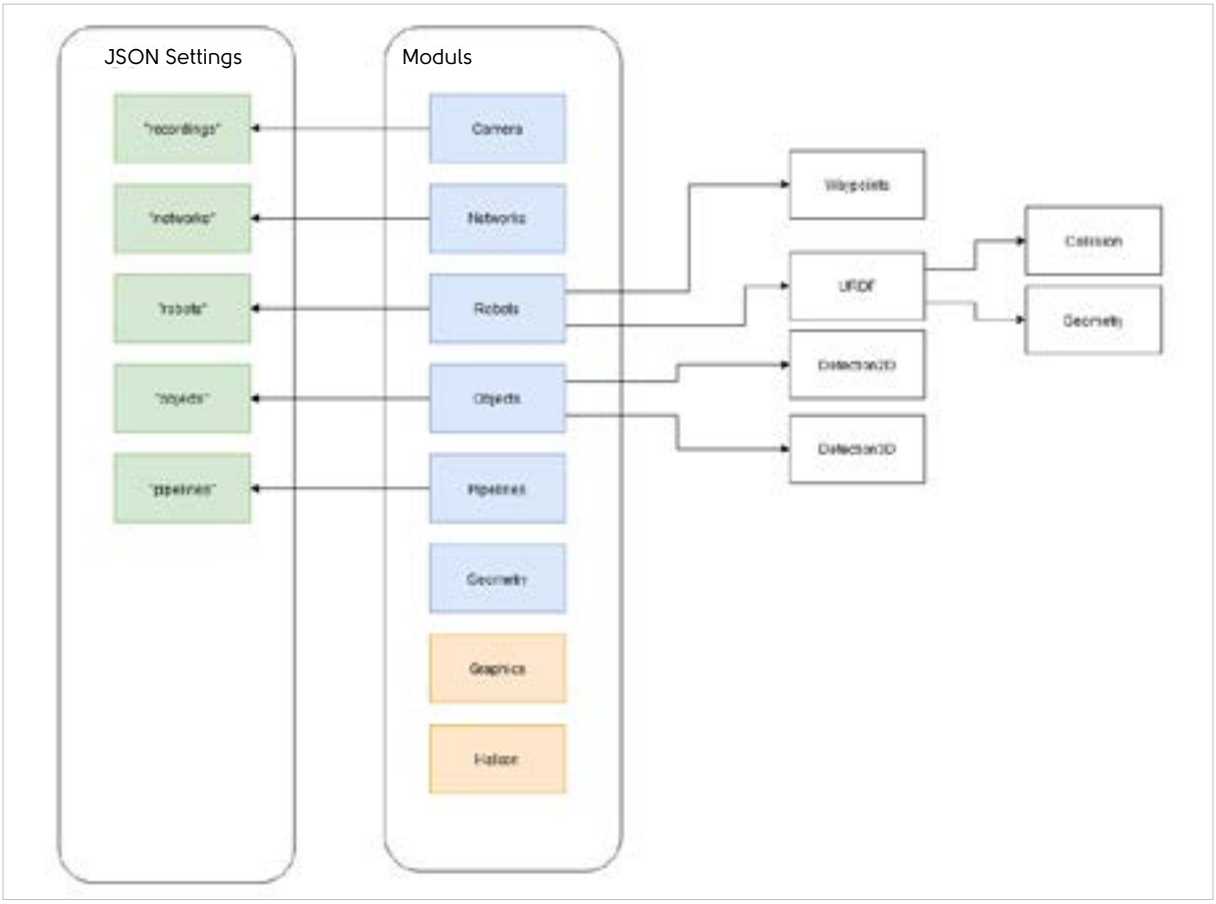


Fig. 2: JSON settings in the general structure of the LumiScan VGR

A project folder is created for each application. All necessary folders and files are stored in it.
The meaning of the standard elements of the JSON settings is explained in Table 1: Lumican VGR: Default elements of the JSON settings.

Table 1: Lumican VGR: Default elements of the JSON settings

Parameter	Description
cameras	All (hardware) cameras are listed under `cameras`. Usually only one camera is needed, but any number can be created. There are only two entries here: `id` (the serial number of the LumiScan camera) and `calibrationFile`.
recordings	Under `recordings`, you define how a LumiScan camera should capture new data. This includes settings such as filters, depth of field range and exposure settings. Each entry corresponds to one physical LumiScan camera. Any number of settings can be made for precise coverage of different scenes and objects.
networks	This lists all the neural networks for the application and defines how a single neural network is imported into LumiScan VGR. Multiple objects may require multiple networks, which in turn may require their own architectures.
robots	Contains information about the geometry of the robot and its spatial position relative to the cameras. A physical robot can be described by several robot objects. For example, several robot objects can be created to represent different grippers. Each entry must have a successful hand-eye calibration transformation and refer to a file that describes the robot. This file has the format `.urdf`. Additional 3D data is required for collision avoidance. Robots and grippers can also be visualized if CAD models are available in `.stl` format. If a collision with the box is to be calculated, it is also listed as a robot.
objects	Corresponds to an object to be detected. All objects to be picked up are listed individually here. The system works simultaneously with 2D and 3D data to recognize and localize objects in space. A distinction is made here between 3D object recognition and 2D recognition using neural networks. Which method is used depends on the application. They are not incompatible with each other, but can even be combined for more accurate detection. Note that we can also define abstract objects, such as composite part characteristics or classification results (e.g. `emptyContainer`).

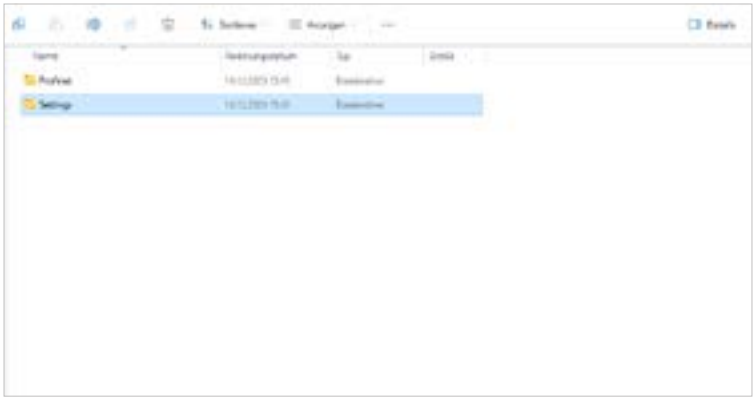
Parameter	Description
pipelines	A pipeline defines how to process a point cloud to obtain object orientations (in the camera image). It contains steps for post-processing the point cloud, a definition of the ROI, and a list of objects to be calculated. Any number of pipelines can be created. They are selected by the PLC. Together with the robots and cameras, they are required to perform a gripping operation.
user	(optional) To prevent admin rights from being available to all users, they can be password protected (`adminPassword`, `manualModePassword`).
system	(optional) The system settings are used for recording and debugging. The data to be recorded by the system is defined here.

Detailed information about each parameter of the JSON settings is available in the separate **Documentation_LumiScan_VGR** ZIP file.

2.4.1 JSON Configuration File Documentation

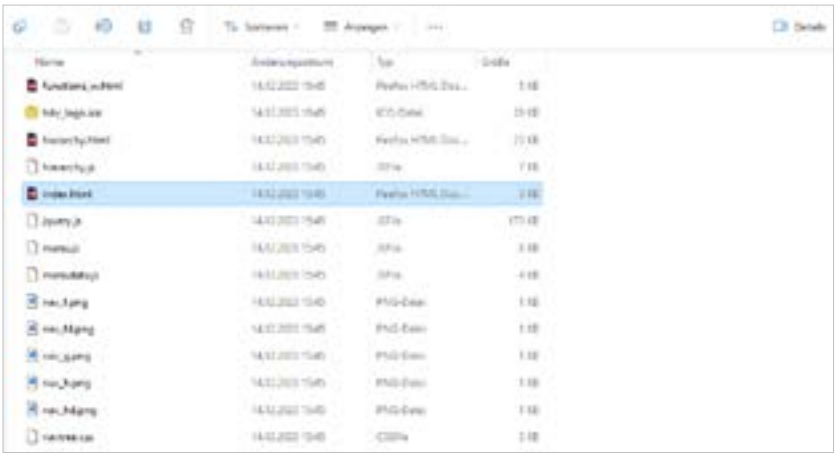
To open the documentation with JSON settings file:

1. Save the zip file on your computer.
2. Extract the file.
3. Open the extracted file.



4. Open the settings.

5. Open `index.html`.



6. The **Settings JSON File** page opens.

7. Click on the blue highlighted **ProjectSettings**.

√ JSON parameter description for LumiScan VGR opens.

2.4.2 JSON Settings: New Meta Format

NOTE: The meta-format of the JSON parameters has changed since the last LumiScan VGR version 1.7.0.0.
See below for a comparison of the old and new format.

Old Format

```
{
      "inputFileType": "LumiScanVGRSettings",
      "inputFileVersion": "1.2.0",
      "VGRVersion": "1.7.0.4",
      ...
}
```

New Format

```
  {
        "meta": {
            "inputFileType": "LumiScanVGRSettings",
            "inputFileVersion": "1.2.0",
            "targetMachine": "Inspection1",
            "programName": "LumiScanVGR",
            "programVersion": "1.7.0.5"
        },
        ....
    }
```

2.5 Before Installation

NOTE: Before installing the LumiScan VGR software, please read the information about network settings, Windows Firewall and virus protection in the LumiScan^{X} camera manual.

NOTE: In order to install the LumiScan VGR software, you must first install CUDA 11.8.0 and cuDNN 8.8.1. Both installers are provided by HD Vision Systems.

2.6 Installing the CodeMeter Runtime Environment

To license your LumiScan software, you must install the CodeMeter® Runtime Environment. A CodeMeter Runtime Kit installer for Windows 64-bit is available at the following link:
https://www.wibu.com/de/support/anwendersoftware/anwendersoftware.html

Before installing, please check your version of CodeMeter Runtime (version 7.60c or higher).

Follow the manufacturer's instructions for installation:

1. Connect the CmDongle to a free USB port on your PC.
2. The LED on the CmDongle will alternate between red and green for about 1-2 seconds. Your PC reports that a new USB device has been found.

2.7 Installation

1. Install your LumiScanx according to the installation instructions in the LumiScan[x] manual.
2. Close all open applications on your computer.
3. Navigate to the location of the LumiScan installer.
4. Double-click on the file: `Installer_LumiScan_VGR_va_b_c_d.exe`*.
5. The installation is prepared and the license agreement window opens.
6. Accept the license terms by clicking on **Accept**.
7. If you want to change the default installation location, click **Browse**.
8. Navigate to the desired storage location.
9. Press **OK** to confirm your selection.
10. Otherwise, click the **Next** button to continue.
11. If desired, select the **Start Menu** folder for the program links.
12. If you do not want to create shortcuts, select the **Do not create links** option.
13. Then click on **Install**.
14. When the installation is complete, you will see a dialog box.
15. Click **OK**.
16. Click **Finish**.

* where **a**, **b**, **c**, **d** are variables that depend on the version of the software.

2.8 Start Menu

When you start the software, the Start Menu window appears (Fig. 3).

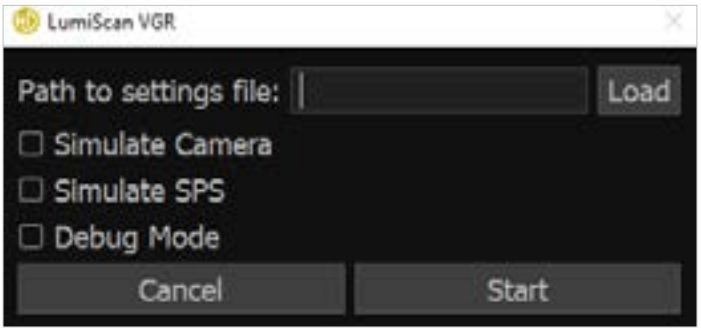


Fig. 3: LumiScan VGR: Start Menu Window

To start:

1. Enter the path to the configuration file.
2. Alternatively, click **Load** to determine the correct path.
3. Click **Start** button.

By default, only the path to the configuration file is required.
All options available in the Start Menu window are described in Table 2: Command Line Arguments.

NOTE: The Start Menu window is optional and can be disabled at the customer's request.

2.9 Command Line Options

The software can be started with command line options.
At least the settings file must be specified as an argument with the `-s` or `--settings` flag (see Table 2).

Table 2: Command line arguments

Command Line Options	Result/Effect
`-s, --settings <filepath>`	(required) Specify the path to the settings file.
`--gen-settings`	Create a settings file.
`-v, --version`	Display version information on the current build.
`--simulate-camera`	(optional) Simulates a camera. When this flag is set, no physical camera needs to be connected. Images and point clouds are loaded from disk. For testing purposes only.
`--simulate-sps`	(optional) Simulates the PLC. There is no need to connect a physical PLC. Communication with the PLC can be simulated on the Profinet tab.
`-d, --debug`	(optional) Start in debug mode.
`-?, -h, --help`	Display help.
`--help-all`	Show help with Qt specific options.

2.10 Keyboard Shortcuts

Table 3: Keyboard shortcut

Keyboard shortcut	Effect
Ctrl + Shift + A	Switching to admin mode.
Ctrl + Shift + D	Switching to debug mode.
Ctrl + Shift + V	Viewing the current build version.

2.11 User Interface

By default, the user interface contains only the Image tab, some status information, and the Manual Mode button (Fig. 4).

Fig. 4: LumiScan VGR: Standard User Interface

The visible purple rectangle represents the region of interest (ROI). It defines the area of the captured image in which the network will search for markers.

When debug mode is active, a yellow auto-exposure polygon frame is also displayed on the screen (see Fig. 5). It is useful for initial parameter settings.

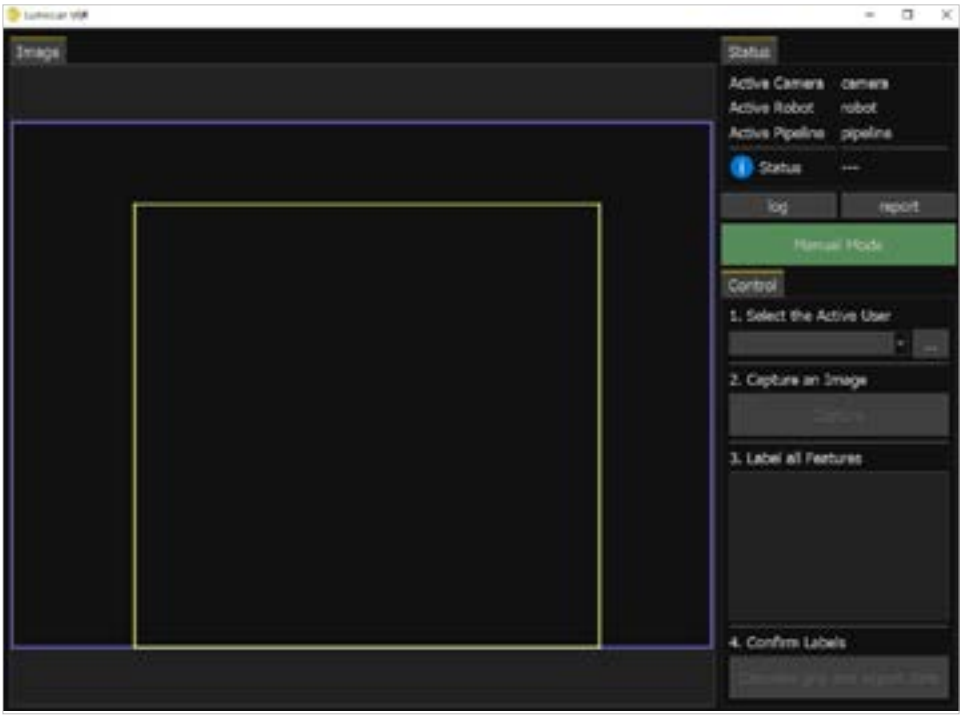


Fig. 5: LumiScan VGR: Standard User Interface in Debug Mode.

For a more detailed description of the user interface, see Fig. 6 and Table 4.

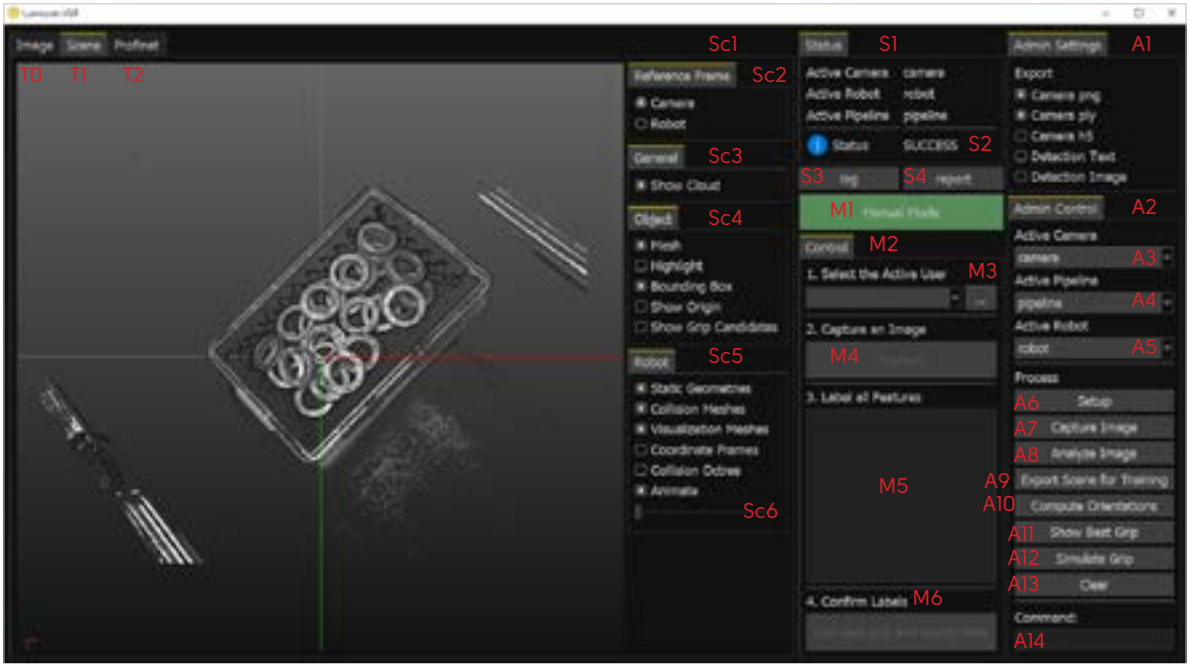


Fig. 6: LumiScan VGR: Described User Interface

Table 4: LumiScan VGR: Description of user interface elements.

