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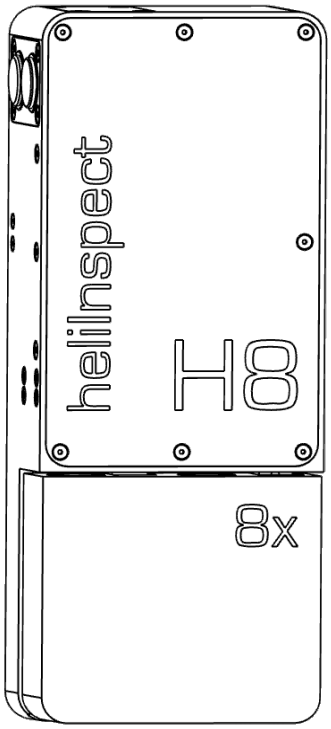
advancing 3D metrology

Operating instructions

heliInspect™ H8



Operating instructions

heliInspect™ H8

Original operating instructions | All non-German editions of this document are translations of the original operating instructions.

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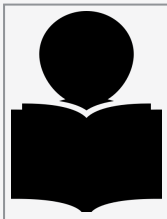
Manufacturer:

Heliotis AG
Längenbold 5
6037 Root
Switzerland
T: +41-41-455-6700
E: support@heliotis.ch
I: www.heliotis.com

CONTENTS

ABOUT THE INSTRUCTIONS

These instructions are intended as an aid to fast and simple mounting of the heliInspect™ H8, putting it into operation and achieving the first measurement results. They include important information on intended use, safety, operation, maintenance and disposal.



Please read these instructions carefully and keep them in a safe place. Pass these instructions on with the product in the event of a resale.

Heliotis AG assumes no liability for damage or failures resulting from non-compliance with these operating instructions, modifications or the use of unauthorised components.

Supplementary documents

You can download the following supplementary and other applicable documents on the Internet at www. heliotis.com (registration required):

- Device-specific datasheets
- Programmer's Guide heliInspect™ H8:

Contents	• Description of the product • System concept • Installation • Operation • Parameterisation • Diagnostics
Target group	• Instructed persons • Application developer • Specialist personnel

- Programmer's Reference heliInspect™ H8

Definitions

Symbols and terms used

►	Start of an instruction
1, 2, 3 …	Steps within an instruction
⇒	Result of an action
»	Link to another part of these operating instructions, to a different document or a website
[BOLD]	Indication of keys and buttons
"..."	Indication of a display text
>	References to subordinate entries in the menu structure heliViewer™

Abbreviations

General abbreviations

Fig.	Figure
or	or
engl.	English
incl.	including
s.a.	see also
e.g.	for example

Specific abbreviations

3D	Three dimensional
API	Application Programming Interface
ARM	Average Range Method
AV	Appraiser-Variation
CMOS	Complementary Metal Oxide Semiconductor
EMVA	European Machine Vision Association
EV	Equipment Variation
FOV	Field of View
GenICam	Generic Interface for Cameras
GND	Ground

LED	Light-Emitting Diode
MCS	Machine Coordinate System
OCS	Object Coordinate System
RCS	Reference Coordinate System
ROI	Region of Interest
RR	Repeatability & Reproducibility
SDK	Software Development Kit
SLED	Superluminescent Diode
SNR	Signal-to-Noise-Ratio
WLI	White-light interferometry

Formula symbols

c_g	Capability index
c_{gk}	Capability index
s_g	Standard deviation
T	Tolerance
x_r	Calibration value

Terminology

Term	Meaning in this document
3D-heliCam	heliInspect™ H8
Camera	heliInspect™ H8

ABOUT YOUR SAFETY

Intended use

The heliInspect™ H8 is intended for layer thickness and surface measurement as a “single workplace” device or as part of a test system. It is suitable for use in quality assurance in production lines, in production-related environments and applied research.

Only ever use the heliInspect™ H8 within the specifications indicated in the technical data. Any other use that deviates from the intended use is deemed improper use.

If you modify the device, you are then responsible for ensuring product conformity.

Classification of symbols

Instructions, in particular safety instructions and warnings are highlighted by the following symbols and signal words:

 Danger

Safety instruction: Non-compliance will result **in death or serious injury**.

 Warning

Safety instruction: Non-compliance may result **in death or serious injury** .

 Caution

Safety instruction: Non-compliance may result in **injury**.

 Attention

Safety instruction: Non-compliance may result in **material damage** .

> Tip

Tip: Supplementary information and instructions for operation of the product.

Personnel requirements

The following qualification requirements are differentiated in this documentation:

- **Instructed persons** have been instructed by the owner/user in the tasks assigned to them and the hazards that may arise from incorrect behaviour.
- **Skilled personnel** are persons who, based on their technical training, knowledge and experience as well as their knowledge of relevant standards, are capable of carrying out the tasks assigned to them and recognising and preventing possible hazards independently.
- **Qualified electricians** are persons who, based on their technical training, knowledge and experience as well as their knowledge of relevant standards, are capable of carrying out work on electrical systems and recognising and preventing possible hazards. The are competent with regard to local occupational safety and accident prevention regulations.

The following qualification requirements apply with regard to the installation and operating activities:

Activity	Qualification
Installation, maintenance	Mechanical: • Practical basic technical training • Knowledge of current industrial safety regulations Electrical: • Practical basic technical training • Competent pursuant to EMC and Low Voltage Directive
Commissioning, configuration	• Basic knowledge of Windows™ - Operating system • Basic knowledge of the design and setting up of the connections and interfaces described • Basic knowledge of data transmission • Knowledge of the programming of image processing systems and network components
Operation in the respective application area	Knowledge of the software and hardware environment of the respective application area

Tab 1: Qualification requirements

PRODUCT DESCRIPTION

Scope of delivery

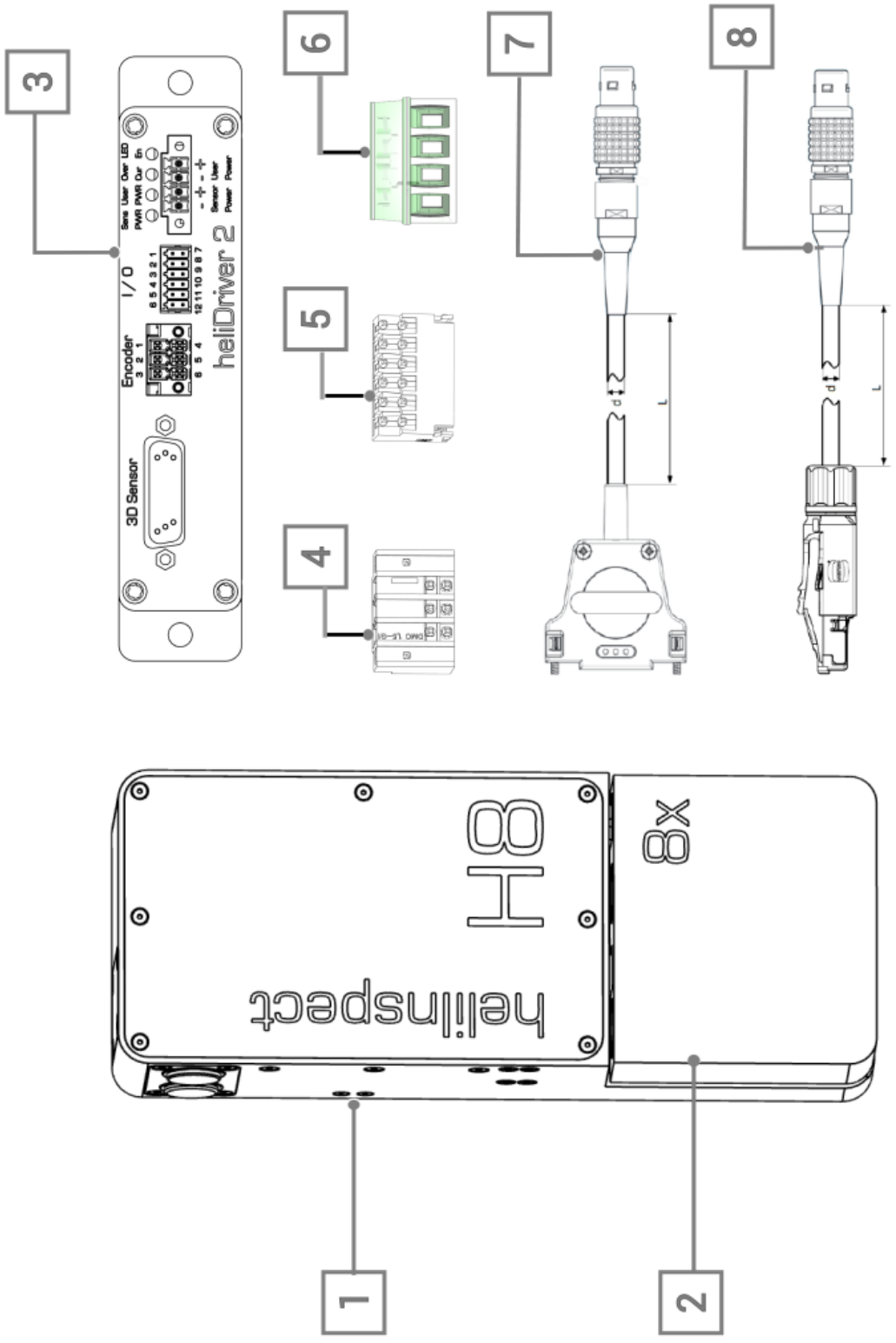


Figure 1: Standard scope of delivery (» "Modules" on page 14)

No.	Name	Quantity
1	HeliInspect H8™ 3D measurement head H8.0-Sxx-Lxx-Mxx-Ex	1
2	heliOptics™ WLI8 White Light Interferometer Module	1
3	heliDriver™ D2.1-A1	1
4	Encoder connector DMC 1.5/ 3-G1F-3.5	1
5	I/O connector DMC 0.5/ 6-G1-2.54	1
6	DC Power connector MC 1.5/ 4-ST-3.5	1
7	Connection cable HI-GE8-Lx.x-CF	1
8	Connection cable HI-CC8-Lx.x-CF	1
9	Operating instructions heliInspect™ H8 (not shown)	1
10	AC/DC power supply (optional; not shown)	1

Tab 2: Standard scope of delivery (» "Modules" on page 14)

Identifying the product

You can identify the product heliInspect™ H8 unambiguously with the aid of the QR code label on the side of the housing body (» Fig. 2).

Data:

- Product designation
- Type number (TN)
- Serial number (SN)
- Media Access Control Address (MAC)

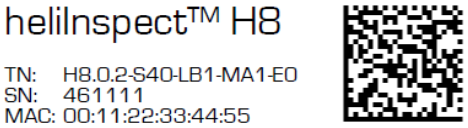


Figure 2: Example of a heliInspect™ H8 QR code label

Product features

The heliInspect™ H8 uses white-light interferometry (» "Functional principle" on page 16) to measure layer thicknesses and surfaces.

Key features

- sturdy industrial WLI™
- non-contact and non-destructive measurement
- 3D-pixel sensor
- measurements of extremely uneven reflective surfaces
- short latency times
- GenICam interface

Software

- intuitive configuration and visualisation software heliViewer™/ heliCommander™
- measurement analysis of surface parameters with industry-leading programs (ImageJ/MountainsMap® Imaging Topography)
- heliSDK™ with interface libraries for Halcon, C++/C, LabVIEW, Python

Modules

The heliInspect™ H8 is modular in design. Figures 3, 4 and table 3 on the next page systemise the configuration options.

Product goup					
H8.0					3D measurement head
	Sensor				
	S40				3D pixel sensor (no microlenses)
		Illumination			
		L	R1		LED red (625nm)
			B1		LED blue (475nm)
			Encoder		
			M	A1	Standard encoder
				A2	Ultra encoder
				Cable outlet	
				E	0 Top
					1 Side
Example:					
H8.0-	S40-	LR1-	MA1-	E0	heliInspect ™, 3D pixel sensor SH4 ™, LED red, Standard encoder, Connection cable on the top of the device

Figure 3: Module key heliInspect™ H8

Product goup					
WLI8.0					heliOptics™ WLI8 module
	Magnification				
	x2				
	x4				
	x8				
		Mirau-objective			
		MR	0		Leica
			1		Nikon or Olympus
			Illumination		
			C	R	LED red (625nm)
				B	LED blue (475nm)
				Glas compensation	
				G	0 no glass
					TBD customer-specific

Figure 4: Module key heliOptics™ WLI8

heliOptics™ WLI8	2x	4x	8x	10x
Field of view [mm²]	6.50x6.10	3.30x3.10	1.60x1.50	1.30x1.20
Working distance[1] [mm]	43.00	42.90	12.80	
Nikon Mirau				7.40
Nikon Mirau				3.60
Resolution[2] (lateral) [µm]	12.00	6.00	3.00	2.40
Numerical aperture	0.10	0.15	0.25	0.30

heliOptics™ WLI8	20x	50x	100x
Field of view [mm²]	0.65x0.61	0.26x0.25	0.13x0.12
Working distance[mm]			
Nikon Mirau	4.70	3.40	2.00
Nikon Mirau	3.60	2.50	n.a.
Resolution (lateral) [µm]	1.20	0.48	0.24
Numerical aperture	0.40	0.50	0.70

Tab 3: Configuration options heliInspect™ H8

[1]Distance between the sample and the nearest face of the optical system.