Element	Description
T0	Image Tab Displays the image of the active camera along with the current object detection results. • In manual mode, you can draw object bounding boxes here.
T1	Scene Tab (Fig. 9). Displays information about the handle point calculation for each object. • You can use the mouse to manipulate the display: - To zoom in or out of the image, scroll the image with the middle mouse button. - To rotate the image, hold down the middle mouse button and turn the mouse. - To move the image section, hold down the Shift key. Press the middle mouse button and move the mouse. • When you open this tab, a number of new options are displayed (see Sc1 to Sc4). • This tab is only visible in Admin Mode.
T2	Profinet Tab (Fig. 10). Used to monitor the current data that can be read by the PLC. • Only visible in Admin Mode.
S1	Displays status information.
S2	Displays information about the current status. See Table 6: Return values for more information.
S3	Opens the window where the log is stored. Provides additional information about the processes in the program.
S4	Collects information about the program. • Can be encrypted and sent to HD Vision Systems if needed to diagnose the problem. • Use requires the activation of the **Camera png** and **Camera ply** options under **Export** in **Admin Settings** (A1).
M1	Activates manual mode (see Manual Mode).
M2	Control elements that are only visible in the manual mode (see Manual Mode).

Element	Description
M3	**Step 1** of the manual control workflow. • A user must be selected. • New users can be added using the **...** button. • The user information is used as metadata when exporting new training data for the neural networks. • Only visible in manual mode (see Manual Mode).
M4	**Step 2** of the manual control workflow. • Pressing this button captures a new image and the objects are recognized. • The detected objects can then be manipulated or missing objects can be labeled using the labels from the M5 list. • Can be pressed multiple times. • Only visible in manual mode (see Manual Mode).
M5	**Step 3** of the manual control workflow. • This list contains all known object labels. • The selected one will be used when drawing new bounding boxes in the T0 image tab. • Only visible in manual mode (see Manual Mode).
M6	**Step 4** of the manual control workflow. If the image is labeled correctly, you will receive a pop-up after pressing **DONE** confirming that the training data has been exported and the grip points have been calculated. If no grip points can be calculated because the 3D information is incorrect (poor point cloud, incorrect configuration), the status changes to: **RESULTS_EMPTY**. No confirmation will be displayed and no training data will be exported. • The training data will be exported to the training data output folder (see Output Data). • Only visible in manual mode (see Manual Mode).
A1	Admin settings group Includes checkboxes to enable and disable data export. • Can be switched at any time, even while the process is running. • Output may vary if debug mode is active (see Debug Mode). • Only visible in admin mode (see Admin Mode).
A2	Admin control group. • Only visible in admin mode (see Admin Mode). • Only active in manual mode (see Manual Mode) to ensure that the process is paused.

Element	Description
A3	Change the active camera. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
A4	Change the active pipeline. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
A5	Change the active robot. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
A6	Initializes the software. This is necessary to enable functions A7 to A13. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
A7	Captures an image from the active camera. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
A8	Analyzes the last image captured by the active camera with the active pipeline. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
A9	Exports the currently labeled image as training data. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
A10	Calculates the object orientation of all objects in the currently labeled image. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
A11	Highlights the object with the highest grip priority. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
A12	Simulates a robot gripping the object with the highest gripping priority. This removes the associated bounding box from the image tab (T0) and saves it as the last gripping position. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).

Element	Description
A13	Clears all internal buffers. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
A14	Executes commands defined by the user. • Only visible in admin mode (see Admin Mode). • Active in manual mode only (see Manual Mode).
Sc1	Scene tab settings group. • Only visible in admin mode (see Admin Mode).
Sc2	**Reference Frame** The **Camera** and **Robot** options can be used to change and display the view from a selected reference point: Camera or Robot • Only visible in admin mode (see Admin Mode).
Sc3	**General** **Show Cloud** option shows the generated point cloud. • Only visible in admin mode (see Admin Mode).
Sc4	**Object**: Is only visible in admin mode (see Admin Mode). • **Mesh**: Shows the CAD model generated from the point clouds. • **Highlight**: Shows the points (highlighted in red) of the point cloud that can be used for object matching. The point cloud (Sc3) must be disabled to use this option. • **Bounding Box**: Shows the bounding boxes of each object (highlighted in yellow). • **Show Origin**: Shows the original orientation of all detected objects in the camera image. • **Show Grip Candidates**: Shows the handle candidates. To see them, **Show Origin** must be unchecked.

Element	Description
Sc5	**Robot**: Is only visible in admin mode (see Admin Mode). • **Static Geometries**: Shows the static elements of the object environment. It is only visible if **Collision Meshes** or **Visualization Meshes** are activated. • **Collision Meshes**: Shows a simplified 3D model of a robot arm (colored purple, semitransparent). Available only when the **Show Best Grip** option (A11) is enabled. • **Visualization Meshes**: Shows a 3D model of a robot arm (highlighted in gray). Available only when the **Show Best Grip** option (A11) is enabled. • **Coordinate Frames**: Shows all coordinate frames of the robot. • **Collision Octree**: Indicates if there is a risk of collision when the robot is moving. • **Animate**: Activating this option automatically simulates the movement of the robot arm. This option is only active if **Show Best Grip** (A11) or **Simulate Grip** (A12) has been clicked.
Sc6	Use this button to move the robot arm. This option is only active if **Show Best Grip** (A11) or **Simulate Grip** (A12) has been clicked and the **Animate** option is unchecked.

2.12 Manual Mode

Manual mode is used to create new training data for neural networks in scenarios where they are not yet working with a high level of robustness. It allows to manually adjust labels. It also allows to manually continue the program and replace the work of the neural network if, for example, 2D recognition is not successful.

NOTE: The manual mode can only be used correctly in the initialized state, e.g. after the Setup has been called in the admin mode or from the PLC. Otherwise, a message will be displayed that the camera is not recognized and no images can be captured.

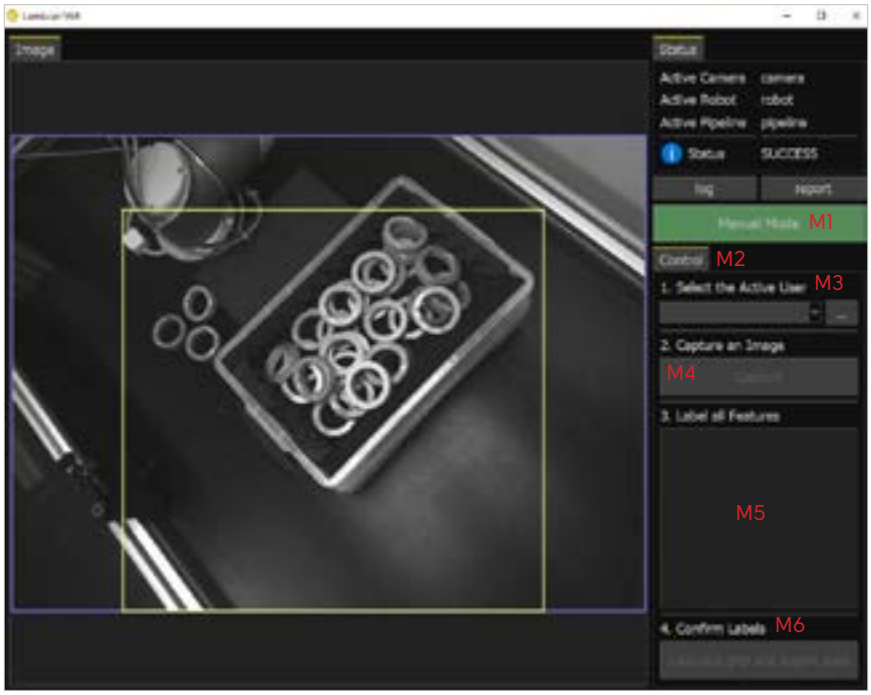


Fig. 7: LumiScan VGR: Manual Mode with the Debug Mode turned on

Manual mode is activated by pressing the **Manual Mode** button (M1).
This requires a password if the one specified in the settings file is not empty.
If admin mode is also enabled, no password is required.

- Displays the control group (M2), the elements M3 to M6 can be selected.
- While this mode is active, PLC communication is paused, i.e., most functions cannot be called.
- The steps in manual mode are described in Table 4 from M3 to M6.

2.13 Image Annotation

In manual mode (see Manual Mode), oriented bounding boxes can be edited or added manually in the Image tab (T0):

Adding new boxes: There are three steps to adding new boxes:

1. First, double-click with the left mouse button on the position where you want the bottom edge of the bounding box to be.
   This border will always be colored purple.
2. Without holding down the mouse button, click with the left mouse button on the upper edge of the object to set the height of the bounding box.
3. To determine the width of the bounding box, click on any side point of the object with the left mouse button, again without holding down the mouse button.

Selecting a bounding box: Existing boxes can be selected with a simple left-click. A selected box is highlighted by a slightly different color and four yellow, circular corner handles.

Modification of existing boxes: While a bounding box is selected, you can change its label by selecting another label from the label panel or by typing a new label.

Correcting the bounding box: A selected box can be manipulated in several ways:

- Dragging of the inner area of an active box moves it.
- Dragging the edges of an active box changes its size in that direction.
- Dragging the corners of an active box rotates it around its center point.

Deleting the bounding box: Right-click an active box to remove it.

2.14 Admin Mode

Admin mode is activated by pressing Ctrl + Shift + A (see Table 3: Keyboard shortcut). It is intended for test and maintenance purposes of HD Vision Systems GmbH. The main functions are described in Table 4 (A1 to A13).

NOTE: Most of the functions in the admin group (A1) are only active when switching to manual mode to avoid problems with the PLC.

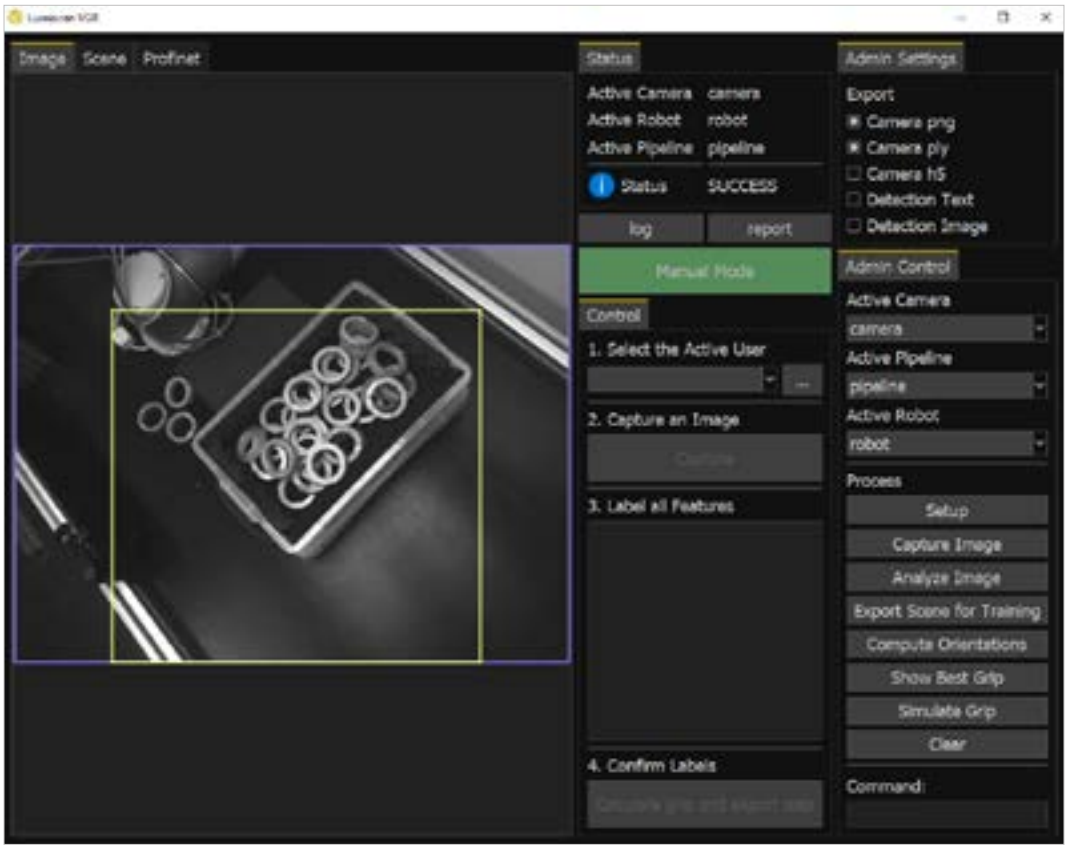


Fig. 8: LumiScan VGR: Admin Mode (Image Tab)

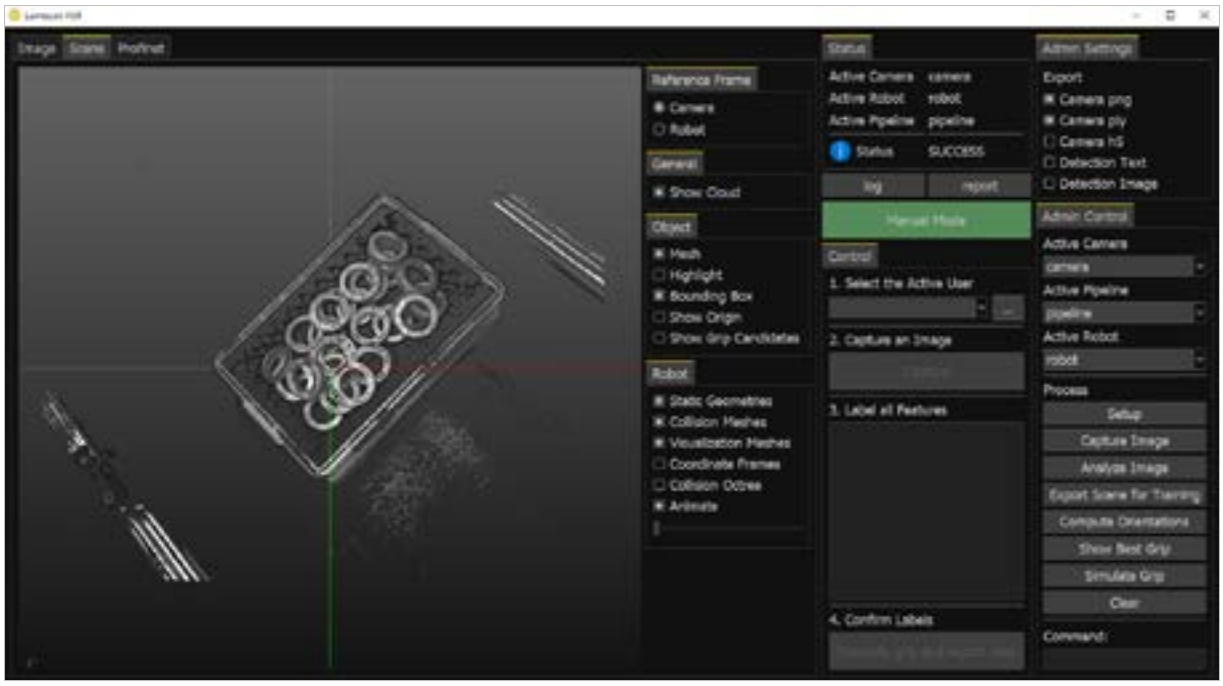


Fig. 9: LumiScan VGR: Admin Mode (Scene Tab)

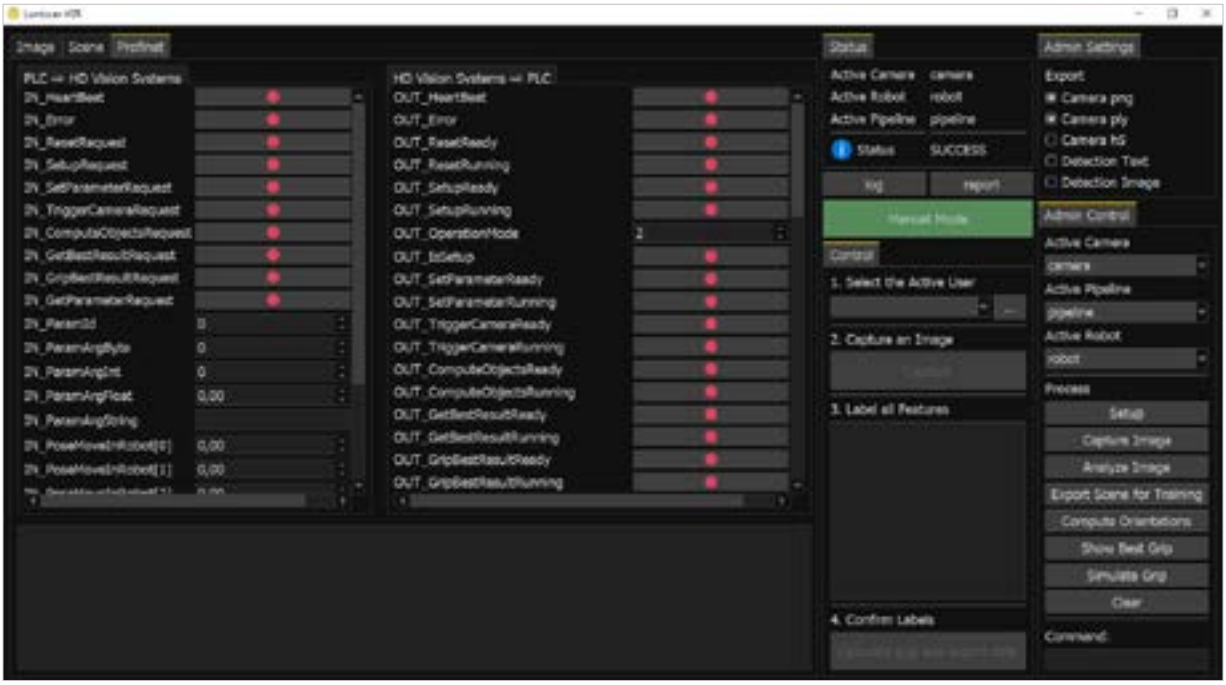


Fig. 10: LumiScan VGR: Admin Mode (Profinet Tab)

2.15 PLC Settings

The PLC parameters are located on the Profinet tab, which is used to monitor the data analyzed by the PLC.
Changes to PLC parameters are only possible when manual mode is disabled.