[2]Value represented by the pixel raster distance. 100x: Optical resolution is diffraction-limited higher.

Functional principle

White-light interferometry (WLI) is a non-contact optical measurement method. It uses the interference capacity of electromagnetic waves. (Depending on the experiment, light shows wave or particle properties.) In order for interference effects to occur, the waves must have a spatially and temporally fixed phase relationship. They must be coherent.

The measuring arrangement consists of:

- Illumination unit
- Beam splitter
- Objective
- Actuator and
- Image sensor.

For illumination the WLI uses light sources with short coherence lengths. The temporal dimension of wave packets emitted by such light sources is in the femtosecond range. A coherence time in the femtosecond range corresponds to a coherence length in the micrometer range. It enables accurate topographic measurements.

The emitted light is first split (beam splitter). One part strikes a mirror in the reference arm, where it is reflected back (reference beam). The other part is focussed on the object point of the sample, whose position is to be determined (measurement beam). The measurement beam is also reflected back. The two beams only interfere with each other if the path length between the beam splitter and the reference mirror is virtually identical with the path length between the beam splitter and the surface of the sample. There is no time difference if the path lengths are the same. The interference contrast is at its maximum.

An actuator varies the optical path difference, whereby interference images are captured periodically. A three-dimensional grey value distribution in the form of an image stack is created in this way. The intensity variation can be seen for each pixel (» Correlogram[1]). The exact z-position of a surface point can be determined using the envelope maximum of the correlogram. (» Fig. 5). the resolution of the z-direction is independent of the magnifying factor of the objective used.

[1]Intensity distribution of a white light interferogram in dependence on the difference of the path length between object and reference beam.

Signal quality

Precision, as a component of the accuracy of the measurement method, depends largely on the signal-to-noise ratio (SNR) of the correlogram. It describes the ratio of the useful signal to the noise signal and is influenced by every component in the arrangement described above. If the amplitude of the correlogram is very small, the signal does not emerge sufficiently from the noise. The higher the signal-to-noise ratio, the better the image quality.

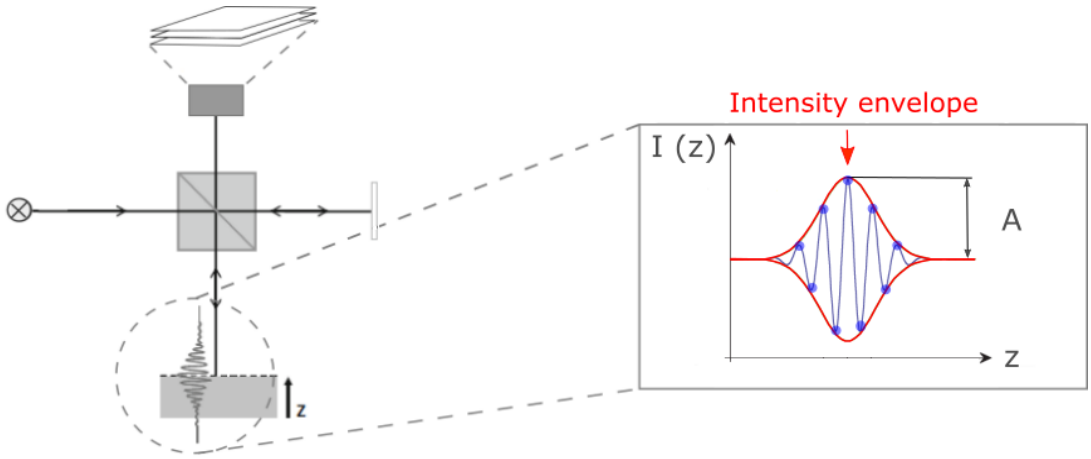


Figure 5: Functional principle

READY!

Unpacking

1. Adjust the temperature to the surroundings
2. Open the carton packaging
3. Remove the top foam padding
4. Check the device and cable for any damage

Never use the heliInspect™ H8 if the cable or plug is damaged. Contact support (» Distributors).

Keep the packaging away from children. Risk of suffocation.

Keep the packaging and these operating instruction for future transport and service purposes.

Selecting the place of installation

The requirements for measuring rooms stipulated in the Guideline VDI 2627-1, - 2 for measuring rooms shall apply for the selection of a suitable place of installation. The requirements derive from the measurement tasks, measurement parameters and their tolerances as well as the features of the measuring equipment. Determining characteristics include temporal temperature profiles, temperature gradients, fluctuations in relative air humidity and base point acceleration as a key parameter for vibrations.

Further requirements:

- no risk of explosion
- normal convection
- maximum 65 % humidity, non-condensing
- thermally conductive, flat installation surface, free of any contamination
- do not bend power and signal cables and ensure they do not come into contact with any sharp edges

The heliInspect™ H8 is not protected against corrosive, infectious, radioactive or other substances hazardous to health. Please ensure that all legal requirements are fulfilled, in particular national accident preventions regulations.

Installing the product

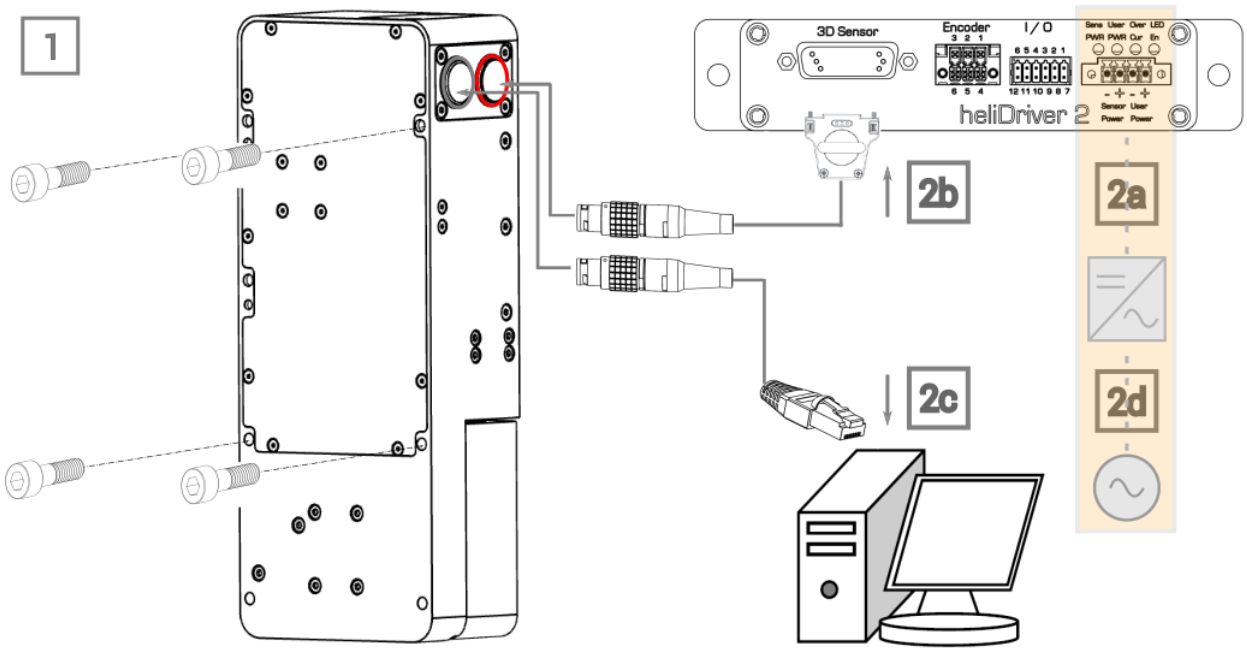


Figure 6: Installation steps

► Installation steps:

1. Mechanical:
   a. Determine the installation substructure
   b. Prepare the drill pattern according to the dimensions in Fig.7

      > Pay attention to perpendicularity to the measurement plane. The reference system consists of an elongated hole and a round hole, whereby the elongated hole adjusts position tolerances.

   c. Create the holes with the respective diameters
   d. Mounting the heliInspect™ H8:

      (+) on the back of the housing body. The screw connections have an M6 inner thread. The maximum screw depth is 8 mm (» Fig. 7 (a))

      or

      (+) on the side of the housing body. The screw connections have an M6 inner thread. The maximum screw depth is 8 mm (» Fig. 7 (b))

Take care that the whole surface of the housing body is level with the substructure.

e. Fix the heliOptics™ WLI8 on the two magnet points on the inside of the housing body for the measurement head (» Fig. 8).

Risk of crushing due to high magnetic attraction. Hold the module with both hands while carefully sliding it in.

Do not touch optical surfaces with your fingertips.

⇒ the V-grooves and balls grip into each other for a force-fitted coupling

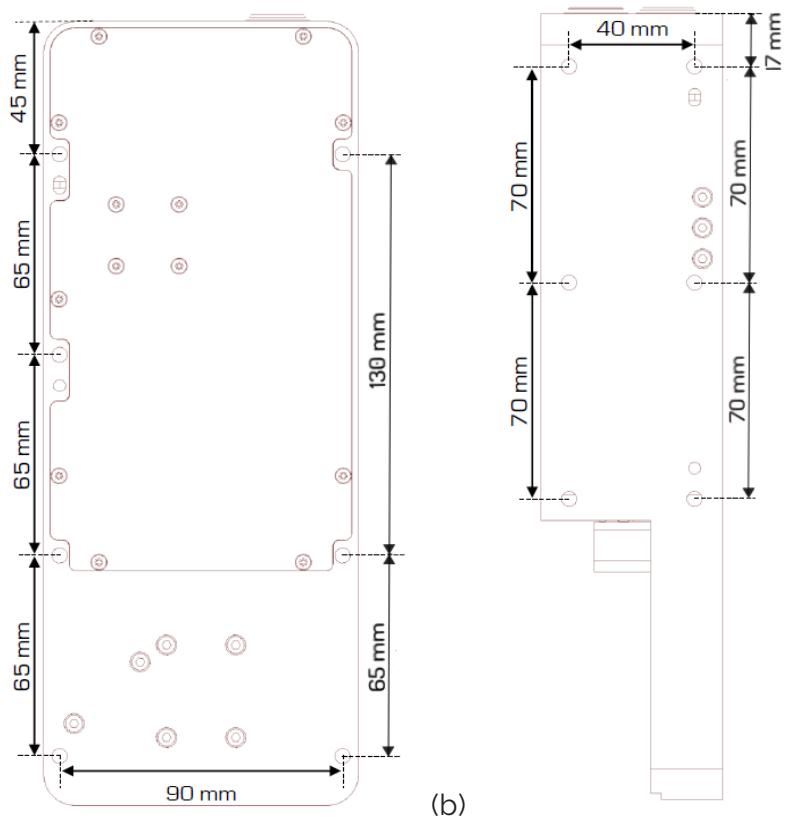


Figure 7: Dimensions of the heliInspect™ H8 housing body

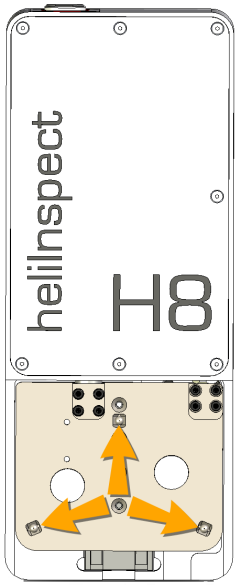


Figure 8: Position of the V-grooves on the housing body of the heliInspect™ H8

2. Electrical:

> Only carry out wiring work if the device is disconnected from the power supply. Only allow qualified electricians to carry out electrical work!
> (» "Personnel requirements" on page 8)

> Damage to the device caused by incorrect supply voltage! Do not switch on the voltage supply for the device until the connection work has been completed and the wiring work carefully inspected!

> Pay attention to minimum core cross-section and bending radii of the cable.

   a. Ensure the 24 V DC voltage supply (» Fig. 9)
   b. Connect the heliInspect™ H8 to the 3D sensor port on the heliDriver™ D2 (use the Connecting cable HI-CC8-Lx.x-CF for this)
   c. Connect heliInspect™ H8 to the Ethernet network port of the host computer (use the Connecting cable HI-GE8-Lx.x-CF for this)
   d. Connect the power supply with primary voltage supply

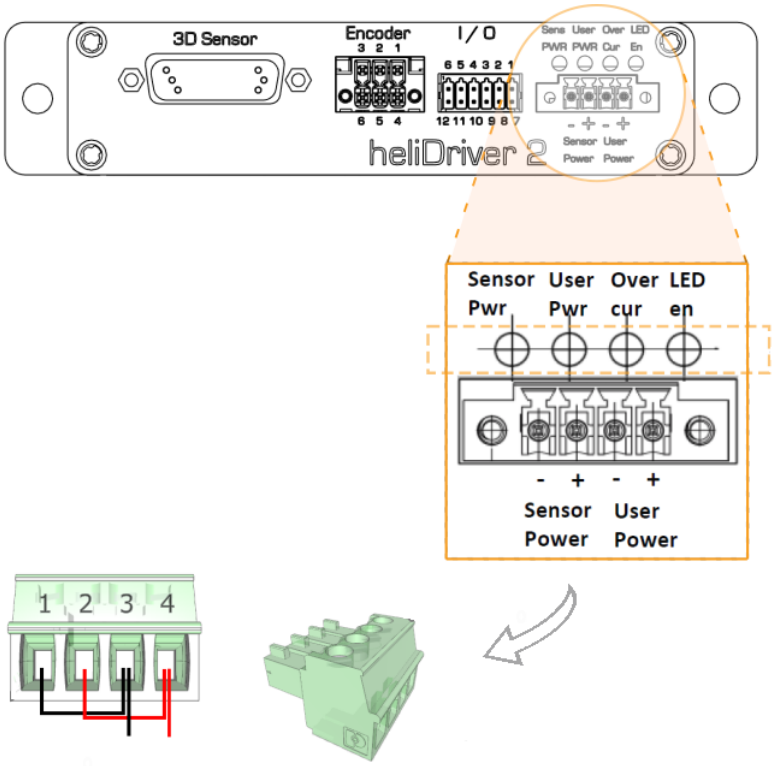


Figure 9: Recommended wiring

Pin	Terminal designation	Details
1	GND	
2	Supply voltage heliInspect™ H8	24V, Miniature fuse 7A
3	USER GND	
4	Supply voltage heliDriver™ D2, heliInspect™ H8 I/O electrical interface signals	24V, Miniature fuse 7A

Tab 4: Terminal assignment

STEADY!

Installing the software

System requirements

► Check whether you computer complies with the recommended requirements:

	Minimum requirement	Recommended
Operating system	Windows 7 (64 bit)	> Windows 7 (64 bit)
Processor:	Intel i3 2.0 GHz	> Intel i5 2.70 GHz
RAM	4 GB	> 8 GB
Screen resolution	1024 x 768 pixels	1920 x 1200 pixels
Interfaces	1x Gbit Ethernet	2x Gbit Ethernet

Tab 5: System requirements

> The following procedure describes the installation steps for a PC with an installed Windows 10 Pro operating system.

► Installation procedure

1. Make sure you have administrator rights
2. Deactivate the anti-virus software
3. Navigate to the website https://www.heliotis.com/support/login
4. Register a user account (» Fig. "Registering an account " on the facing page)
5. Download "C4Utility_#.#.#.exe", „Update Package #.#.#.upkg" und „heliViewer H8 – #.#.#.# (64bit).zip"

> The placeholder "#" represents the version label of the application.

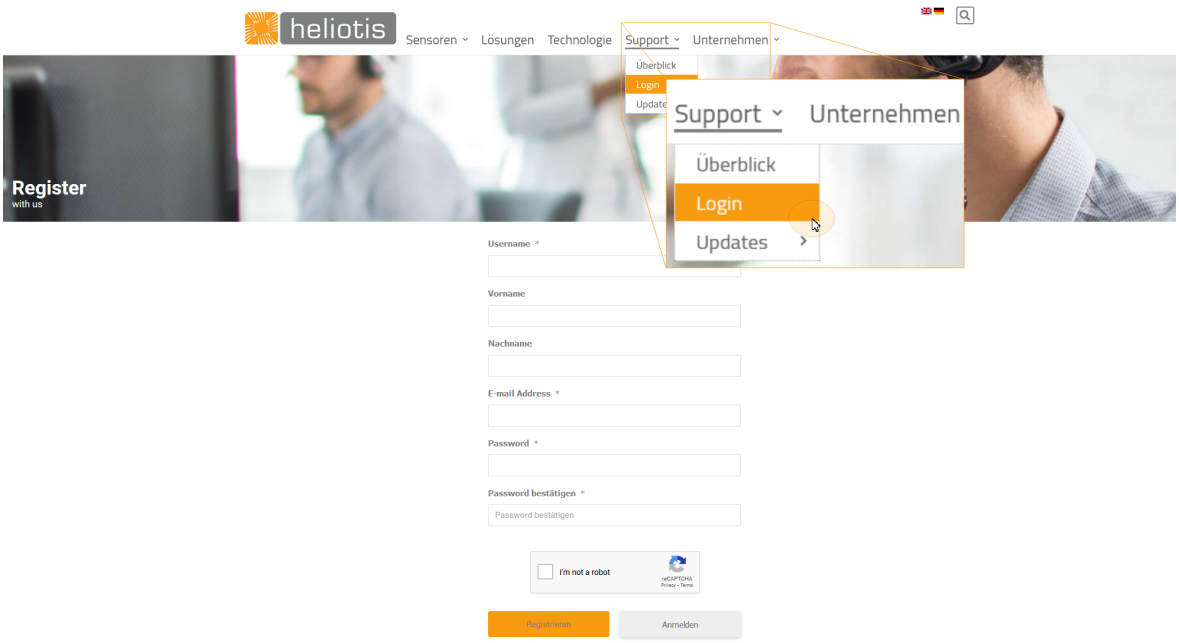
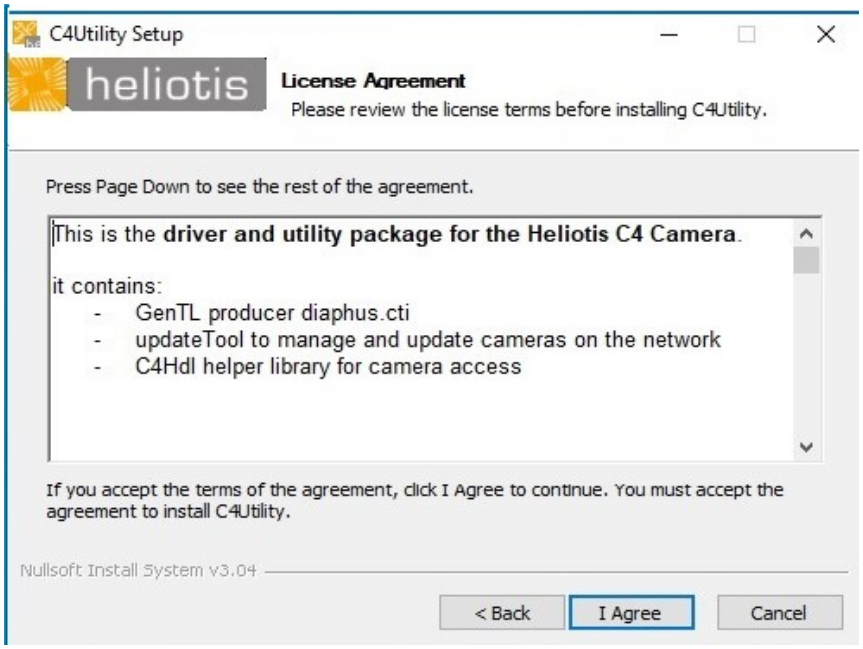


Figure 10: Registering an account

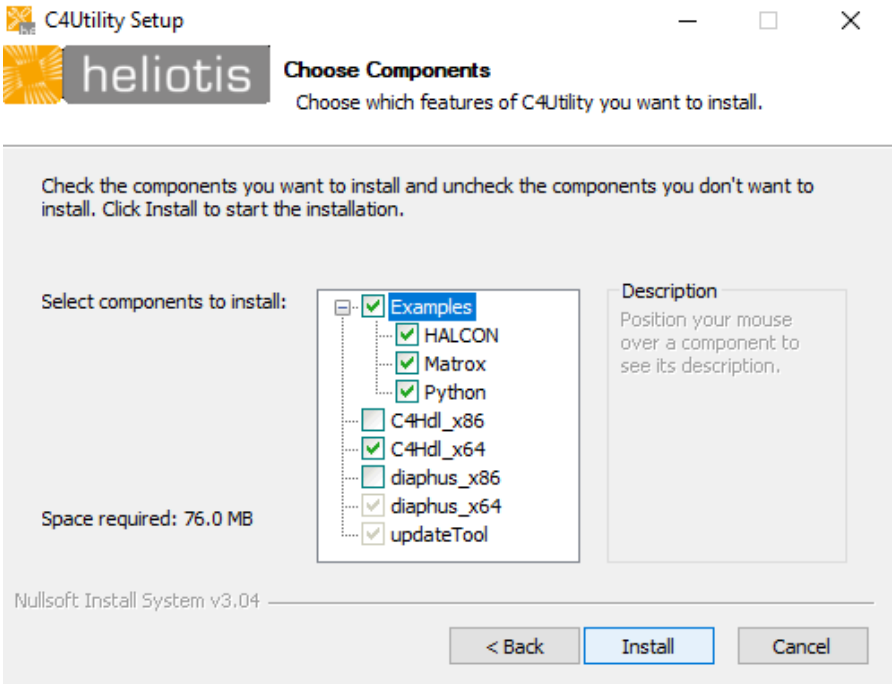
> Install C4Utility before the heliViewer™. The application provides the drivers for communication with the heliInspect™ H8 and the interface libraries.

Installing C4Utility and the Update Package

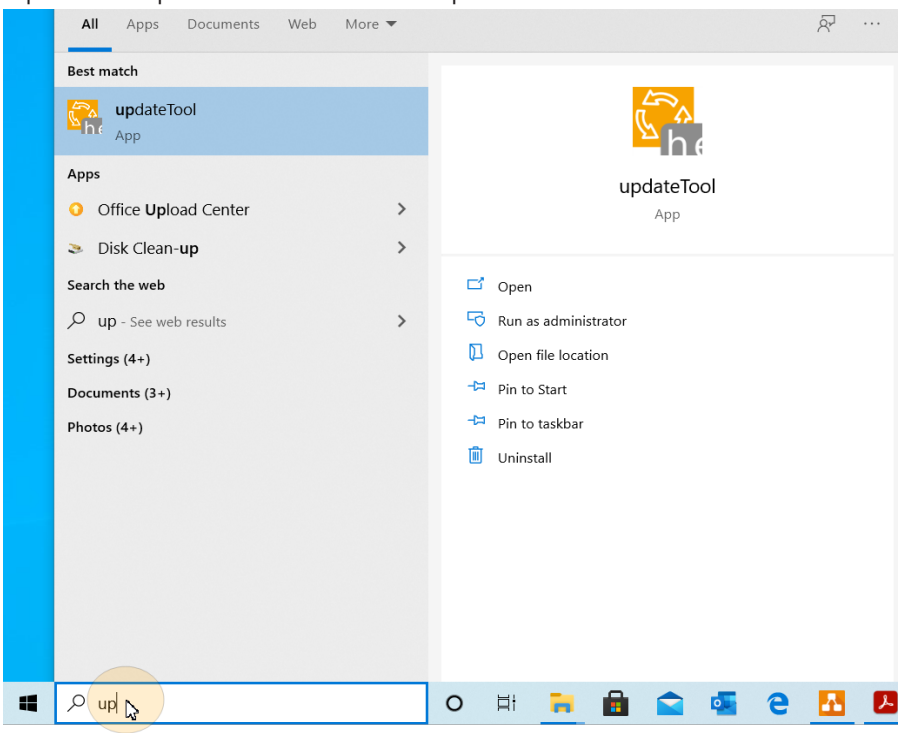
1. Run "C4Utility_#.#.#".exe
2. Read and accept the license agreement