2.15.1 Process Flow

Each process has three variables:

1. OUT_*Ready
2. IN_*Request
3. OUT_*Running

The process is always the same.

Table 5: PLC data transmission: Process sequence

Step	HD Vision Systems -> PLC (OUT)	PLC -> HD Vision Systems (IN)	
1		wait until (OUT_*Ready == 1)	<- Not applicable to reset functions
2		IN_*Request -> 1	
3	if (IN_*Request == 1)		
4	OUT_*Ready -> 0		
5	OUT_*Running -> 1		
6		wait until (OUT_*Ready == 0)	<- Not applicable to reset functions
7		if (OUT_*Running ==1)	<- Otherwise the trigger is discarded
8		IN_*Request -> 0	
9	wait until (IN_*Request == 0)		
10	... (Run function)		
11	... (Define output variables)		
12	OUT_*Running -> 0		

Step	HD Vision Systems -> PLC (OUT)	PLC -> HD Vision Systems (IN)
13	OUT_*Ready -> 1	
14		wait (OUT_*Running == 0)
15		if (Return values are correct)
16		... (Read output variables)

2.15.2 Status Information

The status of each action is displayed both in the status window as a message (e.g. **SUCCESS**) and in the Profinet window in **OUT_ReturnCode** as a numeric value (e.g. **0**) (Fig. 11).

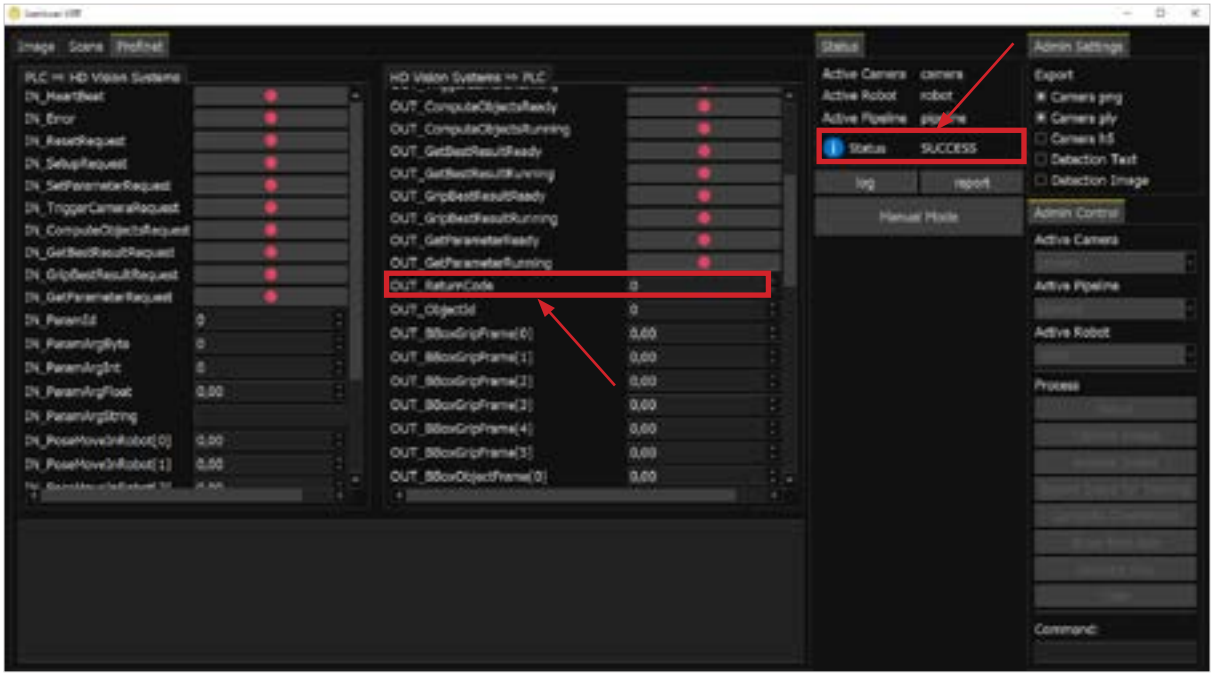


Fig. 11: LumiScan VGR: Status Information

The messages and values are described in Table 6: Return values.

Table 6: Return values

Status	Value	Meaning
SUCCESS	0	No error.
UNKNOWN_ERROR	1	Unknown error.
CAMERA_NOT_INITIALIZED	2	The currently active camera has not been initialized (i.e., it does not exist).
CAMERA_NOT_CONNECTED	3	Es konnte nicht erfolgreich mit der Kamera verbunden werden.
CAMERA_ACQUISITION_ERROR	4	An error occurred while communicating with the camera.
PIPELINE_NOT_INITIALIZED	5	The currently active pipeline has not been initialized (i.e., it does not exist).
ROBOT_NOT_INITIALIZED	6	The currently active robot has not been initialized (i.e. it does not exist).
MISSING_DATA	7	Additional data is required to perform this function (e.g., records/calculation steps).
ID_DOES_NOT_EXIST	8	The specified ID does not exist. Occurs, for example, when you try to switch to active components that do not exist.
MISSING_TRANSFORM	9	It is not possible to transform the data into another coordinate system. This is the case, for example, if the hand-eye calibration has not been entered for all robot-camera pairs.
RESULTS_EMPTY	10	There are no other valid gripping points for the active robot.
CAMERA_HARDWARE_TRIGGER_AGAIN	12	This is due to the failure of Autoexposure. Call TriggerCameraRequest again (take another picture).
CAMERA_BAD_EXPOSURETIME_SETTING	13	The value cannot be reached. This means that the requested auto exposure time cannot be used because it is too short or too long (e.g., if the environment is too dark). Check the auto exposure time settings or contact HD Vision Systems.

NOTES:

Manual Mode

During operation, you can switch to manual mode (**OUT_OperationMode -> 2**) via the user interface. As a result, the processing functions can no longer be started (see Process Flow). When manual mode is exited again, the system switches to idle mode (**OUT_OperationMode -> 0**).
To be able to use all processing functions again, you must switch back to **automatic mode** via the PLC (see **OUT_SetParameter**).

Multiple components

All calculations refer to the active components that can be set with **OUT_SetParameter**. If the project consists of multiple components (cameras, pipelines, robots), make sure that the correct active components are set for each function call.

For more information on PLC setup and function descriptions, refer to the Profinet Interface Description datasheets.

2.16 Debug Mode

Debug mode is activated by pressing Ctrl + Shift + D (see Table 3: Keyboard shortcut). It switches the log level of the console output to debug (i.e. it shows the same output that is written to the log file).
When this mode is activated, the yellow auto-exposure polygon frame is displayed on the Image tab (Fig. 5).
Group A1 elements can also generate additional output for debugging purposes.

2.17 Output Data

The location of all data generated at runtime is shown in Table 7: Output data.
We use `HDVAppData` as a shortcut for the path `C:\Users\<UserName>\AppData\Local\HD Vision Systems GmbH`

Table 7: Output data

Output type	Description
log data	The log files are stored in the `<HDVAppData>\LumiScan VGR\logs` folder. These are implemented as rotating file sinks and create log files with a maximum size of 10 MB. Once a file reaches this size, a new one is created. If more than 5 log files are created, the oldest file is deleted.
crash dumps	If the program crashes, a memory image is created for further analysis under `<HDVAppData>\LumiScan VGR`.
data	Output folder for all recorded and calculated data. The folder and type of output data are defined in the settings file. Some outputs can be switched via the user interface in admin mode (see A1). All related data has the same base name (e.g. timestamp).
training data	All training data is stored in the `training_data` folder located in the **Settings** folder.

3 LumiScan Annotation

3.2 Description

LumiScan Annotation is the software that allows you to annotate objects in an image, providing data for training and retraining Neural Network Models that are later used in tasks such as object detection or quality inspection.

The software allows any number of users, customization of annotation settings, and an unlimited number of annotations.

3.3 Requirements

- Windows 10 or higher

3.1 Before Installation

NOTE: Before installing the LumiScan Annotation software, refer to the LumiScanX manual or the documentation that came with the camera you are using for information on network settings, Windows Firewall, and virus protection.

3.3.1 Installing the CodeMeter Runtime Environment

To license your LumiScan software, you must install the CodeMeter® Runtime Environment. A CodeMeter Runtime Kit installer for Windows 64-bit is available at the following link: https://www.wibu.com/de/support/anwendersoftware/anwendersoftware.html

Before installing, please check your version of CodeMeter Runtime (version 7.60c or higher).

Follow the manufacturer's instructions for installation:

1. Connect the CmDongle to a free USB port on your PC.
2. The LED on the CmDongle will alternate between red and green for about 1-2 seconds. Your PC reports that a new USB device has been found.

3.4 Installing LumiScan Annotation on Windows

1. Close all open applications on your computer.
2. Navigate to the location of the LumiScan installer.
3. Double-click on the file: `Installer_LumiScan_Annotation_va_b_c_d.exe`*.
4. The installation is prepared and the license agreement window opens.
5. Accept the license terms by clicking on **Accept**.
6. If you want to change the default installation location, click **Browse**.
7. Navigate to the desired storage location.
8. Press **OK** to confirm your selection.
9. Otherwise, click the **Next** button to continue.
10. If desired, select the **Start Menu** folder for the program links.
11. If you do not want to create shortcuts, select the **Do not create links** option.
12. Then click on **Install**.
13. When the installation is complete, you will see a dialog box.
14. Click **OK**.
15. Click **Finish**.

* where **a**, **b**, **c**, **d** are variables that depend on the version of the software.

3.5 User Interface

When you start LumiScan Annotation for the first time, an empty window opens (Fig.12).

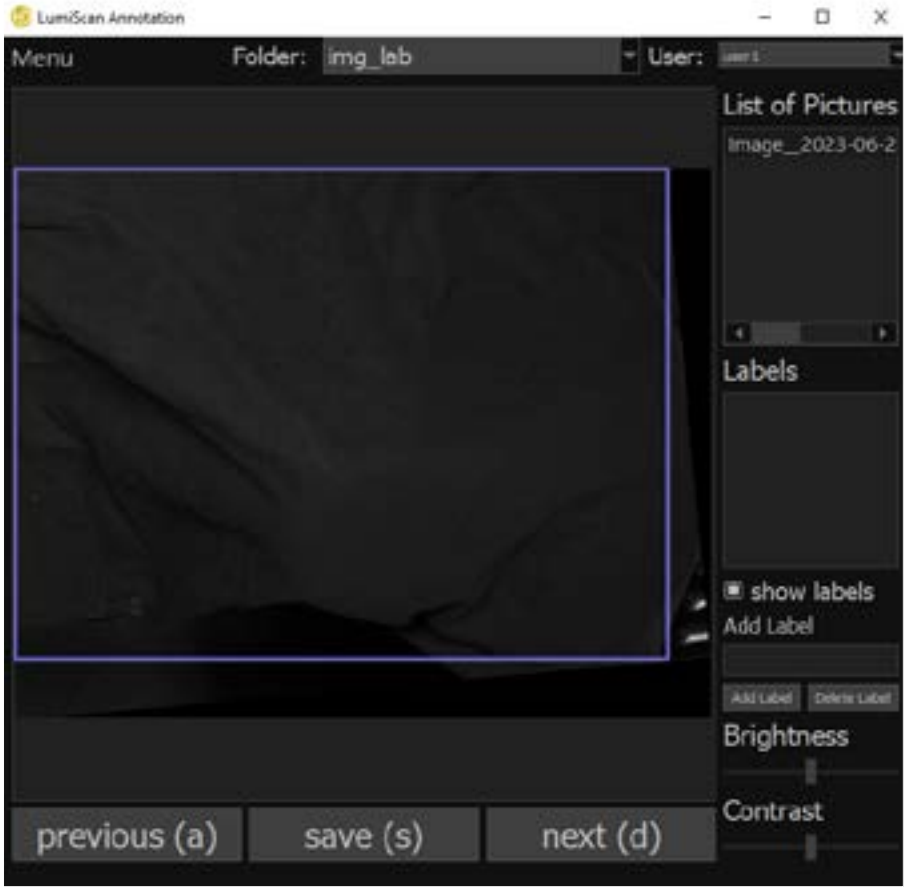


Fig. 12: LumiScan Annotation: Standard User Interface

To start the program:

1. Click on the **Menu** button.
2. Select the **Settings**.
3. Specify the **Data Directory** in the **Settings** window.

The various elements of the user interface are annotated in Fig. 13 and explained in Table 8.

NOTE: When you first start the program json settings file named **settings.json** (see JSON Settings Example) will be automatically generated at: `C:\Users\<USER>\AppData\Local\HD Vision Systems GmbH\LumiScan Annotation`

3.5.1 JSON Settings Example

This JSON settings file is automatically created at `C:\Users\<USER>\AppData\Local\HD Vision Systems GmbH\LumiScan Annotation` the first time the application is started. The `labels` section will be empty at first. You can enter labels there and they will be added automatically. If desired, ROI values can also be specified here and loaded automatically.

See below for an example of the default json settings.

```
{
    "meta": {
        "inputFileType": "LumiScan Annotation Settings",
        "inputFileVersion": "1.6.0.0",
        "targetMachine": "TargetMachine",
        "programName": "LumiScan Annotation",
        "programVersion": "1.6.0.0"
    },
    "labels": ["stuff", "labelB", "somethingElse"],
    "roiSettings": {
        "x": 1.0,
        "y": 1.0,
        "width": 1.0,
        "height": 1.0
    }
}
```

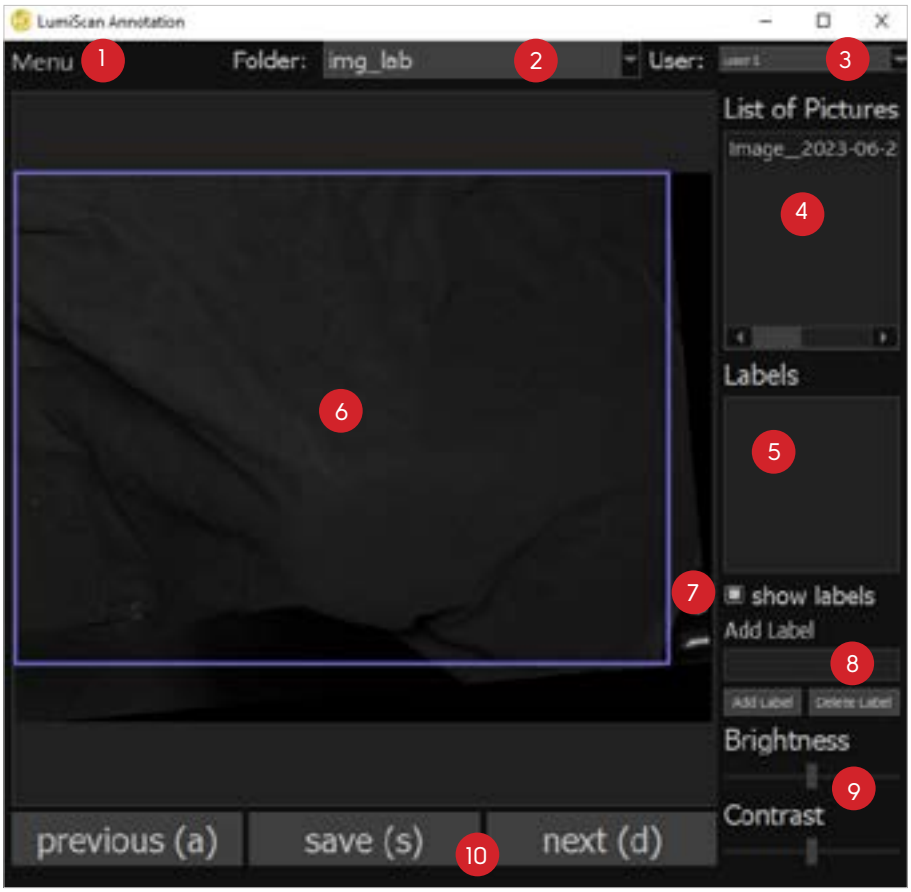


Fig. 13: LumiScan Annotation: User Interface Description

Table 8: LumiScan Annotation: User interface description

Nr.	Description
1	Menu: Access to ROI settings, program settings and help.
2	Folder: Combobox for folder selection.
3	User: Combobox for user selection. • Selected user is saved when changes are made.
4	List of images from the selected folder. • When a new class is saved, the changed image is highlighted. • The highlighting disappears when you change the folder (see **2** in this table) or reload the program.
5	List of all available labels in the selected folder.
6	Central view with display of the currently selected image and labels. Image can be deleted by right-clicking. **NOTE: This will also remove the deleted image from the record.**
7	Shows the selected labels.

Nr.	Description
8	Adds a new label.
9	Adjusting the brightness and contrast of the image.
10	Navigation menu (see also Navigation).

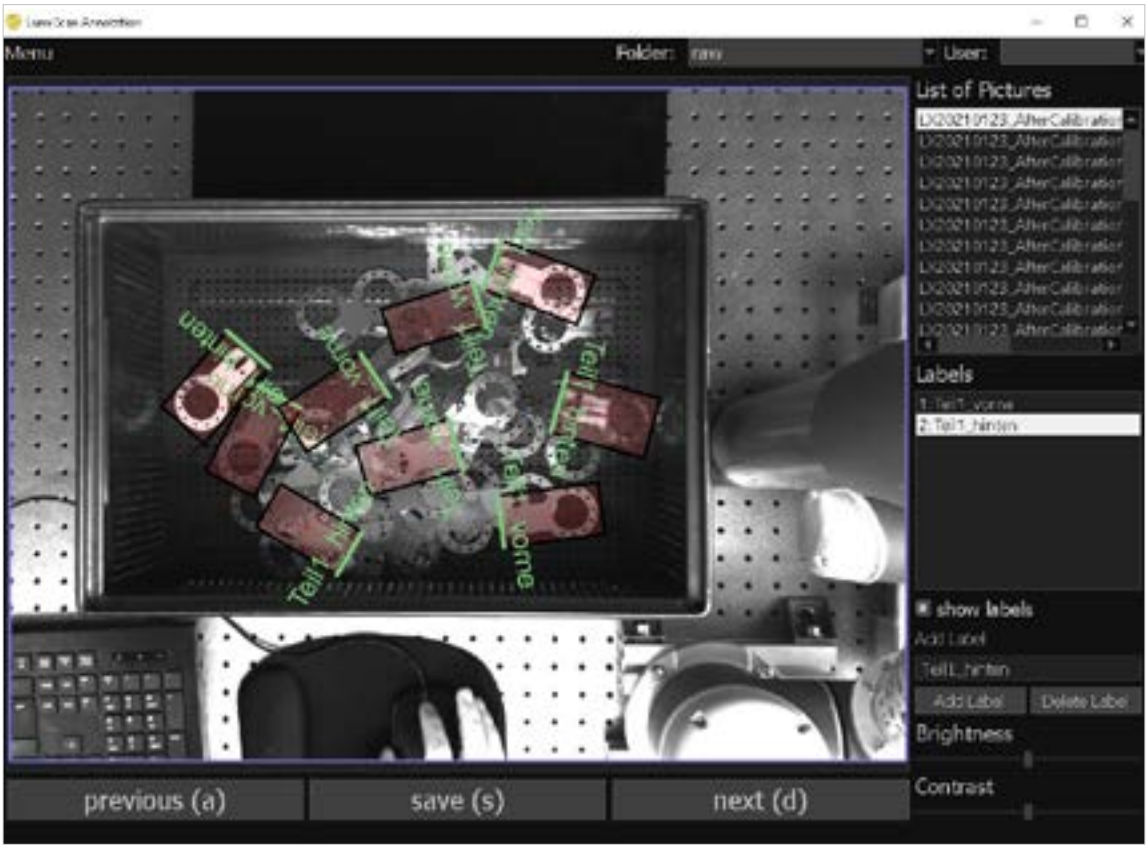


Fig. 14: LumiScan Annotation: Example

3.6 Menu

You can select ROI Settings, Settings, and Help from the menu.

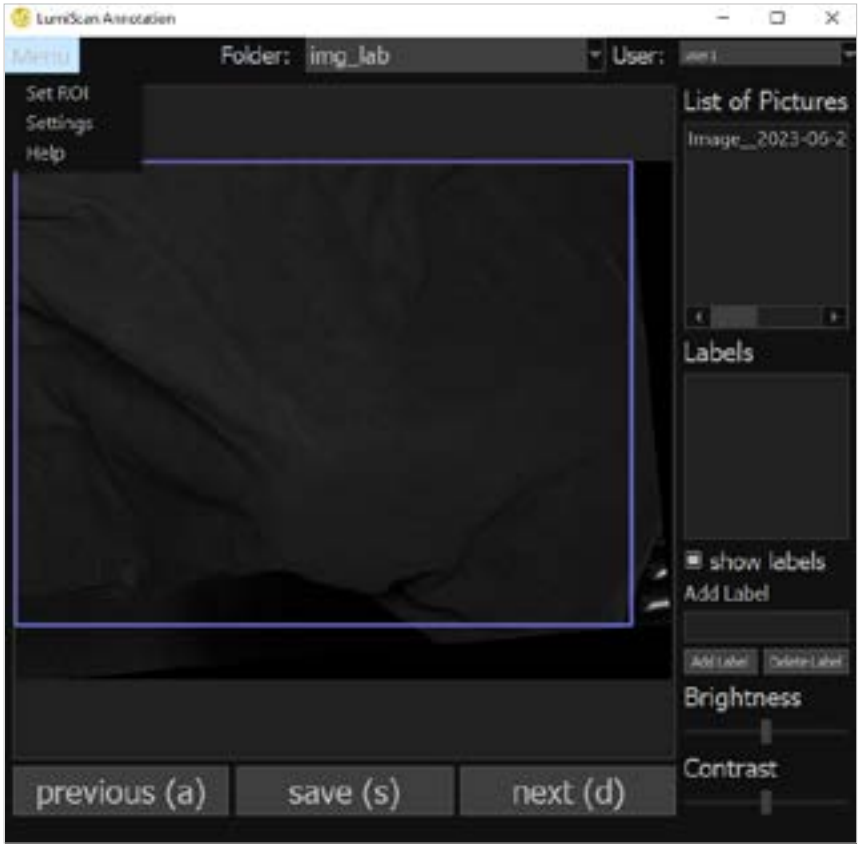


Fig. 15: LumiScan Annotation: Menu

3.6.1 ROI Settings

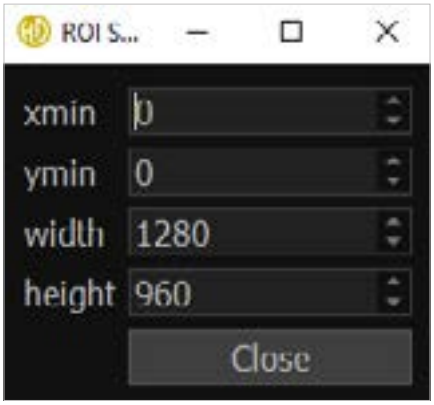


Fig. 16: LumiScan Annotation: ROI Settings

In this setting window, you can define the region of interest (ROI) for training the neural network. The ROI defines the part of the captured image in which the network will search for markers. By default, the ROI is set to the entire image size. In the center view, the borders of the ROI are colored blue.

3.6.2 Settings

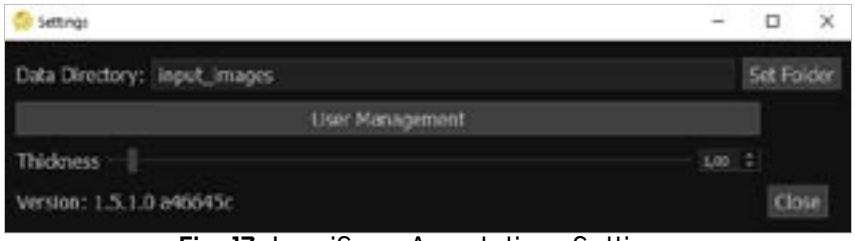


Fig. 17: LumiScan Annotation: Settings

In this settings window you can:

- Specify the directory from which the marker should load images.
- Open the User Management window.
- Modify the Thickness slider to set the thickness of the bounding box frame.

To specify an input folder, click **Set Folder** and select the folder that contains the images.

3.6.2.1 User Management

After you click the User Management button, the Users window opens, where you can add new users or delete existing ones.

Fig. 18: LumiScan Annotation: User Management

To add a new user, type the desired name in the lower edit box, then click **+**. To delete an existing user, select the user in the list and click **-**.

3.7 Image Annotation

Oriented bounding boxes can be manually changed or added in the central view (6 in Fig. 13):

Adding new boxes: There are three steps to adding new boxes:

1. First, double-click with the left mouse button on the position where you want the bottom edge of the bounding box to be. This border will always be green (Fig. 14).
2. Without holding down the mouse button, click with the left mouse button on the upper edge of the object to set the height of the bounding box.
3. To determine the width of the bounding box, click on any side point of the object with the left mouse button, again without holding down the mouse button.

The box label corresponds to the active class in the list (**5** auf Fig. 13).

Selecting a bounding box: Existing boxes can be selected with a simple left-click. A selected box is highlighted by a slightly different color and four yellow, circular corner handles (Fig. 14).

Modification of existing boxes: As long as a bounding box is selected, you can change its label by selecting another label from the label overview or by typing a new label.

Correcting the bounding box: A selected box can be manipulated in several ways:

- Drag the inside of an active box to move it.
- Dragging the edges of an active box changes its size in that direction.
- Drag the corners of an active box to rotate it around its center.

Deleting the bounding box: Right-click an active box to remove it.

After each saved annotation, the LumiScan Annotation Framework also writes the following information to a JSON file:

- User name
- Unix timestamp
- Image name (PNG)
- Save file name (CSV)

The JSON file is saved in the raw directory under the name of the saved image. Sequential comments are appended so you can track who made a change and when.

3.8 Shortcuts for Common Operations

To perform typical bounding box manipulations, such as rotating, moving, expanding, or extruding, you can use the keyboard shortcuts described in the following table.

Table 9: Keyboard shortcuts for common operations

Keyboard shortcut	Operation
Ctrl/Shift + i/j/k/l	Move current box one/ten pixels in the corresponding direction
Ctrl/Shift + u/o	Rotate current box one/ten degrees counter/clockwise.
Ctrl/Shift + v/b	Increase/decrease current box height by one/ten pixels
Ctrl/Shift + n/m	Increase/decrease current box width by one/ten pixels

3.9 Navigation

To view the previous or next image, or to save your changes, you can use the button in the navigation menu (10 in Fig. 13) or the shortcut keys.

Table 10: Navigation keys

Button	Keyboard shortcut	Operation
previous	a	Switch to previous image.
save	s	Save image.
next	d	Switch to next image.
	alt + s	Save and copy labels to next image. Useful when content changes little between images.
	1-9	Set label for selected region. This option can also be used to change the label of the bounding box. After selecting the desired box (left mouse button), the name can be changed by entering the desired label number (1 - 9).

This table, along with shortcuts for common operations, can also be accessed via **Menu > Help** (Fig. 19).

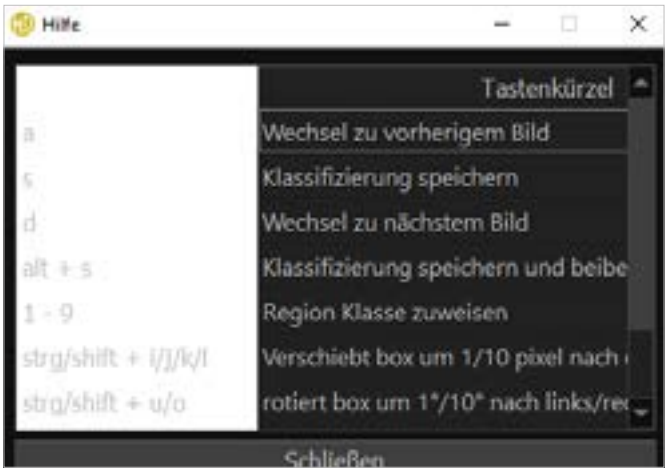


Fig. 19: LumiScan Annotation: Help Window

3.10 Folder Structure

To annotate a single folder of images, simply select the folder containing the png images and start annotating.
To load multiple folders of images, the images should be located on your hard disk in the following folder structure:

```
<Any Folder Name>
|-----<Any Folder Name>
        |
        |---- .png
        |---- *.csv
        |----.json
|-----<some other folders>
```

In this case, you can select a folder that contains one or more folders of png images and then use the folder drop-down menu at the top to select the correct folder you want to annotate.

4 LumiScan Training

4.1 Description

The LumiScan Training allows easy training of neural networks for computer vision tasks. This includes object recognition tasks. It also allows the user to train an existing network to adapt it to new data, or to train a network from scratch and convert it to ONNX.

4.2 Requirements

- CUDA Toolkit 11.8 or higher
- Code Meter 7.60 or higher
- NVIDIA GeForce RTX 2080 SUPER
- Anaconda
- Windows 10 or higher/Linux

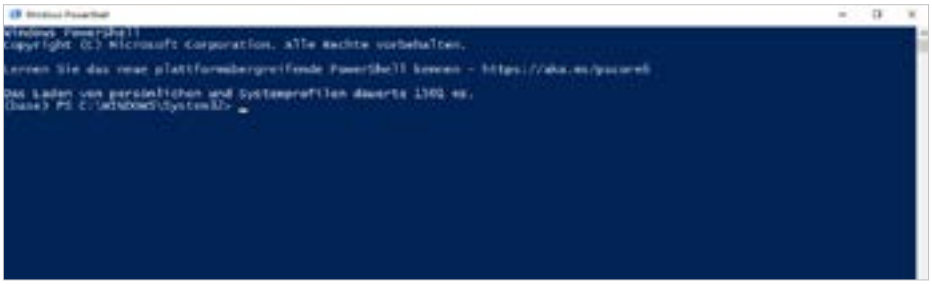
4.3 Before Installation

4.3.1 Customizing the PowerShell Execution Policy

NOTE: When in doubt, contact your IT department. They can manually run the installation script line by line to see what has changed in your system.

To start:

1. Type **PowerShell** in the Windows Search bar.
2. When Windows PowerShell appears in the list, open it.
3. PowerShell opens as a blue text/command-line interface.



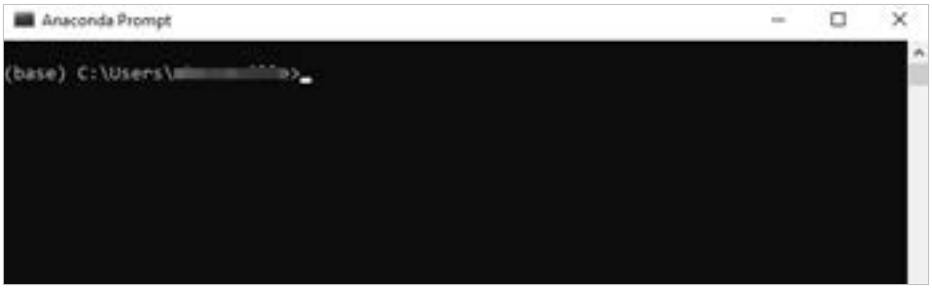
4. Disable execution policy protection with:
   Set-ExecutionPolicy -ExecutionPolicy Bypass -Scope CurrentUser
5. You can now close the command prompt.

4.3.2 Activation of Annaconda for PowerShell

This requires the following steps:

1. Type **Anaconda Prompt** in the Windows search bar.
2. When the Anaconda Command Prompt (Anaconda3) appears in the list, select it with the right-click.
3. Select **Run as administrator**.

4. The command prompt opens as a black text interface (terminal).



5. Enable Anaconda for Powershell with the command: **conda init powershell**
6. You can now close the command prompt.

4.4 LumiScan Training Installation

To install LumiScan Training Framework:

1. Enter **PowerShell** in the Windows search bar.
2. Select **Run as administrator**.
3. Open the folder with the installation file.
4. Copy the address of this folder from the address bar (referred to below as `<path_to_installation_directory>`).
5. Enter the command `cd <path_to_installation_directory>` in Powershell.
6. Execute the installation script in Powershell with the command: `Install.ps1`
7. This will create a shortcut called **LumiTraining.lnk** (the extension may not be visible).
8. Copy this shortcut to any location you want to start the training from.
9. Double-click on the shortcut.
10. Program starts.

Please contact HD Vision Systems if you have any problems.

4.5 User Interface

After starting the program, the standard user interface opens (Fig. 20).

Fig. 20: LumiScan Training Framework: Default User Interface

The various elements of the user interface are annotated in Figure 21 below and explained in Table 11.