3. Follow the instructions of the installation wizard (select "components_x86" for 32bit operating systems)

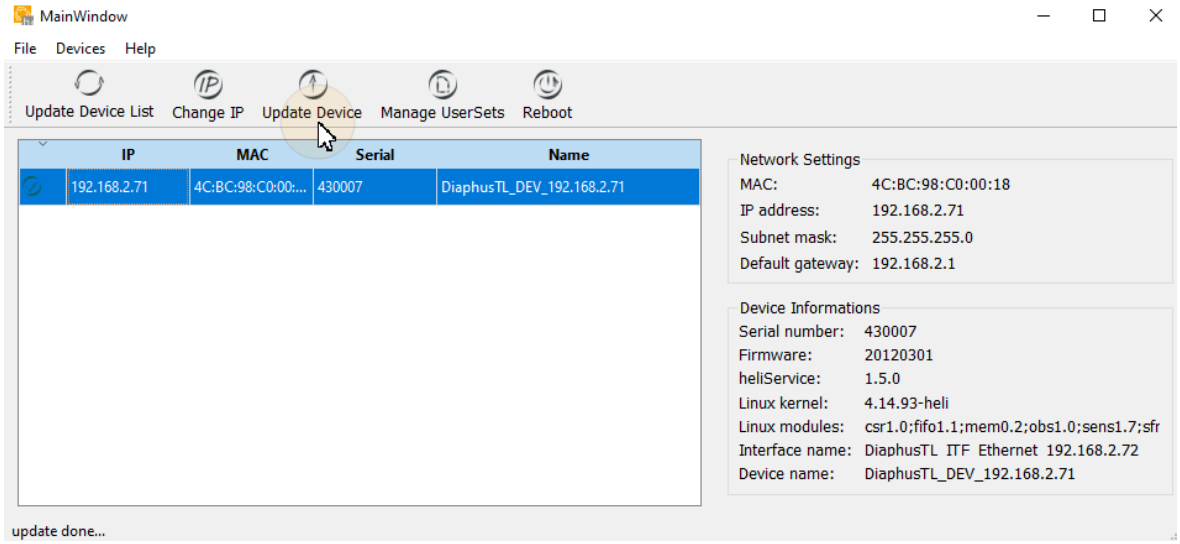


4. Open the update tool (Start –> Update Tool)

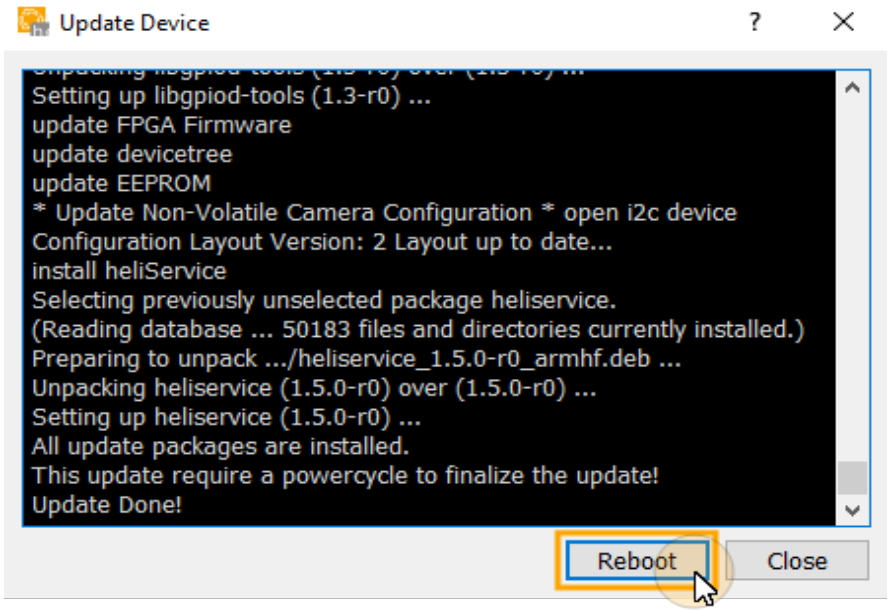


> This requires successfully configured interfaces (» "Configuring the interfaces " on page 31)

5. Wait until the light on the heliInspect™ H8 has gone off
6. Click on “Update Device” in the update tool and select the device



7. Click on “Upload File“ and select the downloaded file “Update Package_ #.#.#. upkg” (this process can take several minutes)

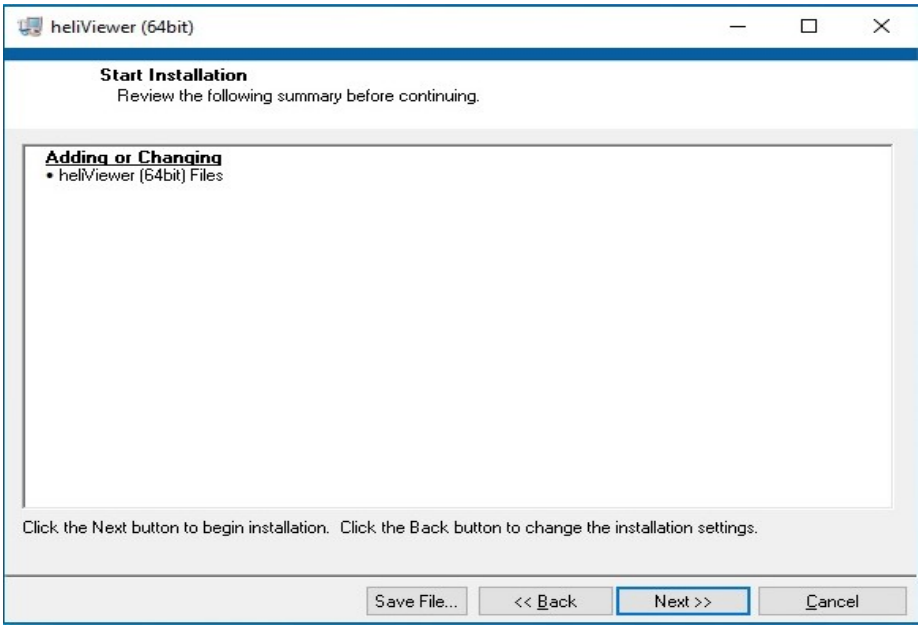


⇒ The message "Upload Done" will be displayed in the console

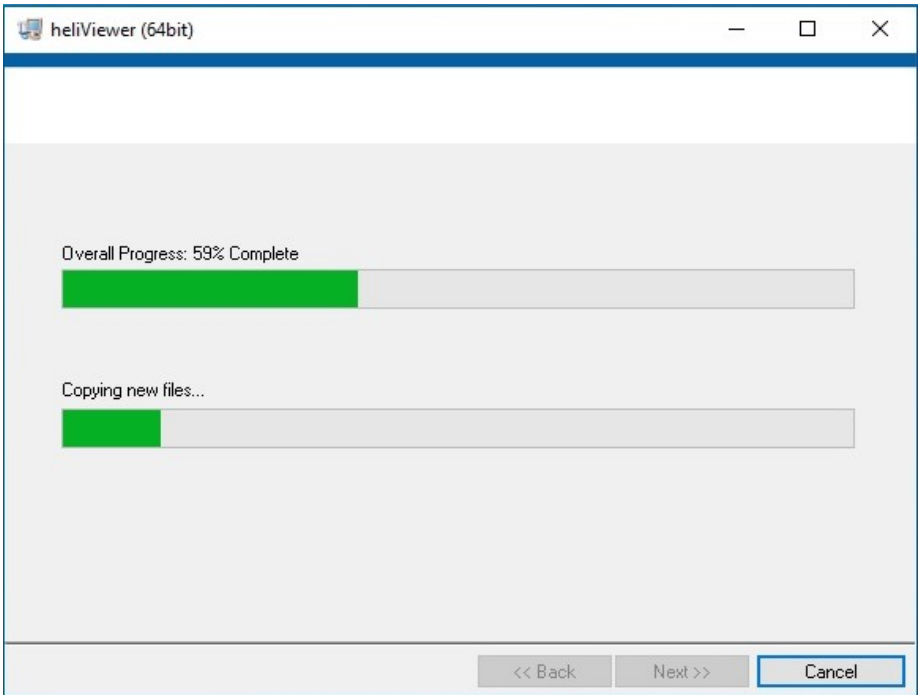
8. Reboot the device

Installing heliViewer™

1. Unzip the files (right click on the file > “Extract all...”)
2. Run the file "setup.exe"



3. Follow the instructions of the installation wizard



⇒ A directory C:\Program Files\Heliotis\heliViewer\ has been created

Configuring the interfaces

Configuring the IP address of the host computer

1. Open Network settings (Start > System control> Network & Internet > Name of the network adapter to which the heliInspect™ H8 is connected)
2. Change adapter options
3. Select network
4. Open TCP/IPv4- properties
5. Set the IP address to 192.168.2.x (with x=1-70 or 72-254)

> The factory setting of the IP address of the heliInspect™ H8 is 192.168.2.71 (subnet mask: 255.255.255.0). Avoid any address conflicts by assigning different IP addresses to the host computer and the heliInspect™ H8 within the same subnetwork.

6. Set the subnet mask to 255.255.255.0

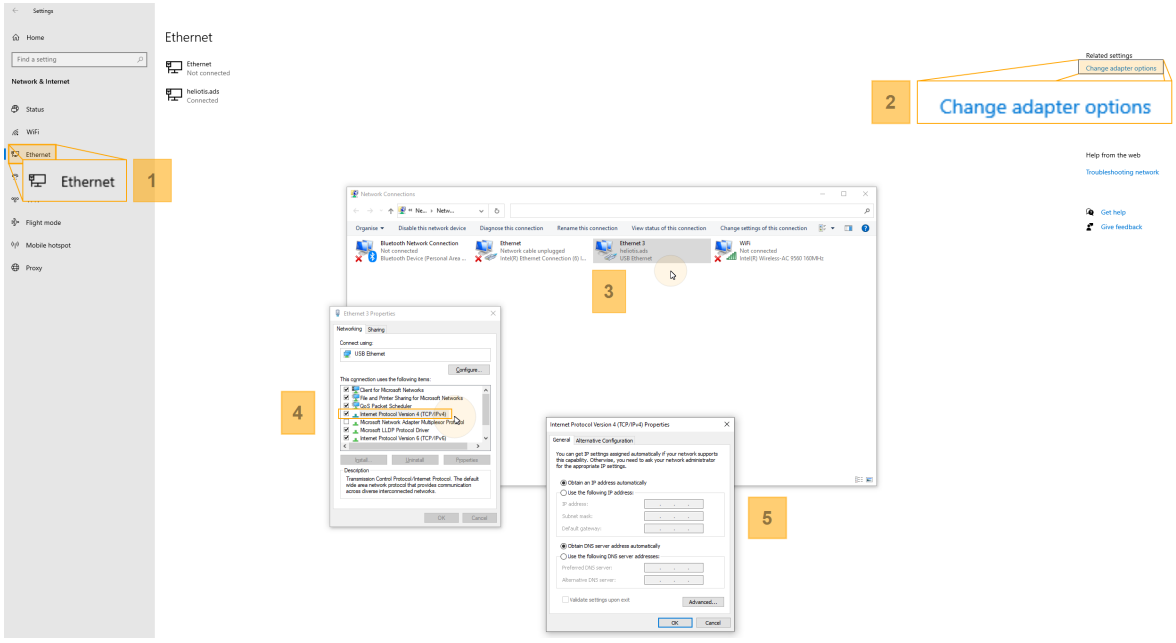


Figure 11: Configuring the IP address

Configuring the Windows Firewall

Possibility 1:

1. Open the Windows firewall (Start > System Control > Windows Firewall)
2. Open the dialog “Allow an app through the Firewall”
3. Open the dialog “Change settings”
4. Add authentication exceptions for C4Utility and heliViewer™

   ⇒ Add exceptions (tick) for public, private and domain networks

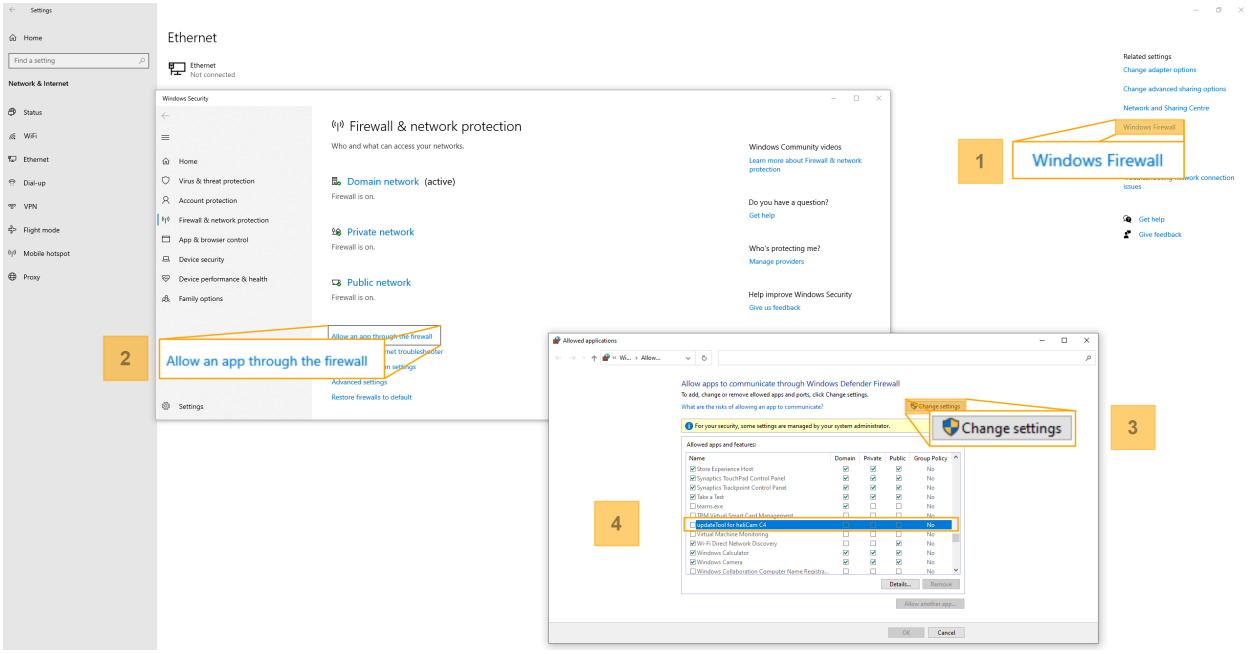


Figure 12: Authentication exceptions for programs

> Add authentication exceptions for all new apps respectively.

Possibility 2:

1. Open the update tool (Start –> Update Tool)

   ⇒ Windows Defender Firewall blocks the application
2. Add authentication exceptions (see above)

Finding heliInspect™ H8 in the network

1. Open the update tool (Start –> Update Tool)

   (Requires successful installation » "Installing C4Utility and the Update Package" on page 27)

2. Update the list of available devices (Update Tool > Update Device List)

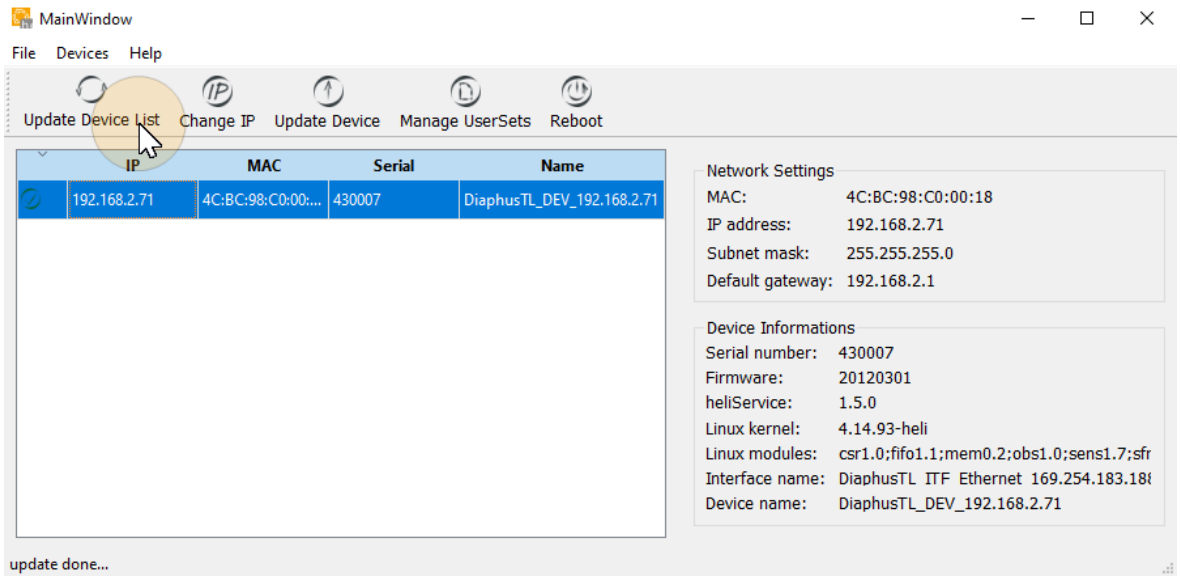
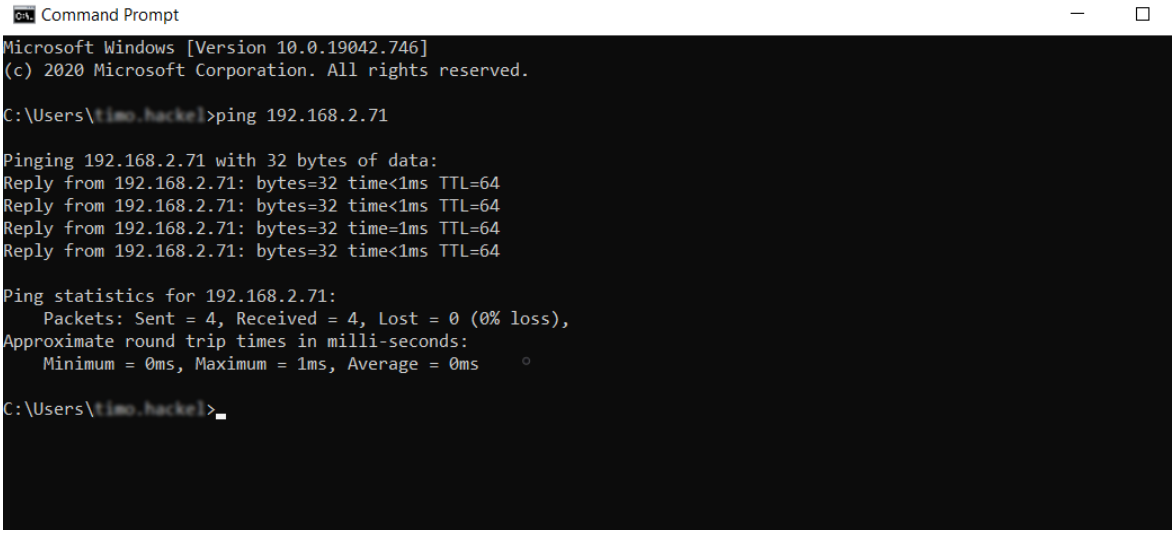


Figure 13: Updating the device list

> The IP address of the heliInspect™ H8 can be read here (see above Configuration requirements).

Checking network parameters

1. Open the Windows command prompt
2. Execute "ping [ID]" (replace [ID] here with the IP address of the heliInspect™ H8).



⇒ Reply of the heliInspect™ H8 in a few milliseconds

GO!

Getting acquainted with the user interface

Areas of the user interface

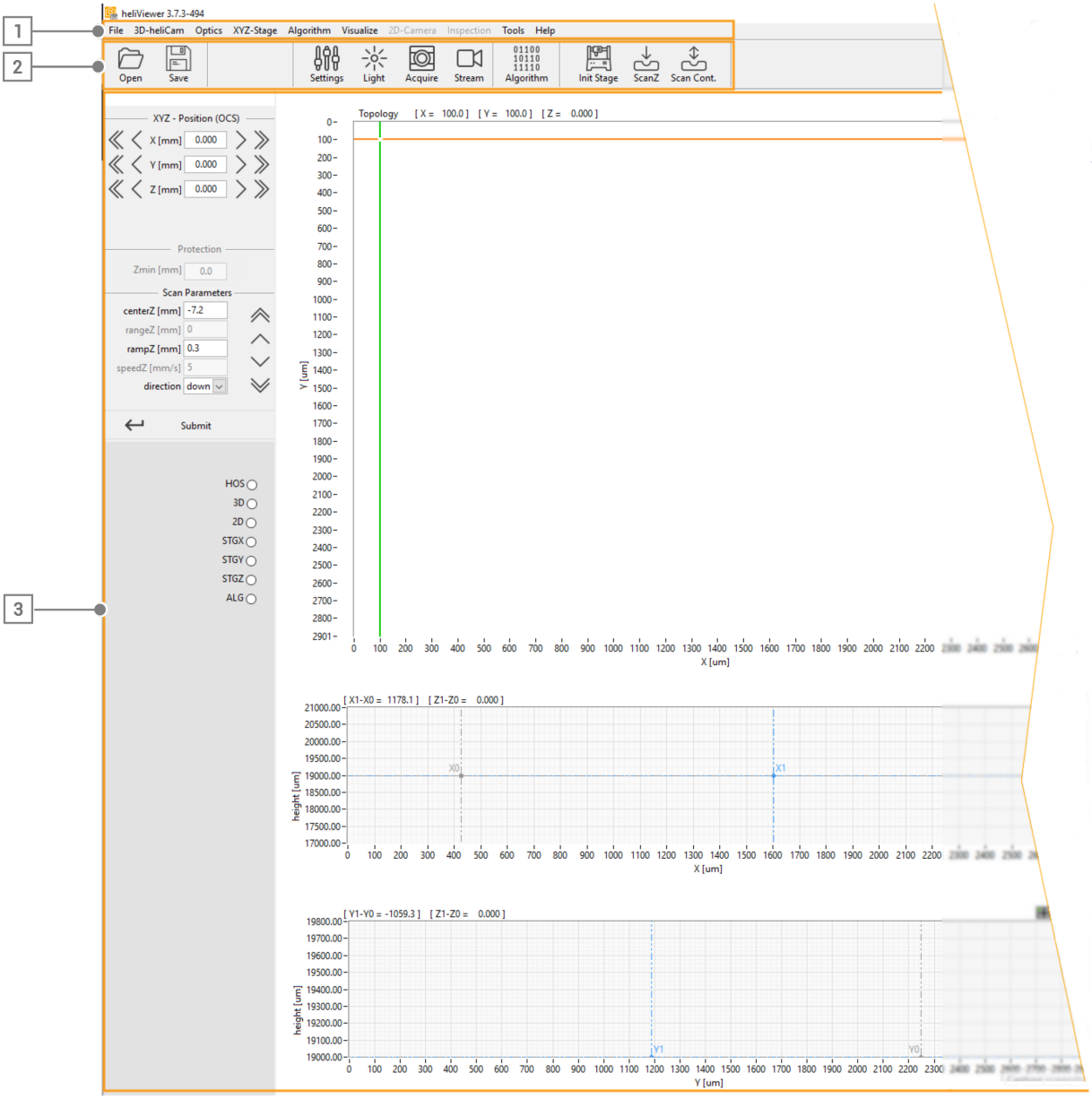


Figure 14: Areas of the user interface

No.	Name
1	Menu bar (» Menu bar) – Area with dropdown menus, in which commands are grouped according to categories. – Categories: File, 3D heliCam, Optics, XYZ-Stage, Algorithm, Visualize, Tools, Help
2	Toolbar (» Toolbar) – Bar with buttons for menu options and commands – Functions: Open, Save, Settings, Light, Acquire, Stream, Algorithm, Init Stage
3	Main area (» Main area) – Area with parameter sets, control windows and data visualisation – Sub-areas: Axes area, scan area, status display, measurement area, view area

Tab 6: Description of the areas of the user interface

Menu bar

All functions implemented in the software can be accessed via the menu bar.