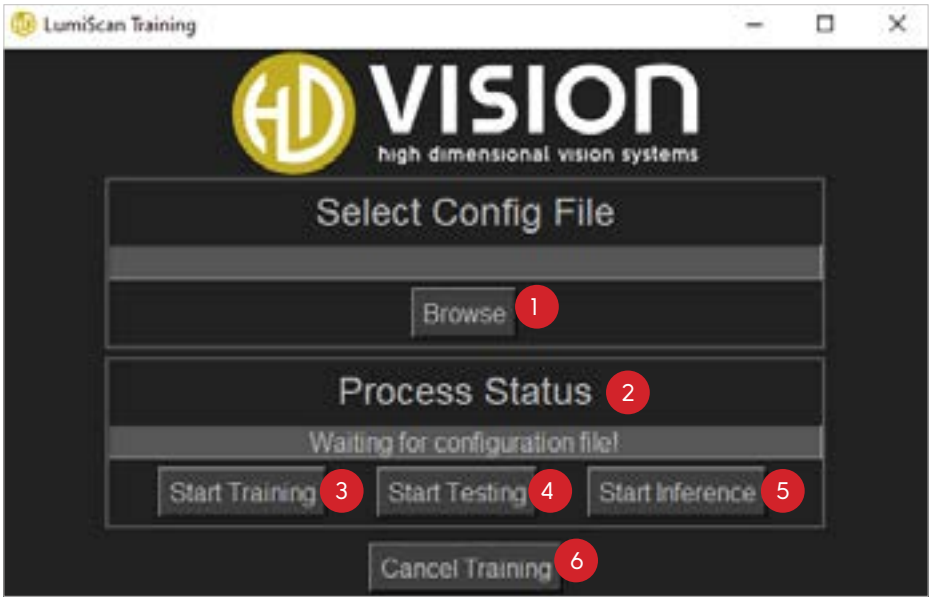


Fig. 21: LumiScan Training Framework: Described User Interface

Table 11: LumiScan Training Framework: Described user interface

Nr.	Description
1	**Select Config File/Browse** is used to select the training data.
2	**Process Status** displays the current status of the process. Possible messages: • **Waiting for configuration file!** The program is waiting for training data selection. • **Testing Network!** appears after clicking on **Start Testing**. Indicates that an existing network is being tested with a new test data set. • **Waiting for deployment!** After training, the network must be converted and exported to an onnx file. This message be displayed during the process. • **Finished cleanup** marks the end of the training. • **Time Remaining** displays the remaining process time. • **Latest test scores** is metric for evaluating networks. Should not be used as an absolute value, but as a means of comparing different networks tested with the same data set.
3	**Start Training** starts training the data.
4	**Start Testing** starts the test of the network configuration specified in the Configuration Test Data Set. The results are stored in the Export folder.
5	**Start Inference** Clicking this button opens a pop-up window that lets you select a folder containing images in which the network results will be displayed. The images in this folder will then be extracted from the network, and the results will be saved under predictions in the export directory.
6	**Cancel Training** interrupts an ongoing training, test, or inference process.

For correct and successful training, it is necessary to configure all relevant parameters in the JSON settings beforehand. An example of such a setting is given in the next section.

4.6 JSON-Settings


```
{
    "trainingDataRoot": "C:/Users/user_name/Desktop/recordings/raw",
    "validationDataRoot": "C:/Users/user_name/Desktop/recordings/raw",
    "exportDirectory": "C:/Users/user_name/Desktop/recordings/net-
work",

    "finetuneDataRoot": "C:/Users/user_name/Desktop/recordings/raw",
    "classList": [
        "Arrow",
        "Disk"
    ],
    "nonRotables": [
        "Disk"
    ],
    "imageScale": 0.5,
    "networkBase": null,
    "baseConfiguration": "LumiScanROD",
    "schedule": "Full",
    "trainingProfile": "B8x1",
    "deploymentConfiguration": "LumiScanVGR",
    "anacondaActivation": "C:/tools/Anaconda3/Scripts/activate.bat",
    "tempFiles": "tmp"
}
```


These are standard elements of the JSON settings. Their meaning is explained in Table 12. Exactly which parameters are needed depends on the application.

4.6.1 JSON-Parameters Description

Table 12: LumiScan Training: JSON settings

Parameter	Description
trainingDataRoot	Path to training data. * This folder is generated by LumiScan Annotation and contains the images along with the label data. The latter is available as CSV or JSON files. There should be one label data file for each image.
validationDataRoot	Path to the trained data to see how training improves accuracy.* It can be set to the same path as trainingDataRoot.
exportDirectory	(optional) Storage path for ONNX, classes/labels in CSV or JSON files generated from LumiScan Annotation and other training results.* If this option is left empty, the data will be stored in `/recordings/raw` (see also path of `trainingDataRoot`).
finetuneDataRoot	The data for the tuning must be entered here. The address is exactly the same as in `validationDataRoot`.
classList	List of the available classes / labels in CSV format that have been received by the LumiScan Annotation and that are to be recognized by the network.
nonRotables	Describes objects without a clear orientation (e.g. a disk or a scratch). If these classes do not have a defined orientation, their name should be entered here. It must match the name specified in classlist.
Arrow, Disk	Examples of class names to recognize.
imageScale	Shows the scaling of the image compared to the original image. Only two values are possible: **0.5** or **1.0**.
networkBase	Path to the network base *. Here you can select a network that has already been trained. The value is: `null`** if there is no previous network or if you want to start training from scratch. If you want to add an existing network to the training, enter the path of the network here.

* NOTE: When specifying the path, pay special attention to the direction of the slashes. All **backslashes (\)** must be replaced with **slashes (/)**.

** If the value is zero, you must ensure that it is written exactly like this: `null` and does not contain any capital letters or quotation marks.

Parameter	Description
baseConfiguration	It is provided by HD Vision Systems. Here you can choose between two options: • `LumiScanOOD`: if the object has a top side and you want to localize it. • `LumiScanROD`: on rotation, if the top of the object has not been localized.
schedule	Two options are possible in the schedule: **Full** und **Finetune**. • **Full** performs a new training, assuming a network is seeing the dataset for the first time. This takes longer and should only be used for initial training. • **Finetune**: All further refinement steps should be done with this option. It shortens the training time, but is designed so that all data is available. The goal is to achieve consistent results for existing and new properties. You must enter the tuning data in the `finetuneDataRoot`
trainingProfile	An option to set the allowed number of GPUs and influence the required memory. Currently only 1 GPU is supported, with the following options: • **B8x1**: Please set this as a default value • **B4x1**: If the training fails with the default value set, or the part of the training is outsourced to shared GPU memory, please select this option. You can check this in the Task Manager. An unexpectedly long training time (of several days) is also a good indicator.
deploymentConfiguration	Basic application configuration. This parameter is already defined as `LumiScanVGR` and remains unchanged.
anacondaActivation	This is the path to activate the BAT file [Batch-Skript] ("activate.bat"), normally to be found under: "C:\tools\Anaconda3".
tempFiles	Path for saving temporary files, is deleted after training. This can be any path to which the program has write permission.

5 LumiScan File Transfer

5.1 Description

LumiScan File Transfer is divided into two roles: Runner and Trainer, which have two different tasks.

- The **Runner** transfers the generated and labeled images to the Trainer to further improve the neural networks.
- The **Trainer** receives the images generated by the Runner and stores them in the specified folder for training.
  You can also use the Trainer to send the newly trained neural networks (also called models) back to the Runner.

5.2 Before Installation

5.2.1 Installing the CodeMeter Runtime Environment

To license your LumiScan software, you must install the CodeMeter® Runtime Environment. A CodeMeter Runtime Kit installer for Windows 64-bit is available at the following link:
https://www.wibu.com/de/support/anwendersoftware/anwendersoftware.html

Before installing, please check your version of CodeMeter Runtime (version 7.60c or higher).

Follow the manufacturer's instructions for installation:

1. Connect the CmDongle to a free USB port on your PC.
2. The LED on the CmDongle will alternate between red and green for about 1-2 seconds. Your PC reports that a new USB device has been found.

5.3 Installing LumiScan File Transfer on Windows

1. Navigate to the location of the LumiScan installer.
2. Double-click on the file: `Installer_LumiScan_File_Transfer_va_b_c_d.exe`*.
3. The installation is prepared and the license agreement window opens.
4. Accept the license terms by clicking on **Accept**.
5. If you want to change the default installation location, click **Browse**.
6. Navigate to the desired storage location.
7. Press **OK** to confirm your selection.
8. Otherwise, click the **Next** button to continue.
9. If desired, select the **Start Menu** folder for the program links.
10. If you do not want to create shortcuts, select the **Do not create links** option.
11. Then click on **Install**.
12. When the installation is complete, you will see a dialog box.
13. Click **OK**.
14. Click **Finish**.

* where **a**, **b**, **c**, **d** are variables that depend on the version of the software.

5.4 Before Starting the Program

5.4.1 Folder Structure

The folders for the training data and the trained data must have a specific structure and name. It is therefore advisable to create them before starting the program.
The easiest way is to create a folder for **Runner** and one for **Trainer** on the computers on which they are running. Each of these two folders has a specific structure:

- **The Runner folder**: This folder must have two subfolders whose names are predefined and cannot be changed: **networks** and **training_data**:
  - The **networks** folder, which is empty at the beginning, contains the trained networks sent by the Trainer.
  - The **training_data** folder contains the image data sent by LumiScan Labeling. This folder is sent to the Trainer and saved in one of his folders.

  The Runner folder with both subfolders is selected in the Runner settings for the **Annotated Data Directory**.

- **The Trainer Folder:** This folder should also contain two subfolders, which you can name as you wish:
  - A subfolder contains the training data received from the Runner. This folder will be specified later in the trainer settings for the **Training Data Directory**.
  - The second subfolder should contain subfolders with specific date names according to the key: **yyyy-mm-dd**.
    This is where the trained networks are stored that can later be sent to the Runner.
    This folder is selected in the trainer settings for the directory of trained networks.

5.5 Starting the Program for the First Time

When you run the program for the first time, a message appears on the screen telling you where the files were created (Fig. 22).

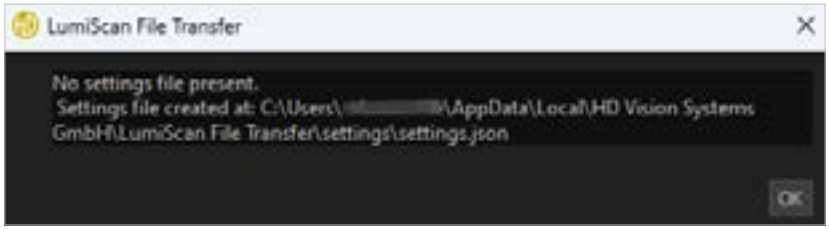


Fig. 22: Message after first program start

NOTE: When the program is started for the first time, it opens in the Runner role.

5.6 Switching Roles

To switch roles between Runner and Trainer:

1. Go to the file's location:
   `C:\Users\<UserName>\AppData\Local\HD Vision Systems GmbH\LumiScan File Transfer\settings\settings.json`
2. The JSON configuration file opens (Fig. 23).

Fig. 23: LumiScan File Transfer: Switching Roles

3. Enter the new role in the window that opens.
4. Save changes with Ctrl+S.

NOTE: The names of RUNNER and TRAINER should be written in **capital letters only**.

After changing the settings, the program should be reopened so that both the Runner and Trainer interfaces are visible at the same time.

5.7 LumiScan File Transfer Runner

The Runner sends the generated and labeled images to the trainers to further improve the neural networks, and receives the neural networks back from the Trainer.

5.7.1 User Interface

When you start the Runner for the first time, the following window appears (Fig. 24).

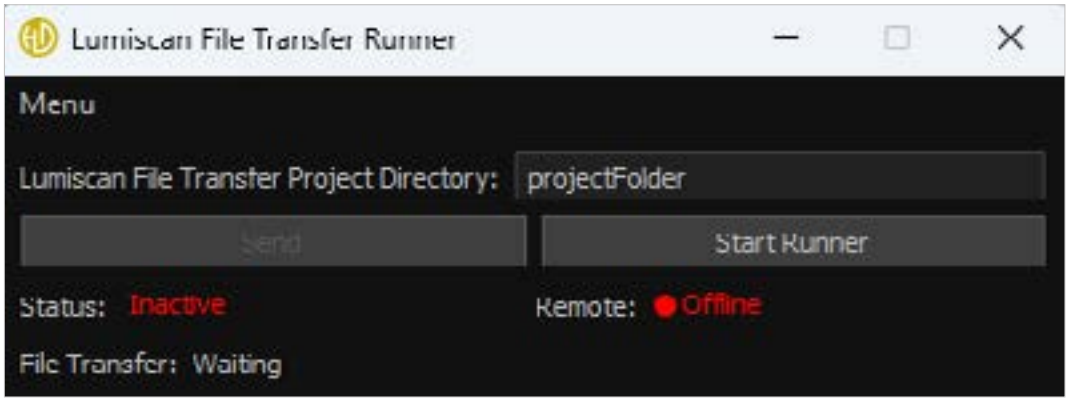


Fig. 24: LumiScan File Transfer Runner: Standard User Interface

The various elements of the user interface are shown in Fig. 25 below. They are explained in the following Table 13.

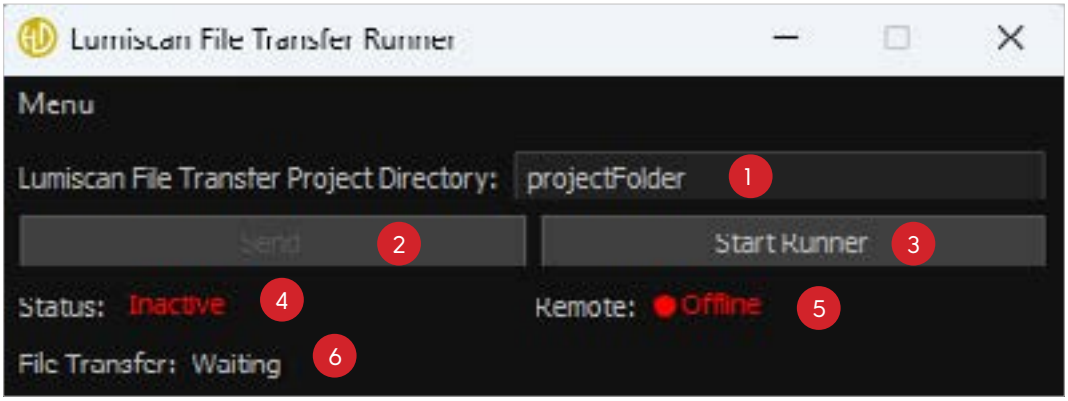


Fig. 25: LumiScan File Transfer Runner: Described User Interface

Table 13: LumiScan File Transfer Runner: Standard user interface

Nr.	Description
1	Path to your LumiScan File Transfer Project Directory.
2	Button to send images to the Trainer.
3	Button to start/stop the Runner.
4	Indication of whether the Runner has started or not.
5	Indication that the Trainer is started and connected.
6	Display of the current status of the Runner.

To use Runner:

1. Set the LumiScan File Transfer Project Directory.
2. Click on **Menu** button.
3. Click on **Settings.**

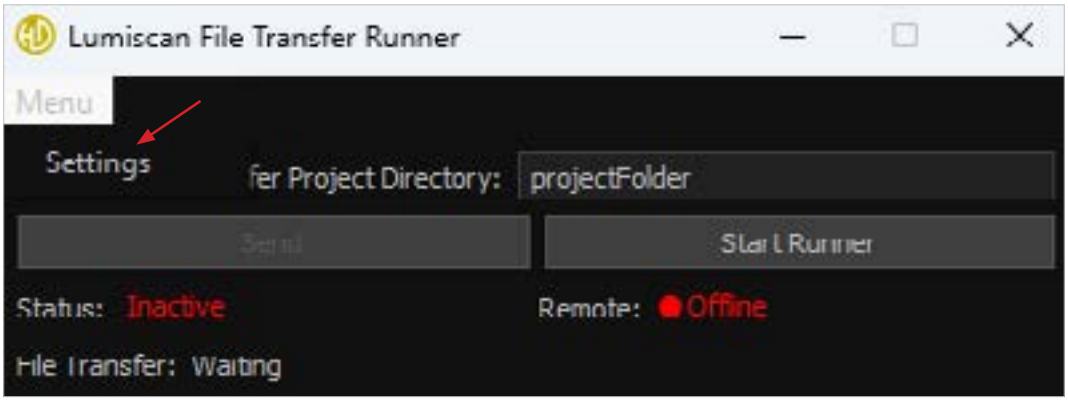


Fig. 26: LumiScan File Transfer Runner: Menu

4. Configure the network settings.

5.7.1.1 Settings

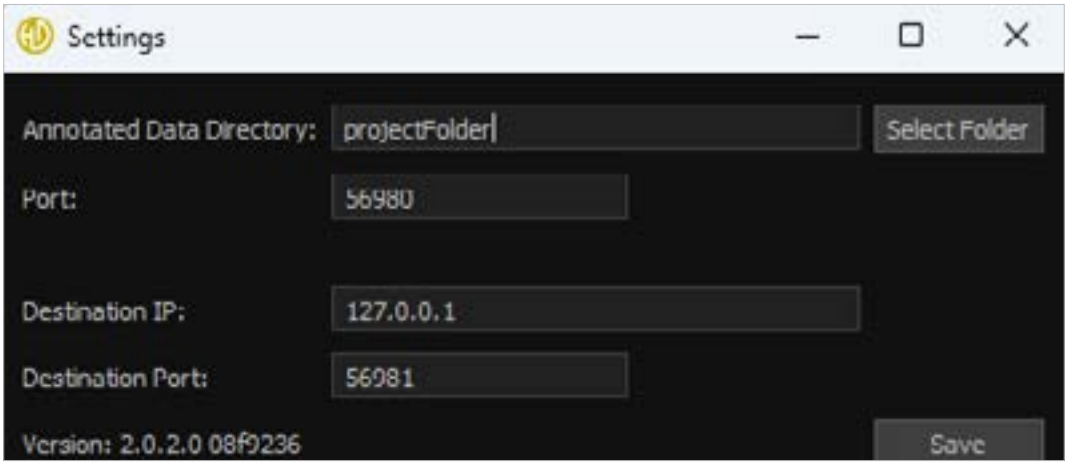


Fig. 27: LumiScan File Transfer Runner: Settings

You can set the following parameters in **Settings**:

- **Annotated Data Directory**: Directory of the Runner projects. All images, networks and configuration files for Runner can be found here.
- **Port**: The network port on which this tool waits for incoming file transfers. This port should be used as the target port in the Trainer.
  Please contact your IT department to find out which ports you can use and which are permitted in your firewall settings.
- **Destination IP**: The IPv4 address of the system on which the Trainer is running. Please ask your IT department for the correct address.
- **Destination-Port**: The network port on which the trainer waits for incoming connections.