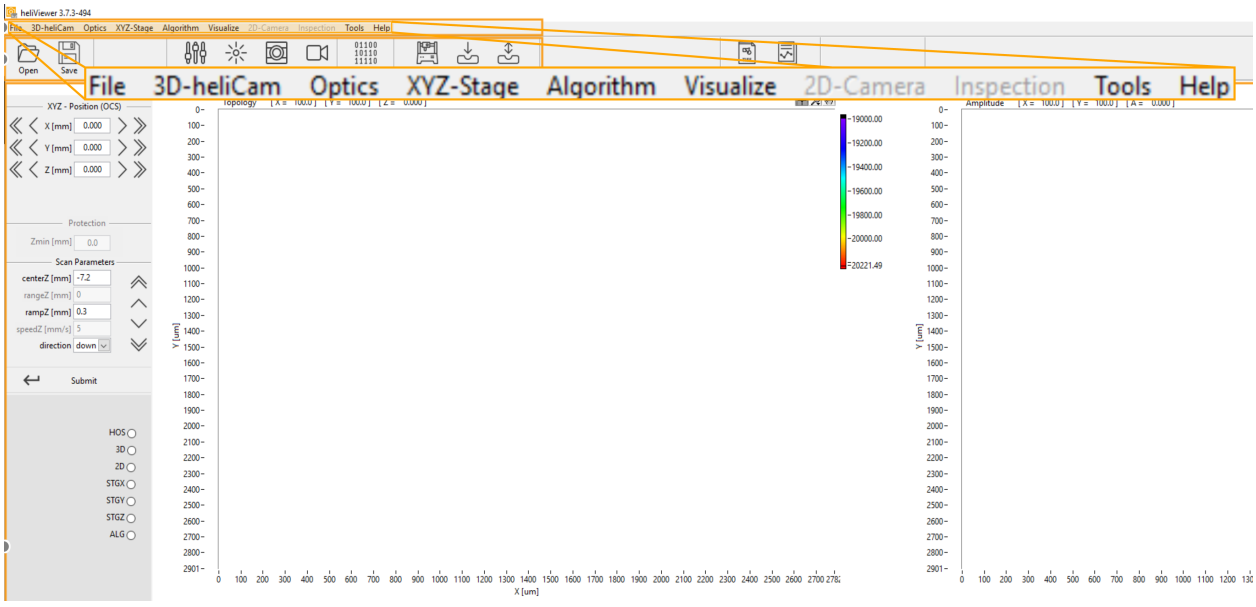


Figure 15: Menu bar

Menu	Submenu	Description
File	Open Measurement	Opens a saved measurement ("*.hdat")
	Save Measurement	Saves the current measurement ("*.hdat")
	Export as Text Image*	Exports the measurement as an ASCI file ("*.txt") Topology: The topology image is saved as "name_Z.txt" and the amplitude image as "name_A.txt" Volumes: Each frame is saved in a separate file. (e.g.: "name_1.txt", "name_2.txt", "name_3.txt")
	Export as TIF*	Exports the measurement as a TIF file ("*.tif") Topology: Topology and amplitude images are exported in the same file Volumes: All frames are exported in the same file
	Export as TIF set*	Exports the measurement as a TIF set ("*.tif") Topology: The topology image is saved as "name_Z.tif" and the amplitude image as "name_A.tif" Volumes: Each frame is saved in a separate file (e.g.: "name_1.tif", "name_2.tif").
	Export as Matlab	Exports the measurement as a Matlab file ("*.mat")
	Export as MountainsMap*	Exports the measurement as a MountainsMap file ("*.sur")
	Export settings as zip	Exports the settings in a zip file ("*.zip")
	Exit	Ends the program. The same as when you click on 'x'.
3D-heliCam	Select Configuration	Select camera configuration
	Manage configuration	Add, delete, edit or select a camera configuration
	Acquire	Data are acquired from the camera (camera must first be initialized)
	Init heliCam	The camera is initialized with the 'ad-hoc' configuration
	Close heliCam	Connection to the camera is ended (acquiring data with heliViewer™ is no longer possible)
Optics	Select Configuration	Selection of an optics configuration

Menu	Submenu	Description
	Manage configuration	Add, delete, edit or select an optics configuration
	set Origin	Sets the current position as the zero point of the coordinates system
	clear Origin	Resets the zero point to the coordinates set in the optics configuration
XYZ Stage	Select Configuration	Select axes configuration
	Manage configuration	Add, delete, edit or select an axes configuration
	Scan	Carries out an axis movement in compliance with the parameters defined in the “Scan range”
	Init Stage	Initializes the axis and carries out axes commands defined in the axes configuration ⚠ Axis movement! Prevent collision with sample!
	Send Command	Opens a window in which the commands to the axes can be entered directly
	getRCS	Opens the current reference coordinates of the heliInspect™ H8
	getMCS	Opens the current machine coordinates of the heliInspect™ H8
	Park	Moves the axis to the park position. ⚠ Park position can be lower than the start position of the scan movement. Prevent collision with sample!
	CloseStage	Closes the connection to the axes controller (re-initialize the axes to continue with data acquisition)
Algorithm	Select Configuration	Selection of a pre-processing algorithm (» Image pre-processing)
	Manage configuration	Add, delete, edit or select a image pre-processing algorithm

Menu	Submenu	Description
Visualize	ImageJ	Opens the current measurement with ImageJ
	MountainsMap	Opens the current measurement with MountainsMap

Tab 7: Categories and functions in der menu bar

Measurement data are exported according to the application selected in the image pre-processing algorithms. In contrast, when a measurement is saved as an ".hdat" file the raw data remain unchanged. You can open "*.hdat" files, reverse or edit applied image pre-processing algorithms.

Toolbar

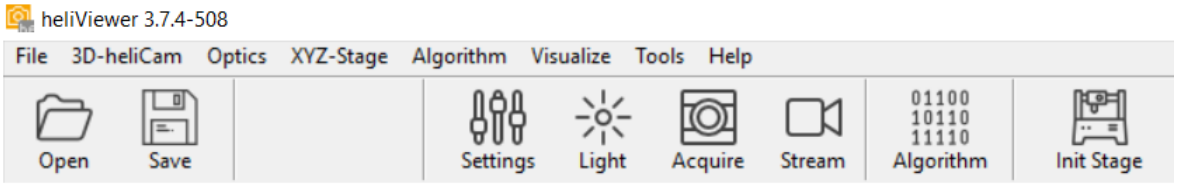


Figure 16: Toolbar

Function of the buttons in the Toolbar:

Button	Description
Open	Opens previously saved 3D measurements (".hdat")
Save	Saves the current measurement (".hdat")
Settings	Opens the 'ad hoc' configuration in order to enable initializing of the camera
Light	Activates the light
Acquire	The Z-axis carries out a 'scan' in compliance with the parameter defined in the scan range and the computer acquires the data of the camera ⚠ Check the center Z-position before starting acquisition in order to prevent a collision with the sample. The Z-position in the 'Axes range' and the center Z-position in the 'Scan range' are not identical.
Stream	Scans in compliance with the parameters defined in the 'scan range' are carried out continuously and the computer acquires the data of the camera ⚠ Check the center Z-position before starting acquisition in order to prevent a collision with the sample. The Z-position in the 'Axes range' and the center Z-position in the 'Scan range' are not identical.
Algorithm	Opens the 'Algorithm Configuration' dialog
InitStage	Initializes the axis and carries out commands defined in the axes configuration ⚠ Axis movement! Prevent collision with sample!

Tab 8: Buttons in the toolbar and their functions

Main area

Area	Description
Axes area	Display and control of the position of the measurement head
Scan area	Display and control of the scan parameters
Status display	Shows the current status of data acquisition
Result area	Shows the measurement result
View area	Changes the view of the measurement area

Tab 9: Areas of the main area of the user interface

Axes area

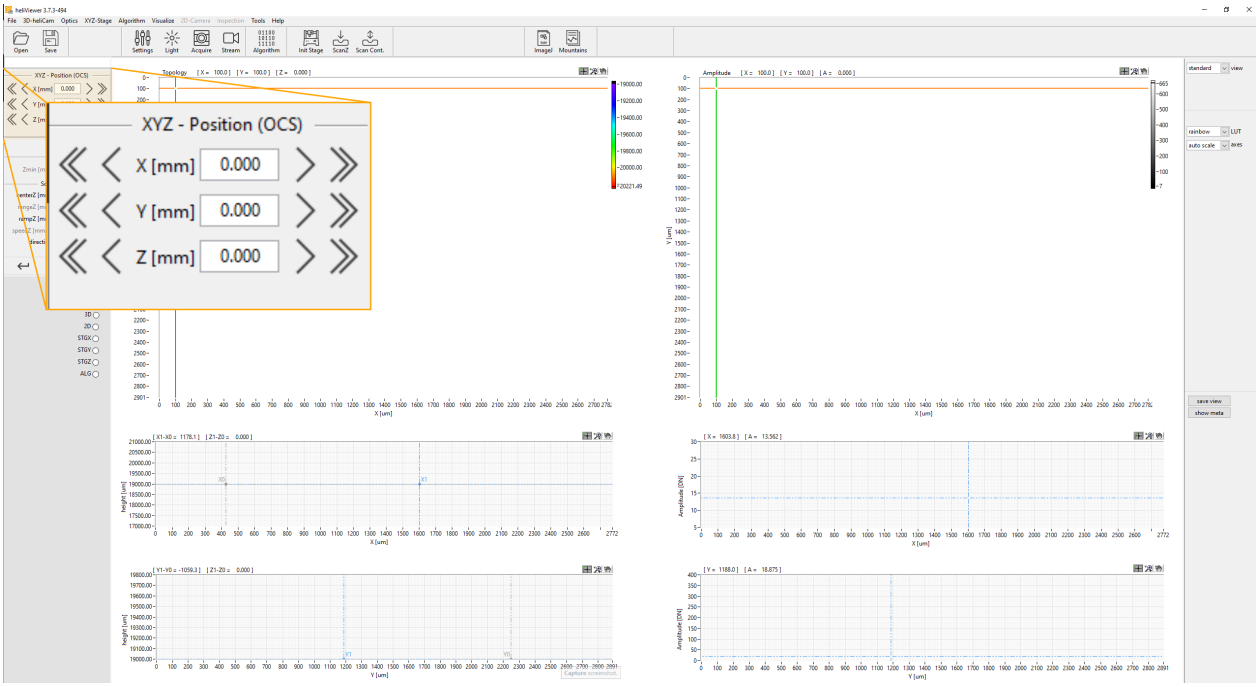


Figure 17: Axes area

The axes area shows the current position of the axes in the OCS. Control of the position of the axes by entering a new value in the coordinate fields manually or by clicking on the arrows right and left next to the coordinate field. Actions if you click on:

- Single arrow: Movement of 0.1 mm
- Double arrow: Movement of 0.5 mm

Scan area

The Scan area shows the currently active scan parameters.

> You can set the parameters rangeZ and speedZ in the camera configuration (» "Manage configuration" on page 38).

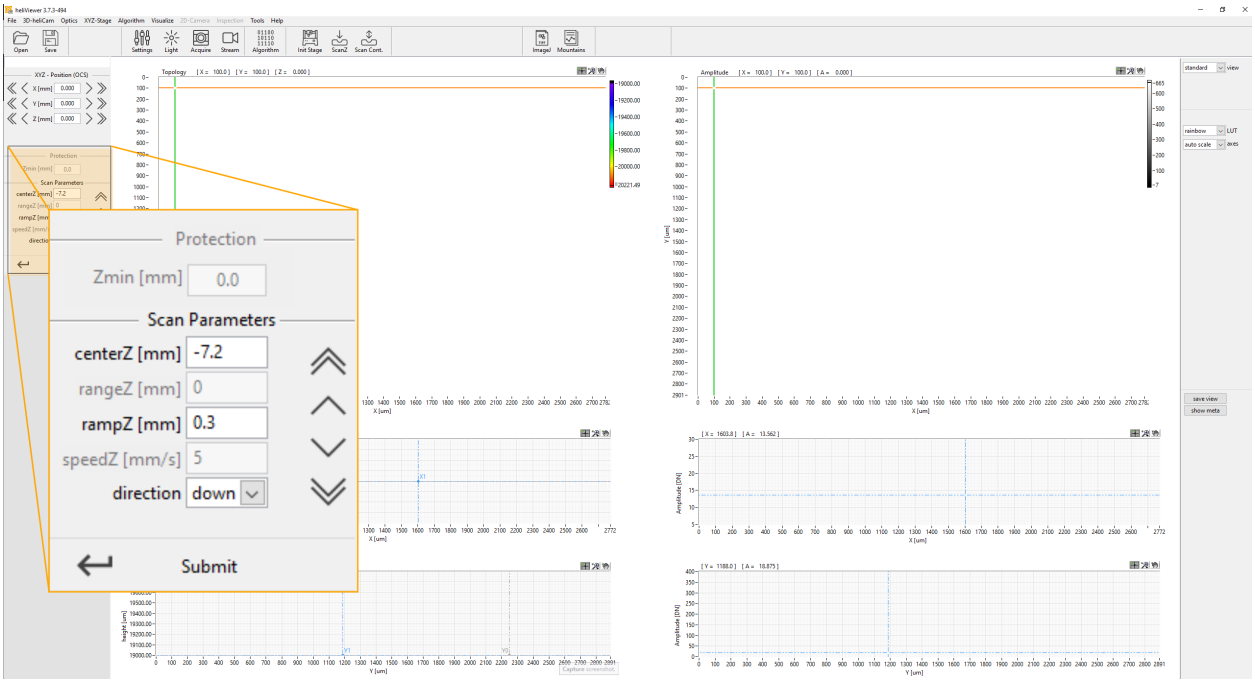


Figure 18: Scan area

Parameter	Description
centerZ	Center position of the scan range
rangeZ	Indicates the actual measurement range
rampZ	Defines the distance used for acceleration and deceleration (total movement range is rangeZ + 2 x rampZ).
speedZ	Scan speed
Direction	Defines the direction of the scan. The measurement is carried out in either an upwards (up) or downwards (down) direction or alternately in both directions (bidir).