When you click the **Save** button, the settings are checked. If an error occurs, a message is displayed explaining which setting is incorrect (Fig. 28).

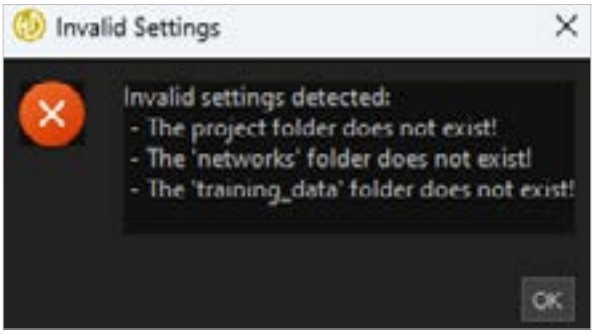


Fig. 28: LumiScan File Transfer Runner: Invalid Settings

If all settings have been checked successfully, they will be saved in the registry and will be automatically loaded the next time the program is started.

5.7.2 File Transfer

Once you have set up the Runner and successfully saved your settings, you can start the Runner:

1. Click on the button **Start Runner**.
2. The status changes to **Active** (Fig. 29).
3. Next to the status, the parameter **Port** is displayed with the address from which the data is sent.

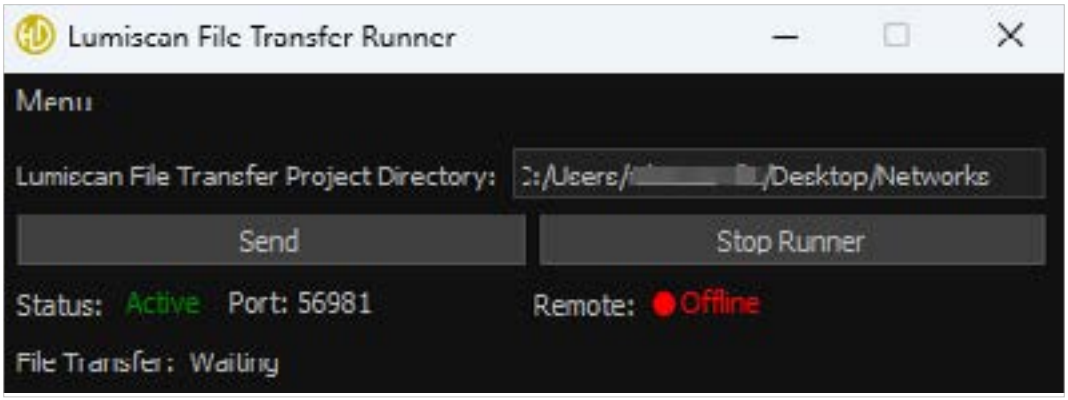


Fig. 29: LumiScan File Transfer: Runner started

4. If the connection to the Trainer is successful, the **Online** message will appear on the remote display (Fig. 30).

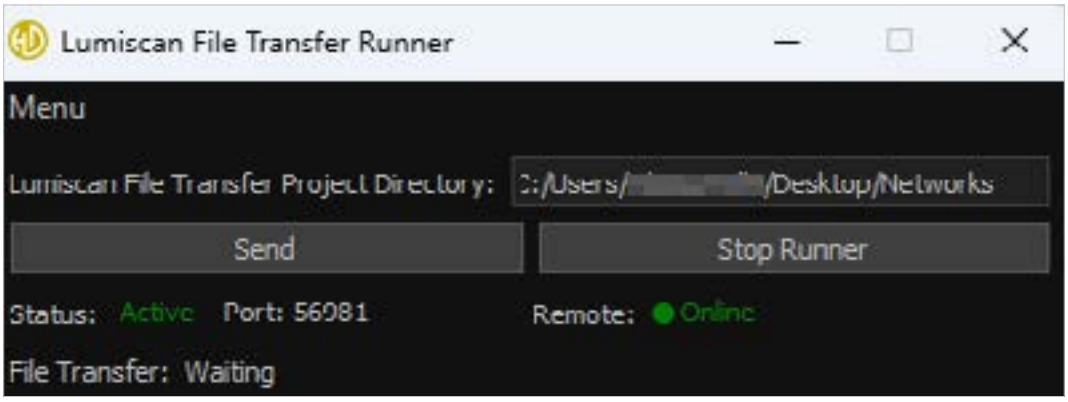


Fig. 30: LumiScan File Transfer: Runner connected to Trainer

5. Now you can click on **Send** to send the images captured by the Runner software to the Trainer.

NOTE: The Runner will delete images from the Runner folder only after they have been successfully transferred. Newly captured images will not be deleted.

When a user sends a new neural network from the Trainer, the **File Transfer** screen informs the user of the incoming data and shows the current progress of the transfer (Fig. 31).

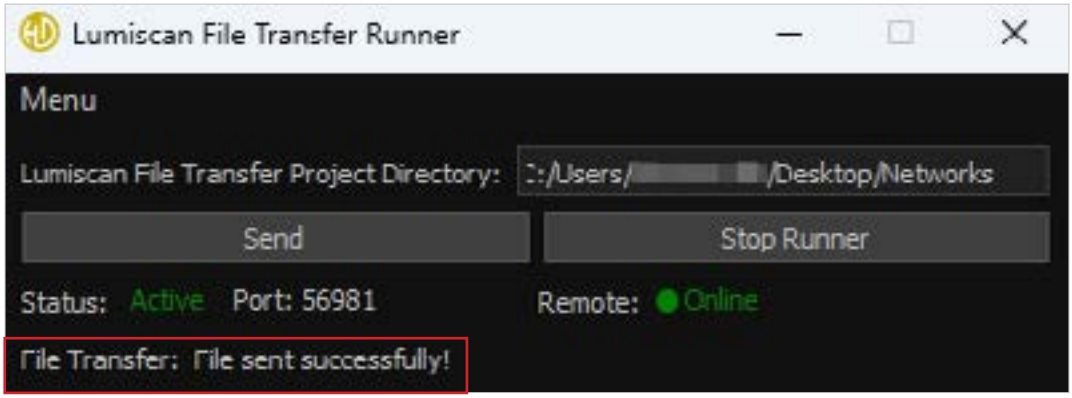


Fig. 31: LumiScan File Transfer Runner: Sending Status

Once the transfer has been successfully completed, the network is stored in the corresponding folder in the Runner Project Directory.

5.8 LumiScan File Transfer Trainer

The Trainer receives the images generated by the Runner and stores them in the specified folder in order to process them for training. You can also use the Trainer to transfer the newly trained neural networks to the system on which the Runner is running.

5.8.1 User Interface

When you start the Trainer for the first time, the following window appears (Fig. 32).

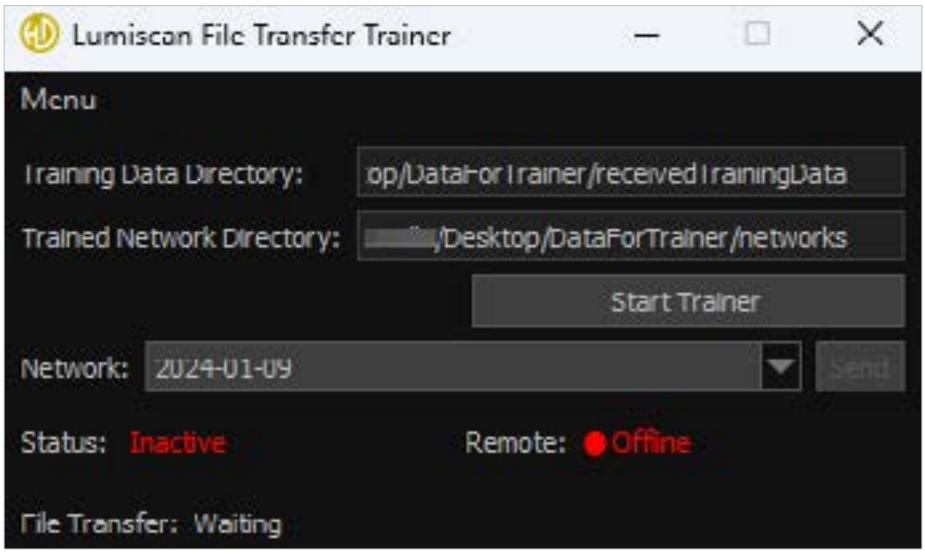


Fig. 32: LumiScan File Transfer Trainer: Standard User Interface

The various elements of the user interface are shown in Fig. 33 below. They are explained in the following Table 14.

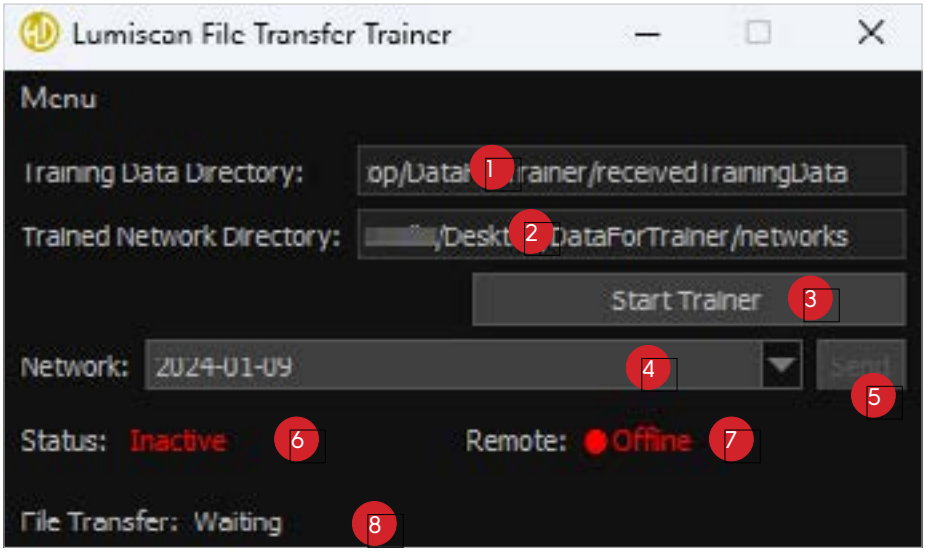


Fig. 33: LumiScan File Transfer Trainer: Described User Interface

Table 14: LumiScan File Transfer Trainer: Standard user interface

Nr.	Description
1	Path to your Data Directory where the images received by the Runner will be stored.
2	Path to the Network Directory where the neural networks for recognition are stored.
3	Button to start/stop the Trainer.
4	Combo box to select which neural network to Transfer.
5	Button for sending the model to the Runner.
6	Display whether the Trainer has started or not.
7	Indication that Runner is started and connected.
8	Display of the current status of the Trainer.

To use Trainer:

1. Set the **Training Data Directory**
2. Set the **Trained Network Directory**
3. Adjust the network settings in **Settings**:
   a. Click on **Menu**.
   b. Click on **Settings** (Fig. 34).

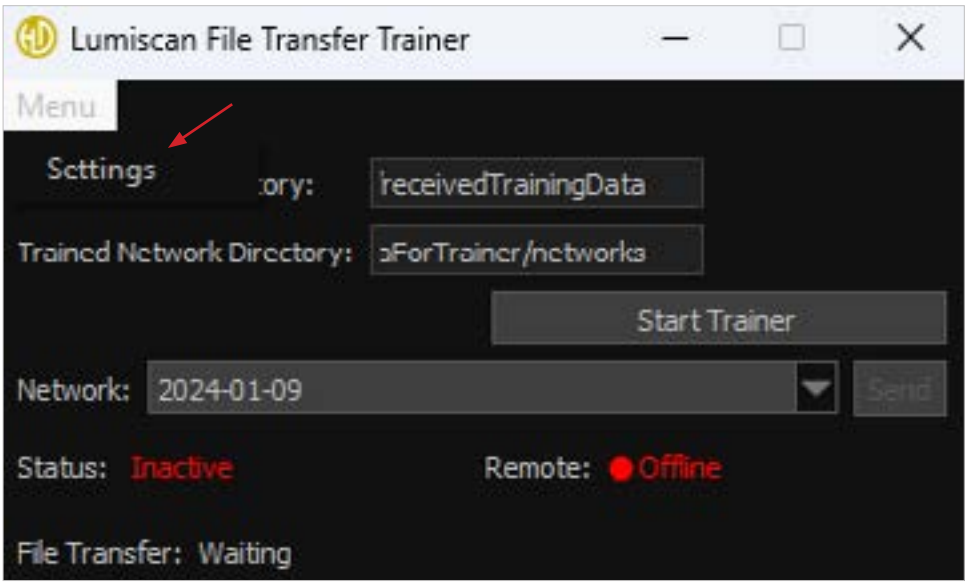


Fig. 34: LumiScan File Transfer Trainer: Menu

5.8.1.1 Settings

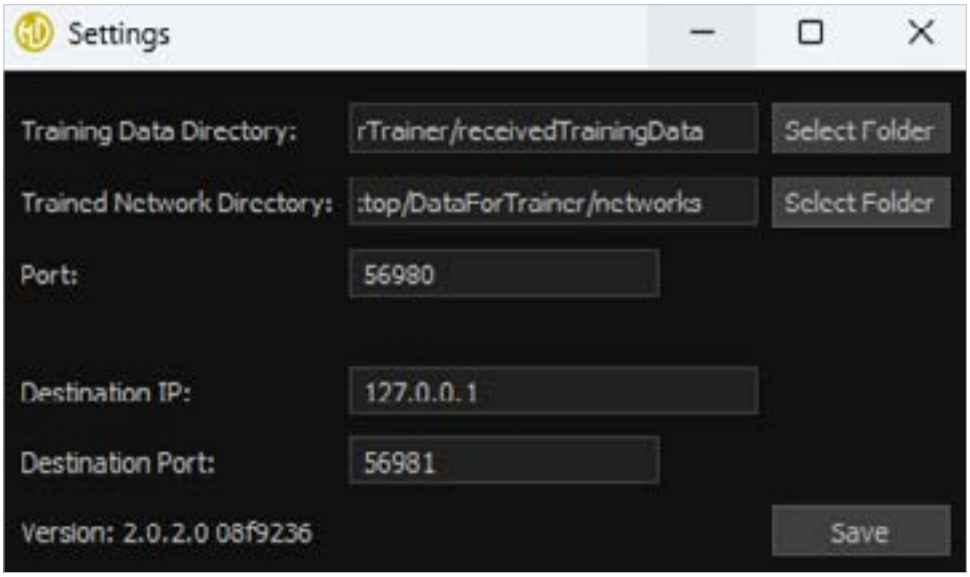


Fig. 35: LumiScan File Transfer Trainer: Settings

You can set the following parameters in the settings window:

- **Training Data Directory**: Folder where images received by the runner will be saved.
- **Trained Network Directory**: Folder containing the neural networks generated by the Trainer.
- **Port**: The network port on which this tool waits for incoming file transfers. This port should be used as the destination port in the Runner. **Check with your IT department about which ports you can use and which are allowed in your firewall settings.**

- **Destination IP**: The IPv4 address of the system on which the Runner is running. **Ask your IT department how to obtain the correct address.**
- **Destination Port**: The network port on which the Runner waits for incoming connections.

When you click the **Save** button, the settings are checked. If an error occurs, a message will appear indicating which setting is incorrect (Fig. 36).

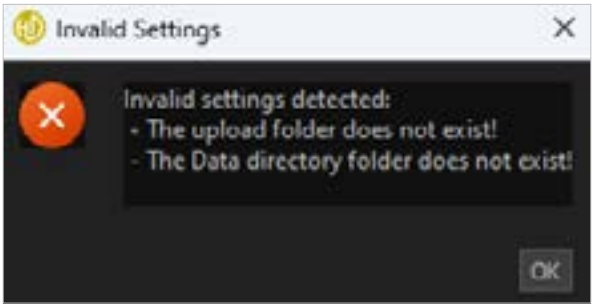


Fig. 36: LumiScan File Transfer Trainer: Invalid Settings

If all settings have been checked successfully, they will be saved in the registry and will be automatically loaded the next time the program is started.

5.8.2 File Transfer

Once you have set up the trainer and successfully saved your settings, you can start the Trainer:

1. Click on the button **Start Trainer.**
2. The status changes to **Active** (Fig. 37).
3. Next to the status, the **Port** parameter is displayed with the address from which the data is being sent.

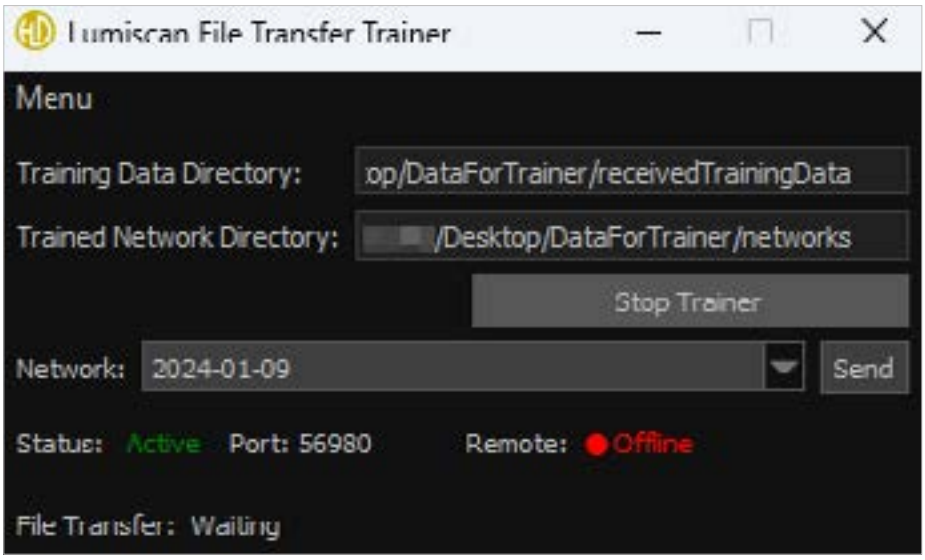


Fig. 37: LumiScan File Transfer Trainer started

4. If the connection to the Runner is successful, the **Remote** displays **Online**. (Fig. 38).

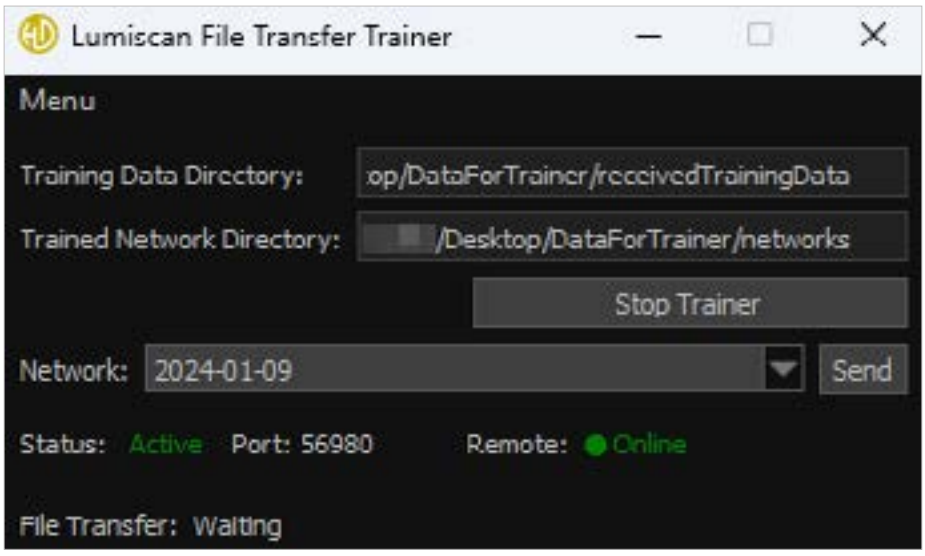


Fig. 38: LumiScan File Transfer: Trainer connected to Runner

5. Now you can select in **Network** which neural network should be sent to the Runner.
6. Click on the **Send** button to start the transfer.

When a user sends new images from the Runner, the status bar at the bottom will notify you of the incoming data and display the current transfer progress (Fig. 39).

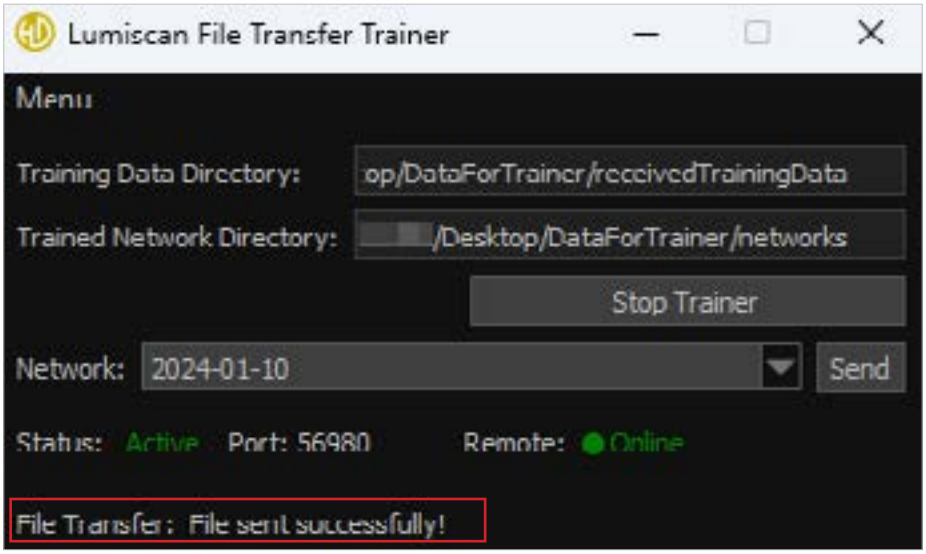


Fig. 39: LumiScan File Transfer Trainer: Sending Status

If the transfer is successful, the data will be saved in the data directory.

6 LumiScan Hand-Eye Calibration

Hand-eye calibration is required for communication between the robot and LumiScan[X]. Without hand-eye calibration, the camera cannot recognize the relative position of the TCP to itself.

NOTE: If the camera or robot has been moved, the hand-eye calibration must be repeated. Even small movements, such as a bump on the camera, require a new calibration.

NOTE: If this type of calibration is used, it must always be checked whether new coordinates are sent via the PLC. The coordinates can be viewed for each shot in the Pose Editor.

If you are using a Universal Robots robot, continue with the hardware preparation.

6.1 Getting Hardware Ready

1. Attach the calibration plate to the robot:
   - It does not matter how the plate is attached to the robot, as long as it is fully visible to the camera and cannot be moved until the end of the calibration.
   - Also make sure that the robot can move freely in all its degrees of freedom while the calibration plate is attached.

If you are using a robot from Universal Robots and still want to use an external hand-eye calibration software instead of the integrated URCaps tool, please follow the two steps below. Otherwise, continue with the URCaps part of the guide.

a. Attach the adapter ring to the universal robot flange using M6 x 16 mm screws.

b. Attach the calibration plate to the adapter plate of the adapter ring using a mounting bracket (Fig. 40).

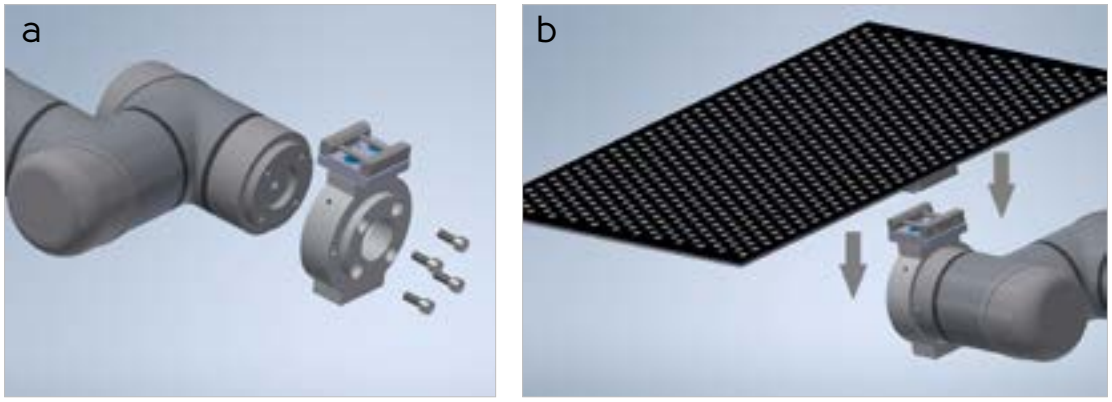


Fig. 40: Attaching the Calibration Plate to the Robot.

2. Connect the camera and the robot to your computer or network to obtain the necessary information from both systems.

6.2 Before Installation

NOTE: Before installing the LumiScan Hand-Eye Calibration software, please read the information about network settings, Windows Firewall and virus protection in the LumiScan^X camera manual.

6.2.1 Installing the CodeMeter Runtime Environment

To license your LumiScan software, you must install the CodeMeter® Runtime Environment. A CodeMeter Runtime Kit installer for Windows 64-bit is available at the following link:
https://www.wibu.com/de/support/anwendersoftware/anwendersoftware.html

Before installing, please check your version of CodeMeter Runtime (version 7.60c or higher).

Follow the manufacturer's instructions for installation:

1. Connect the CmDongle to a free USB port on your PC.
2. The LED on the CmDongle will alternate between red and green for about 1-2 seconds. Your PC reports that a new USB device has been found.

6.3 Installation

1. Close all open applications on your computer.
2. Navigate to the location of the LumiScan installer*.
3. Double-click on the file: `Installer_LumiScan_HandEye Calibration_va_b_c_d.exe`**.
4. The installation is prepared and the license agreement window opens.
5. Accept the license terms by clicking on **Accept**.
6. If you want to change the default installation location, click **Browse**.
7. Navigate to the desired storage location.
8. Press **OK** to confirm your selection.
9. Otherwise, click the **Next** button to continue.
10. If desired, select the **Start Menu** folder for the program links.
11. If you do not want to create shortcuts, select the **Do not create links** option.
12. Then click on **Install**.
13. When the installation is complete, you will see a dialog box.
14. Click **OK**.
15. Click **Finish**.

* By default, the program will be installed to the following path: `C:/Program Files/HD Vision Systems GmbH/HandEye Calibration/`

** where **a**, **b**, **c**, **d** are variables that depend on the version of the software.

6.3.1 Configuration after Installation

1. Configure the setup file: `<Installation Path>/config/hand-eye_app_setup.ini`

   a. To modify the file, it must be copied to a different directory with write access.
   Once modified, the new file can be copied to replace the original settings file with administration access.

   b. Copy the corresponding camera calibration file (`*.hdvcal`) and the non-uniformity calibration file to the `<Installation Path>/config/`.

   c. Change the **LumiScan/calibrationFile** and **LumiScan/serialNumber** parameters in `handeye_app_setup.ini`

   d. Copy your calibration plate file (`*.cpd`) to `<Installation Path>/calplates/`

   e. Configure key parameters:

   - **GUI/editable**: Set to **True** if you expect that all GUI settings will never change (except exposure time). If editable is set to **False**, all configuration settings must be configured correctly.
   - **Features/enableCaptureRecordingPose:** The default value is **True**, since some old projects require the camera's recording position to be hard-coded.
   For first time projects it is recommended to set the value to **False**.
   - **LumiScan/serialNumber:** Camera serial number
   - **LumiScan/Kalibrierungsdatei:** The calibration file (`*.hdvcal`) for the default camera. The file name must include the serial number of the camera, e.g. `LX20230101.hdvcal`.
   It is recommended to save the `*.hdvcal` file in the `config/` folder.
   - **CalibrationProcessSettings/calibrationFilePath:** The path to the calibration file. You will normally receive a calibration plate file (`*.cpd`) by e-mail, e.g. `LT300200L2023002_20230327.cpd`.
   The cpd file can be downloaded under `<Installation Path>/calplates/`.

f. Other parameters:

- **CalibrationProcessSettings/CalibrationMode**:
  Standard calibration mode **0:Manual 1:PLC**
  - **Manueller Modus:** Capture the image by clicking the button on the Hand Eye tab.
  - **SPS-Modus:** The PLC controls when the image is captured via Profinet communication.
- **CalibrationProcessSettings/CalibrationType**:
  - **MovingCamera** means that the camera is mounted on the robot.
  - **StationaryCamera** means that the camera is not mounted on the robot and cannot move.
- **InterpreterSettings/TransformName**: Type of rotation in the pose.
  Possible values are:
  - Quaternion WXYZ
  - Quaternion XYZW (Space plays no role for Quaternion)
  - Rodrigues
  - Homogeneous Matrix (must be separated by a space, this does not support CalibrationMode=PLC and PoseMode=SPS)
- **InterpreterSettings/RotationUnit**
  Possible values are:
  - Radian
  - Degree: Used only when Euler Angle is selected as the rotation type in the pose.
- **InterpreterSettings/TranslationUnit**
  Possible values are:
  - Millimeter
  - Meter
- **InterpreterSettings/Labels**
  - Tx;Ty;Tz;Qw;Qx;Qy;Qz
  - Tx;Ty;Tz;Qx;Qy;Qz;Qw für Quaternion

- **[PLCPoseInterfaceLayout]**

  byteAddrVar0=15
  byteAddrVar1=19
  byteAddrVar2=23
  byteAddrVar3=27
  byteAddrVar4=31
  byteAddrVar5=35
  byteAddrVar6=39
  PLC address for the hand-eye to read the current position.

6.3.1.1 Configuration Example

```
[GUI]
editable=True
[Features]
enableCaptureRecordingPose=True
[Lumiscan]
serialNumber=LX20210121
calibrationFile="config/dummyCalibration.hdvcal"
exposureTimeUS=18000
depthMaxMM=600
depthMinMM=400
confidenceThreshold=0.7
pixelFormat=1
preProcessingFilter=1
postProcessingFilter=1
triggerMode=0
enableTriggerOut=0

[CalibrationProcessSetting]
calibrationMode=1
sensorWidth=1280
sensorHeight=960
Cx=640
Cy=480
focus=0.00414
kappa=0.0
Sx=3.75e-006
Sy=3.75e-006
calibrationFilePath="calplates/fakeCalibrationTarget.cpd"
calibrationType=MovingCamera
mirrorMode=Off
scaraRobot=false
```

```
[InterpreterSettings]
transformName=Quaternion WXYZ
translationUnit=Millimeter
rotationUnit=Radian
labels="Tx;Ty;Tz;Qw;Qx;Qy;Qz"

[SPSCalibInterface]
HDVCaptureReadyByte=14
HDVCaptureReadyBit=0
HDVCaptureRequestRecvByte=14
HDVCaptureRequestRecvBit=1
PLCCaptureRequestByte=14
PLCCaptureRequestBit=1
PLCResetRequestByte=0
PLCResetRequestBit=1

[PLCPoseInterfaceLayout]
byteAddrVar0=15
byteAddrVar1=19
byteAddrVar2=23
byteAddrVar3=27
byteAddrVar4=31
byteAddrVar5=35
byteAddrVar6=39
```

6.4 User Interface

Start **Handeye.exe**.

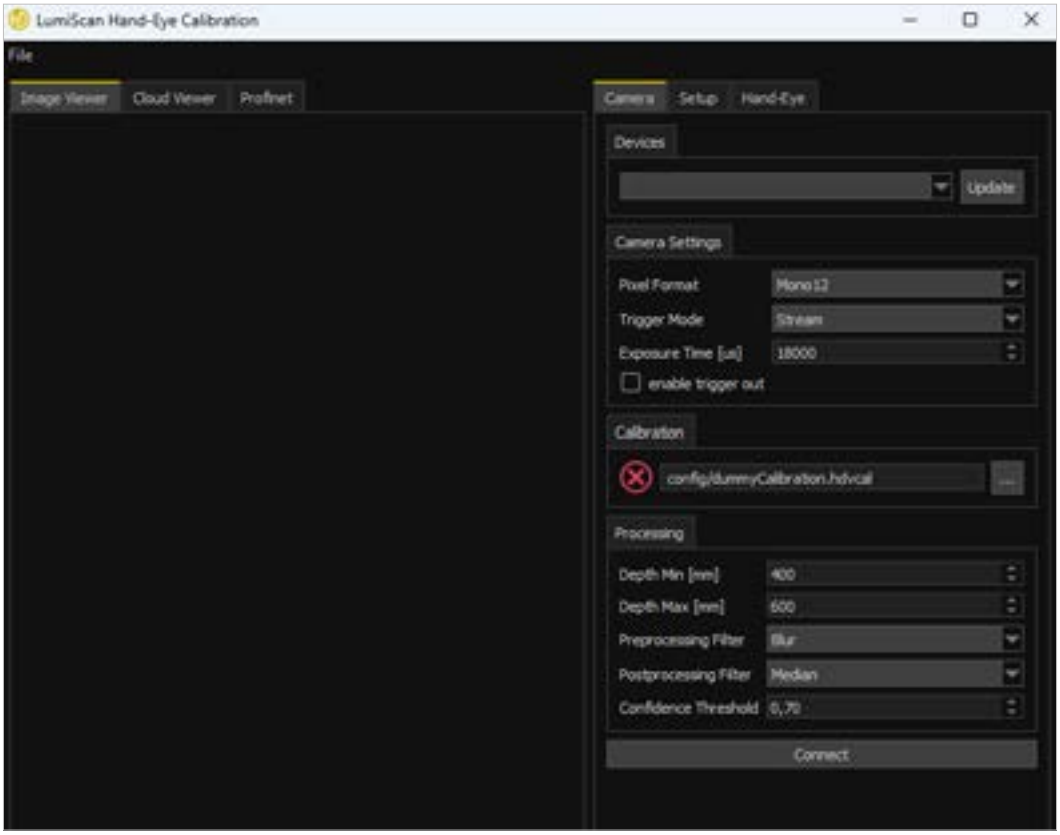


Fig. 41: LumiScan Hand-Eye Calibration: Main Window

The main window that opens is divided into two sections:
On the left, there are three tabs:

- **Image Viewer** displays the current image or the image captured by the camera.
- The **Cloud Viewer** displays the point cloud generated from the 3D image data of the target.
- **Profinet** is used to monitor the current data that can be read by the PLC.

The right section is the control panel with three tabs for settings:

1. **Camera**
2. **Setup**
3. **Hand-Eye**

This is also the recommended order for configuring the parameters.

6.4.1 Camera

The **Camera** tab is used to configure the camera.

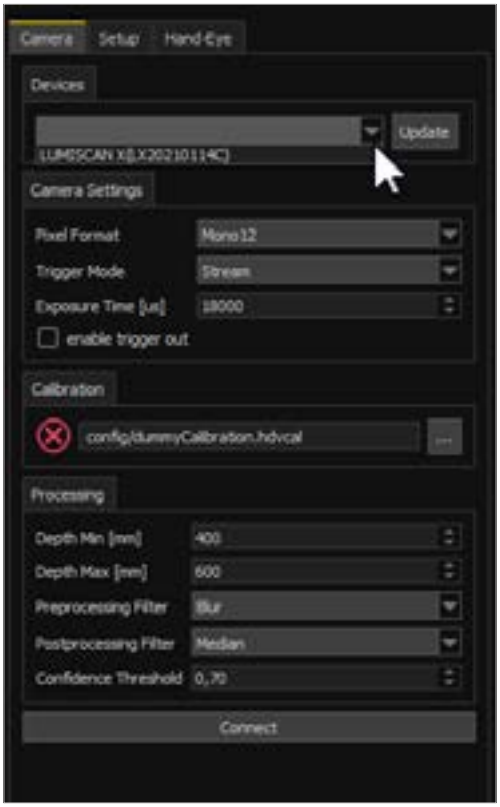


Fig. 42: LumiScan Hand-Eye Calibration: Camera Tab

Under **Devices**, you can select the camera to calibrate:

1. Click on **Update** until you see that your camera is connected. LUMISCAN X and the serial number of your camera will be displayed (e.g. LX20220110).

2. If the camera is not found, click **Update** again.

3. Click **Connect** at the bottom of the page to start recording from the camera.

4. Edit the camera settings:

   - **Pixel Format:** Select Mono12.
   - **Trigger Mode:** Select **Stream** and ignore the other two options. They are intended for special cases and not for normal use. If your application is such a special case, you have already been informed by us.

- **Exposure Time [µs]:** Set the exposure time so that you see a clear image with good contrast and the white dots are not overexposed (highlighted in red).
- **enable trigger out**: When this option is enabled, LumiScan^{X} sends a trigger output signal each time an image is captured. This signal is then used for the LumiSpot.

5. Load the supplied calibration file by clicking the **...** symbol.

   The camera calibration is fixed and only needs to be changed if the hardware is replaced. The calibration file is camera-specific and is supplied by HD Vision Systems with every camera (e.g. `resources\Calib\LX20220110_45cm_200915_022.hdvcal`).

6. To ensure that you are using the correct calibration file, follow these steps:
   - Edit the processing parameters **Depth Min** and **Depth Max** to cover the entire measuring range.
   - Open the **Cloud Viewer** in the upper left corner.
   - You can leave all other parameters at their default settings:
     - **Preprocessing Filter**: Blur;
     - **Postprocessing Filter**: Median;
     - **Confidence Threshold**: 0,70 (Or 0.70, depending on the system installed on the computer.)
   - If you see a point cloud, you have used the correct calibration file.
   - To rotate the view, press the middle mouse button and move the mouse.
   - To move the view, hold down the Shift key and the middle mouse button and move the mouse.
   - The view can be zoomed in and out by scrolling the mouse wheel.
7. Once you have ensured that the correct calibration file is being used, return to the **Image Viewer** in the upper left corner.
8. Navigate to Setup in the upper right corner.

6.4.2 Setup

The **Setup** tab is used to configure robot pose communication.

Fig. 43: LumiScan Hand-Eye Calibration: Setup Tab

NOTE: Verify that the **Pose Data Layout** is the same type as the PLC interface (e.g., whether the PLC uses translation millimeters, quaternion or Euler angles).
If the displayed configuration is different from the PLC configuration, contact HD Vision System GmbH.

Configuring the Setup Parameter:

- **Preset:** Select your robot from the **Preset** drop-down list. The **Translation Unit** and **Rotation Type** will automatically change with the Preset.
- **Calibration Plate:** Select the calibration plate you received from the **Calibration Plate** drop-down list.

- **Calibration Type:**
  - Select **Stationary Camera** for regular bin picking operations if the camera is mounted above the measurement area.
  - Select **Moving Camera** if the camera is mounted on the robot arm itself and moves with it.
- **Pose Mode:**
  - Select **UR** if you are working with a UR robot and the corresponding script.
  - Select **PLC** if you are using the Profinet interface to communicate between the robot and the PC.

  You must specify which bytes are transmitted with which translation positions and rotations of the TCP.

  - Select **Manual** if you want to enter the robot's position coordinates for each image.

√ You have completed the setup of the Hand-Eye Calibration.

6.4.3 Hand-Eye

Finally, the calibration is performed in the **Hand-Eye** tab.

Fig. 44: LumiScan Hand-Eye Calibration: Hand-Eye Tab

For the further procedure, it is important to know whether you have selected Stationary Camera or Moving Camera.

- **Stationary Camera:** Take at least 6 different pictures of the calibration plate attached to the robot.
- **Moving Camera:**
  a. First, move the robot's camera to the capture position of your application.
  b. Press the Capture Recording Position button once. This saves the camera position and is needed for further calculations.
  c. Now take at least 6 different images of the calibration plate, which must be in a fixed position in the scene.

- Make sure that at least two axes are changed in these 6 images.
- Each joint requires at least 60° of rotation.
- The more axes of the robot are changed for a new position, the better the results of the hand-eye calibration.
- The calibration plate must be fully visible for valid pose detection.
- To achieve good results, the calibration plate should always be at a slight angle (max. 35°) to the camera.
- If a pose cannot be correctly interpreted, the individual image can be selected on the right and removed by right-clicking. This means that the entire calibration does not have to be repeated.

The robot pose of the recording is displayed at the bottom and must match the actual robot pose. The pose currently transmitted by the PLC can be checked in the **Profinet** tab.

6.4.3.1 Running the SPS Hand-Eye Calibration Program

To start SPS Hand-Eye Calibration program:

1. Click on **Start** to connect the PLC.
2. Move the robot to scanning position.
3. Wait for **HDV_CaptureReady** to **True**
4. Wait until the robot stops vibrating (4 seconds).
5. Set **PLC_CaptureRequest** to **True**.

NOTE: **PLC_CaptureRequest** can be canceled with **PLC_ResetRequest**.
If you send Request to **True** and decide not to capture image with current position, instead of setting **PLC_CaptureRequest** to **0**, you can set **PLC_ResetRequest** to **True** and then **False** after 0.5 s. As a result, the hand-eye tool will not capture the image.

6. Wait for **HDV_CaptureRequestRecv** to **True**.
7. Set **PLC_CaptureRequest** to **False**.

8. Wait 1 second (must be longer than the exposure time)
9. Repeat steps 2-8 for the next image capture.
   When you are finished capturing images, go to step **10**.
10. End the PLC program.

6.4.3.2 Completing the Hand-Eye Calibration

After the PLC program is completed, the hand-eye calibration can be completed with the following steps:

1. Click on **Pose Editor.**
2. Click on each image with the left mouse button.
3. If the pose error is greater than **0.01** or the message **bad pose quality** is displayed in the **Pose Status**, delete the image by right-clicking on it.
4. When all poses (6-10 poses) have been recorded, the calibration is started by clicking on **Compute Hand-Eye Calibration**.
5. Save die Hand-Eye Calibration file (`*.json`) in correspond folder, by clicking on **File -> Save**.

It is not necessary to take the complete number of shots for each individual recording position:

- Once the first position has been successfully calibrated, the calibration can be saved as such under **File -> Save**.
- This can be reloaded for the next position. To do this, the previous **Capture Recording Position** must be deleted and a new **Recording Position** captured.
- The calibration must then be recalculated using the **Compute Hand-Eye Calibration** button.

6.4.3.3 Checklist for successful Hand-Eye Calibration

- √ Clearly visible and not overexposed calibration plate
- √ Correct camera calibration
- √ Correct calibration plate
- √ Correct robot pose convention
- √ Recorded poses are very differently oriented
- √ **Pose Error** smaller than **0,01**
- √ **Pose Status** of each picture is rated as **good**

7 Troubleshooting

LumiScan Hand-Eye Calibration

Problem	Source	Solution
After the capture **Pose Status** displays the message: Can not be interpreted 	The position read out by the PLC appears to be incorrect.	• Make sure that you are using SPS for Pose Mode and that the Hand-Eye is successfully connected to the PLC. • If you see the following message on the Profinet tab, the connection has not been established.  • Make sure you are using the correct cifx card name: (Usually it is cifx0;0 if you have only one Hilscher Card). 
After the capture **Pose Status** displays the message: Bad pose quality.	The program cannot recognize the patterns well. This can lead to poor calibration.	• Delete the image • Change the orientation of the calibration plate. • Capture new image.

LumiScan Hand-Eye Calibration

Problem	Source	Solution
No image added after capturing.	Calibration pattern was not found.	• Check the image to see if it is over-exposed or underexposed. (too dark or too light). • Make sure the camera can see the pattern dots in the plate. • Change the orientation of the calibration plate.
The calibration result is very poor. i.e. T:Max > 0.02 (depending on the application 	• Too many or too few calibration images captured. • The calibration plate is too far away from the camera. • The viewing angle of the calibration images differs too little.	• Suggestion is to have 6-15 pictures. • Check that the captured images match the orientation suggestion of the calibration plate in the Hand-Eye manual (see Setup).

Alle LumiScan Produkte

Problem	Source	Solution
Timeout Notification + Only a black image is displayed during capture, although the connected sensor is recognized and appears in the drop-down menu.	Firewall is not correctly configured	Check the network configuration of the LumiScan^X camera to ensure that the devices are not blocked by the firewall (refer to the **Virus Protection** and **Windows Firewall** sections of the LumiScan^X manual).

LumiScan VGR

Problem	Source	Solution
No point cloud matching can be performed.	• Halcon license is not installed. • The Halcon installation is not part of the path environment variable.	• Install valid Halcon license. • Check in the power shell that the path variable contains the absolute path to the Halcon-bin directory.
No images acquired from the LumiScan^{X} Sensor system.		Check LumiScan^{X} documentation.
After GripBestResult VGR Program doesn't react anymore.	Check steps and the table below	• To collect the data for further analysis, follow the instruction from below **If LumiScan VGR Program hangs.** • For simple check-up on site, follow the steps 1 to 6 in the Table VGR-Problem

If LumiScan VGR Program hangs:

1. Check if you understand the communication handshake process correctly (see Table 5).
2. Verify if livebit is still running and PROFINET is connected.
   a. Activate admin mode without manual mode.
   b. Check if **IN_HeartBeat** and **OUT_HeartBeat** are blinking red and green
3. Activate Admin Mode
4. Take Screenshot of PROFINET
5. Note down the time, date und export log.
6. If possible, save the current PLC variable status.
7. Check, if function is called or finished in the log file (LumiScanVGR.log):
   a. Check, if the function execution is finished/Search in the log (LumiScanVGR.log)/Search string: **PLC - Procedure** „`FunctionName`" **finished**, to ensure called function is finished.
   b. Check, if the function execution is called by PLC/or search **PLC - Procedure** „`FunctionName`" **called**, to ensure function is really called by PLC.

Possible `FunctionName:`

- `TriggerCamera`
- `ComputeObjects`
- `GetBestResult`
- `GripBestResult`
- `SetParameter`
- `GetParameter`
- `Setup`

VGR-Problem: After GripBestResult VGR Program doesn't react anymore

Nr.	Source	LumiScan VGR Programm	PLC
1	Profinet lost the connection: Verify, if livebit is still running.	• Activate Admin Mode without Manual Mode • Verify, if **IN_HeartBeat** and **OUT_HeartBeat** are blinking red and green	
2	Program is waiting for trigger camera signal.	• Verify, if **IN_HeartBeat** and **OUT_HeartBeat** are blinking red and green • Check whether **IN_TriggerCameraRequest** in VGR Program Profinet Tab is set to **True** (Green) If not, it means VGR Program didn't receive Trigger signal.	Ask your PLC programmer to check whether PLC really set the parameter **IN_TriggerCameraRequest** to **True**.

VGR-Problem: After GripBestResult VGR Program doesn't react anymore

Nr.	Source	LumiScan VGR Programm	PLC
3	Handshake process problem while triggering camera	• Verify, if **IN_HeartBeat** and **OUT_HeartBeat** are blinking red and green. • Verify, if **IN_TriggerCameraRequest** is set to **True**. • Verify, if **OUT_TriggerCameraReady** is set to **False** and • **OUT_TriggerCameraRunning** is set to **True**. • One PLC sees, that **OUT_TirggerCameraRunning** ist **True**, PLC should set **IN_TriggerCameraRequest** to **False**. • Confirm, that PLC really set **IN_TriggerCameraRequest** to **False**. • Inform HD Vision Systems at which step PLC or VGR Program hangs.	
4	PLC considers program as not ready to start.	• Verify, if **IN_HeartBeat** and **OUT_HeartBeat** are blinking red and green • Verify, if **OUT_TriggerCameraReady** is set to **True**.	

VGR-Problem: After GripBestResult VGR Program doesn't react anymore

Nr.	Source	LumiScan VGR Programm	PLC
5	PLC considers the last step in program as not finished.	• Verify, if these parameters are set to **True**: **OUT_SetParameterReady** **OUT_TriggerCameraReady** **OUT_ComputeObjectReady**	
6	PLC considers itself as not ready, therefore it didn't send signal.	**OUT_GetBestResultReady** **OUT_GripBestResultReady** **OUT_GetParameterReady** • Verify, if these paramaters are set to **False**: **OUT_SetParameterRunning** **OUT_TriggerCameraRunning** **OUT_ComputeObjectRunning** **OUT_GetBestResultRunning** **OUT_GripBestResultRunning** **OUT_GetParameterRunning** • Please check the return code **OUT_ReturnCode**, it should be **0** or **10** (siehe Tabelle 6).	If VGR Program prerequest is met: • Check whether your PLC program has some unmet condition to set **IN_TriggerCameraRequest**. • Check whether **IN_TriggerCameraRequest** in VGR Program Profinet Tab is set to **True** (Green). **NOTE**: If PLC sets **IN_TriggerCameraRequest** to **True**, but in the profinet Tab stilll shows IN_TriggerCameraRequest as **False**, please inform HD Vision System that VGR Program has internal error due to execution concurrency.

VGR-Problem: After GripBestResult VGR Program doesn't react anymore

Nr.	Source	LumiScan VGR Programm	PLC
7	Unknown error	Check the steps 1 to 6 and provide HD Vision Systems the following information: • Version of VGR (**ctrl + shift + v** will display the program version). • Whether PLC still has connection with VGR program (See step 1). • Whether PLC is waiting for some signals. • Whether PLC has sent/ set **request** signal already. • Whether PLC has some internal check or process status check, which is not relevant to VGR Program (e.g. Robot Error or Cylinder Error).	

If you have any problems or questions about the product, please contact HD Vision Systems Customer Support at: +49 6221 6721905, or by e-mail: customer.success@hdvisionsystems.com

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9 General Disclaimer

1. The manufacturer is not liable for damage to life, body or health or damage to property resulting from improper use. Please note that operating and/or connection errors are beyond our control. We cannot accept any liability for damage resulting from this.

2. Any damage caused by unauthorized debugging activities to inspect, analyze or manipulate the software provided by HD Vision Systems is the sole responsibility of the user. Any attempt to use a debugger is strictly prohibited and may result in irreversible consequences such as loss of data, interruption of service, and even legal action. The manufacturers, developers and distributors of the software are not liable for any damage or loss resulting from the user's failure to comply with this warning.

3. Claims for damages on the part of the purchaser arising from culpa in contrahendo, breach of secondary contractual obligations and tort are excluded, unless they are based on intent or gross negligence on the part of HD Vision Systems GmbH itself or one of our vicarious agents.

4. Recourse claims in the sense of §12 of the Product Liability Act (Produkthaftungsgesetz) are excluded, unless the party entitled to recourse proves that the defect was caused by HD Vision Systems GmbH and was due to at least gross negligence.

5. If any provision of this Agreement is or becomes invalid or unenforceable, the validity of the remaining provisions shall not be affected. The invalid or unenforcea-

ble provision shall be replaced by a valid and enforceable provision whose effects come as close as possible to the economic purpose pursued by the parties with the invalid or unenforceable provision. The foregoing provisions shall apply mutatis mutandis in the event that the contract proves to be incomplete. German courts shall have exclusive jurisdiction over all disputes arising in connection with this disclaimer.

For more information about the warranty, please contact the manufacturer of the product.

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