Actions if you click on the following icons:

- Single arrow: Movement of the scan area by 0.1 mm in the direction of the arrow
- Double arrow: Movement of the scan area by 0.5 mm in the direction of the arrow

- Submit: Acknowledge the values entered manually by clicking on the button **Submit**

Status display

Shows whether an area of the scan and editing sequence is currently active (◉) or inactive (○).

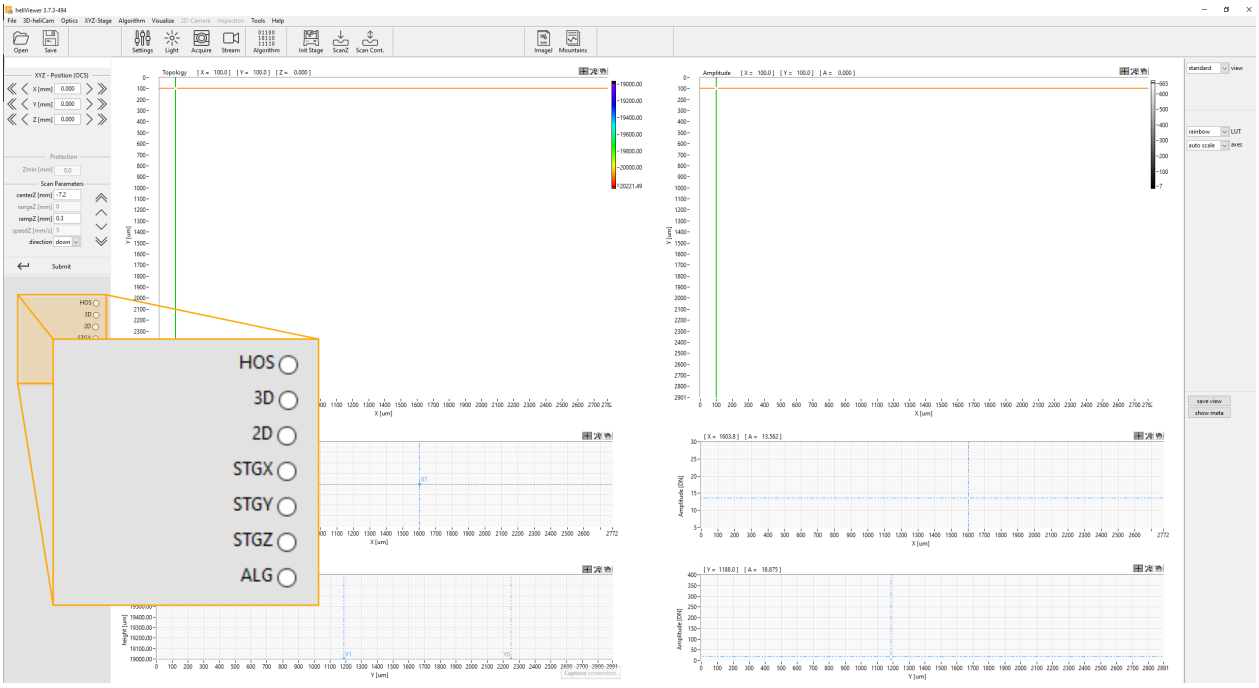


Figure 19: Status display (for debugging purposes)

Result area

The currently loaded measurement is shown in this area of the window. The view changes depending on the type of data (surface, volumes etc.).

In the surface mode the amplitude value provides information on the surface reflectivity of the sample and represents a quantitative measure for the signal quality (» Signal quality).

The views are interactive (zooming, moving of lines etc.).

> If the cursor is in the 'Measurement area', the axes can be moved with the arrow buttons or the mouse wheel.

View area

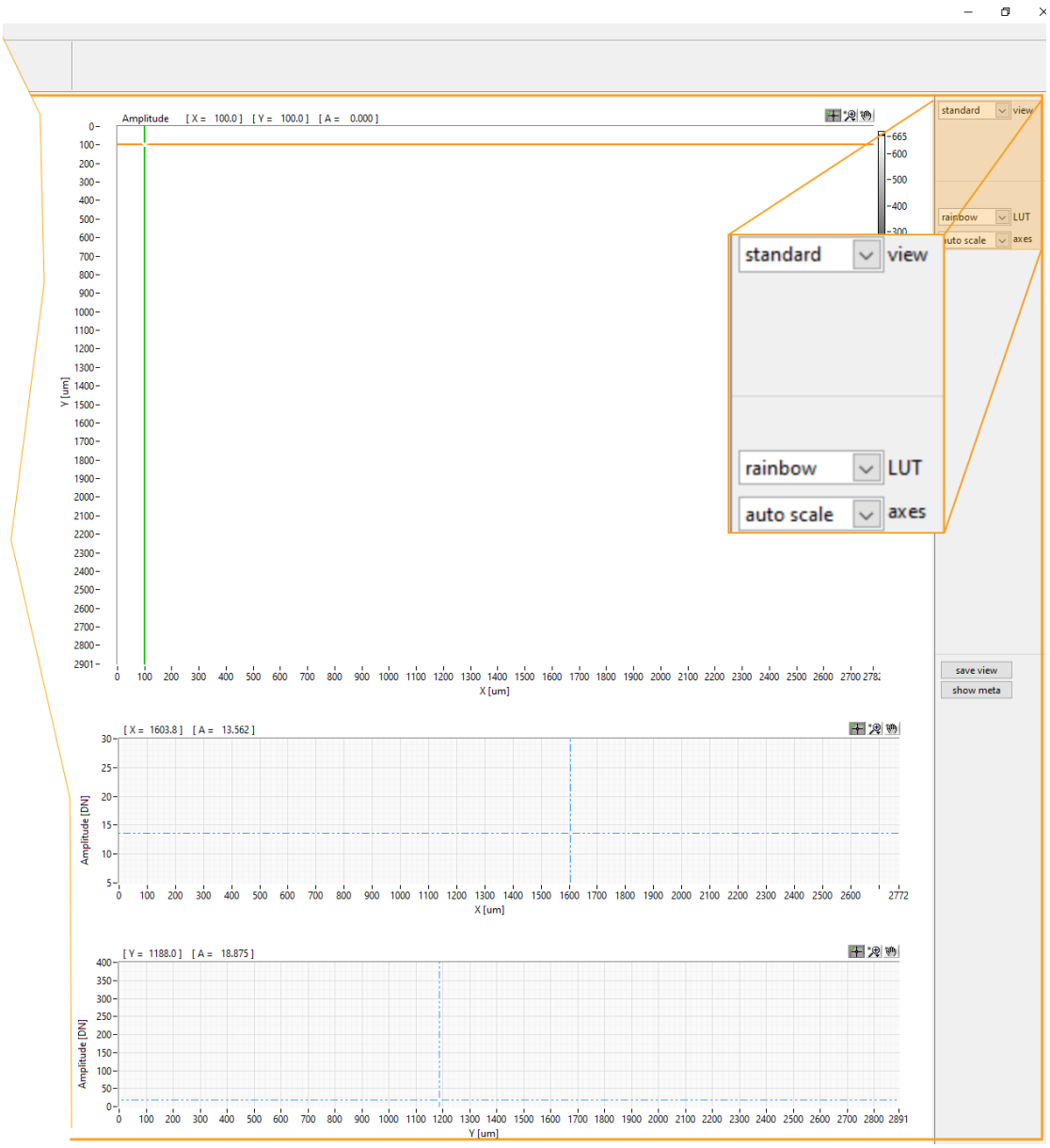


Figure 20: View area

Options:

- Switching between surface display in a colour view or as a 3D rendering
- Changing the colour view of the surface display
- Changing of automatic scaling in order to show the entire measurement range or manual selection of the scaling.

Carrying out first measurements

Determining step height with heliInspect H8

Measurement process	Instructions for execution
heliViewer™ start	
Load hardware example configuration	1.) Execute command “Menu bar > 3D-heliCam > Select Configuration” (» Select Configuration) 2.) Execute command "Menu bar > Optics > Select Configuration” 3.) Execute command “Menu bar > XYZ-Stage > Select Configuration” (» Select Configuration) ⇒ First use after installation requires adding hardware configurations (» Manage configuration on Page1 (3D-heliCam) and Manage Configuration (Optics and axes))
Switch on the light	Click the button “Toolbar > Light” (» Light)
Start streaming	Click the button “Toolbar > Stream” (» Stream)
Position sample in the field of view (rough positioning x,y lateral)	
Set the scan position until surface is detected in the scan range	1.) Select axes scaling “View area > axes > full range” (» View area) 2.) Enter scan position manually or set with single/double arrow (“Scan range > Scan-Parameter > centerZ”) (» Scan range) 3.) Acknowledge entry with button "Scan range > Scan-Parameter > Submit” (» Scan range) ⇒ Optic is 1xworking distance from the surface of the sample (» Configuration options) ⇒ Surface of the sample is in the measurement range (i.e. Noise < 10µm and topology of the surface is captured)
Optimising the image parameters to A~200	Adjust scan speed and exposure under “Tool-

Measurement process	Instructions for execution
for detection	bar> Settings > Wizard H8" as outlined in the Figure (» Optimising the image parameters)
Fine position sample in x,y	Move flat areas on both sides of the step into the field of view, so you can define a suitable test window for calculating the step height
Pre-process the image	Recommended procedure (» Recommended procedure)
Read off the step height	1.) Select axes scaling "View area > axes > full range" 2.) Define centers of the test window by moving the cursor and read off step height (» "Evaluation") ⇒ You can define the size of the test window by selecting the filter size in the step "Pre-process the image"
Export data	Select option under "Menu bar > File > Export as ..." (» File)
Close connection to the camera	Possibility 1: Execute command "Menu bar > 3D heliCam> Close heliCam" (» Close heliCam) Possibility 2: Execute command "Menu bar > XYZ- Stage > Close Stage" (» Close Stage)
Close program	Execute command "Menu bar > File >Exit"

Tab 10: Measurement process - Determining the step height with heliInspect H8

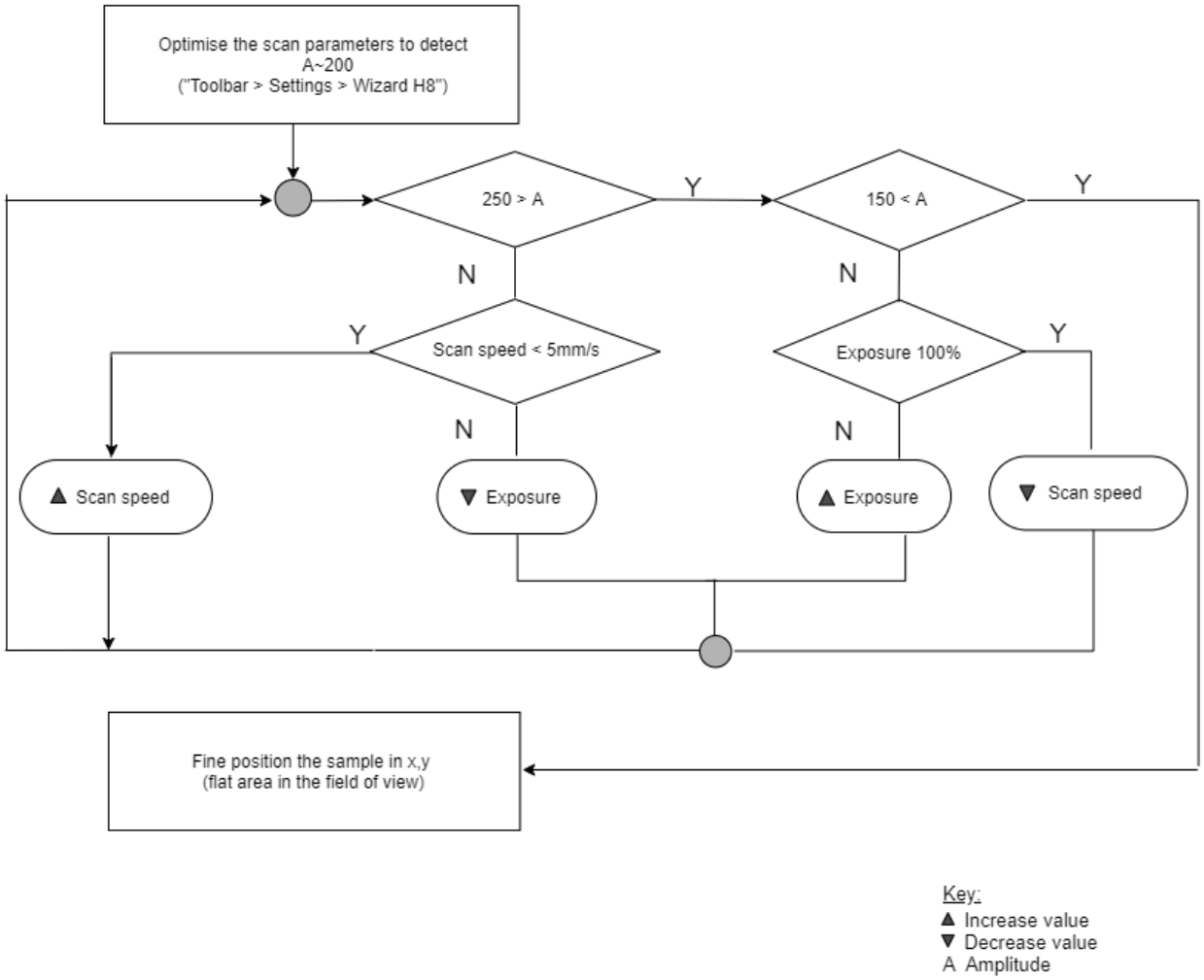


Figure 21: Optimising the image parameters

Image pre-processing

Image pre-processing is a key step in the quantitative evaluation of image data. The aim is to increase the SNR (» Functional principle) and/or to remove artefacts. Whereby the following must be differentiated in the heliViewer™:

Operator	Description
convertRAW ()	Minimum configuration to enable the display of the data (must be called up at the beginning of the script and may only be used once)
levelSURF (type=none)	No levelling of the measurement
levelSURF (type= gradient)	An angle of the object is calculated by calculating the gradient and then deducting it

Operator	Description
levelSURF (type= fitPlane)	Fitting and subtraction of a plane
filterSURF (type= none; kernelSize=#.#; threshold= #.#)	No filtering of the surface
filterSURF (type=mean; kernelSize=#.#; threshold=#.#)	Application of a mean filter with kernel size “kernelSize”
filterSURF (type= median; kernelSize=#.#; threshold= #.#)	Application of a median filter with kernel size “kernelSize”
filterSURF (type= remove Outliers; kernelSize=#.#; threshold= #.#)	The surface is edited with a mean filter with kernel size “kernelSize” and saved as an internal copy. If the difference in height between the original and the copy is a single pixel above the threshold value, then this pixel is replaced with the filtered value. If the difference is below the threshold, then the original value is retained.

Tab 11: Image pre-processing algorithms

Recommended procedure

Step 1

Ignoring extreme pixel values (“threshold value”-based):

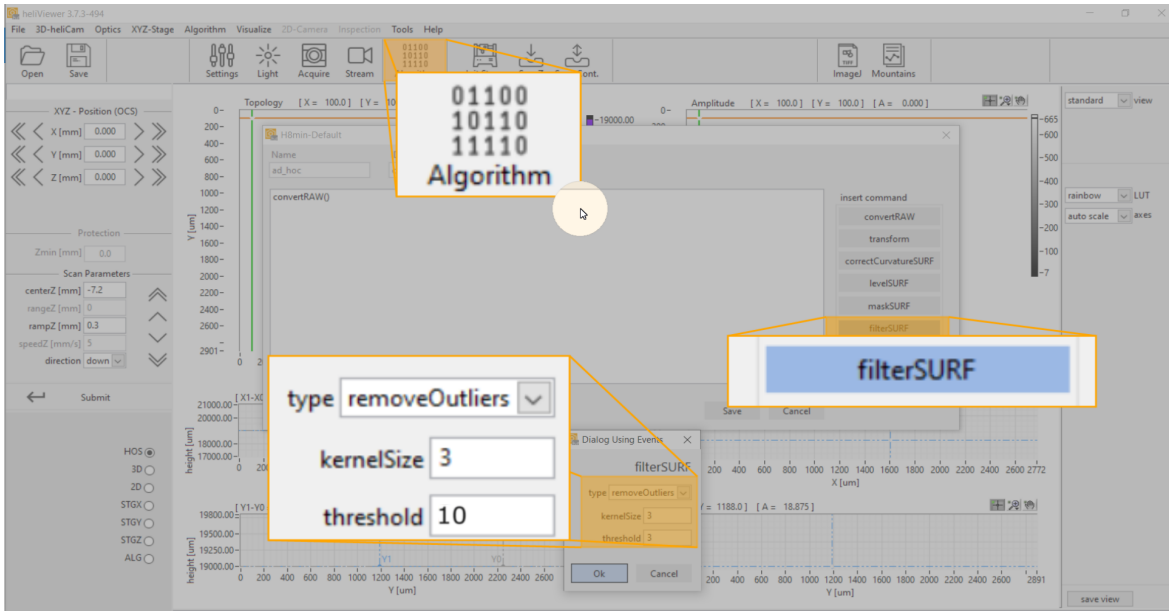


Figure 22: Image pre-processing - "Remove Outliers"

Step 2

Averaging in the 4-pixel neighborhood

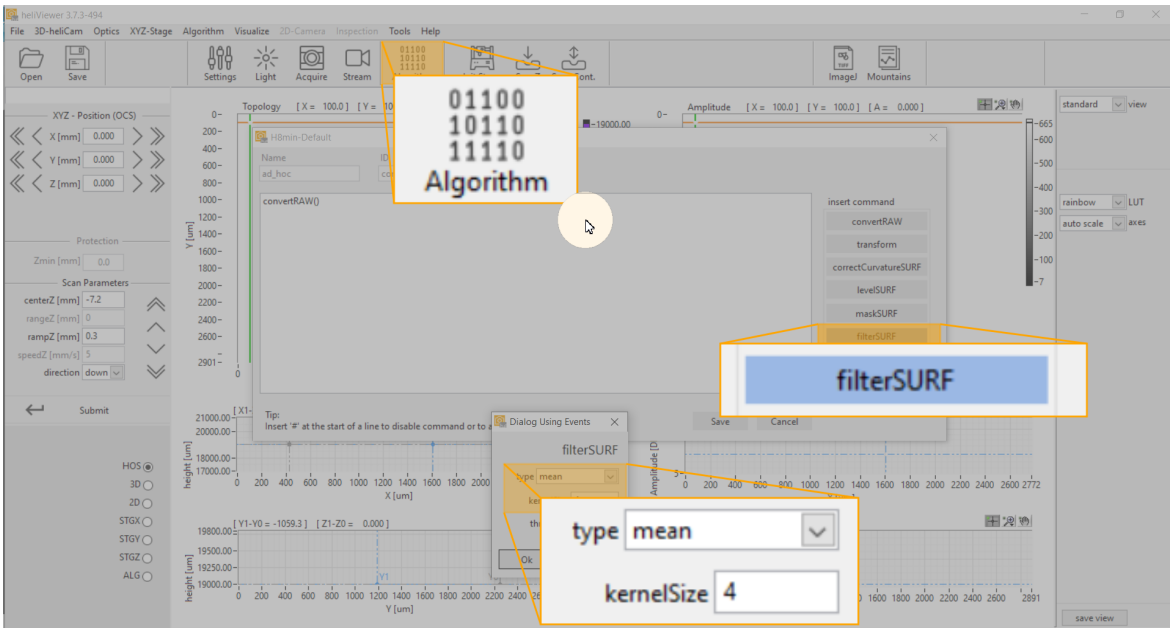


Figure 23: Image pre-processing - Averaging

Step 3

Levelling:

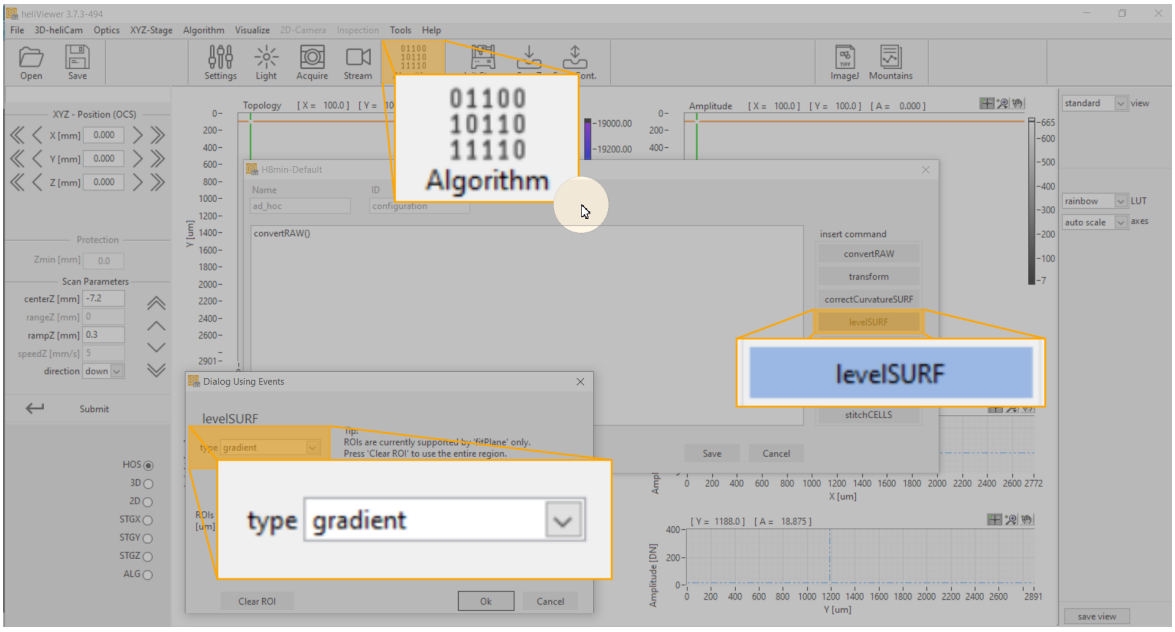


Figure 24: Image pre-processing - Level

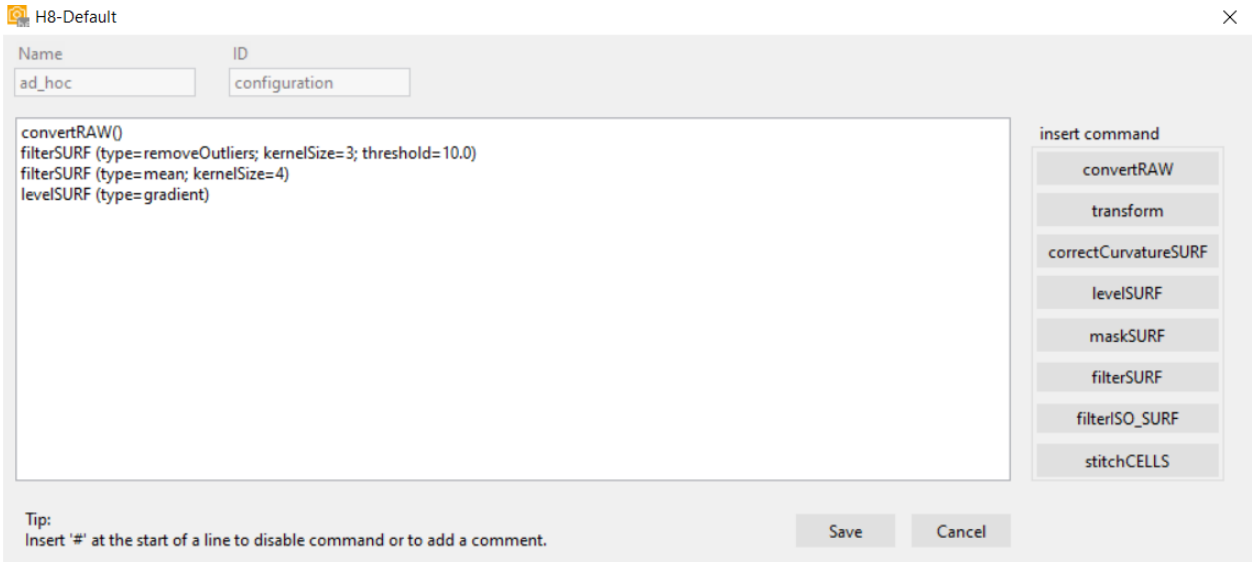


Figure 25: Image pre-processing - command cells according to selection of the algorithms

Evaluation

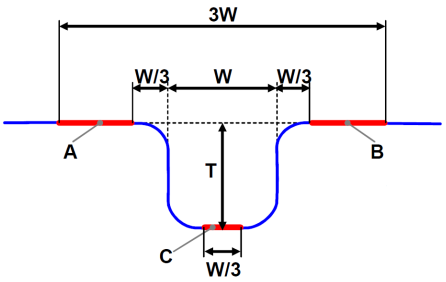


Figure 26: Determination of a step height in compliance with DIN EN ISO 5436-1:2000, ISO 25178-70:2014 (A, B = upper reference level, C = lower reference level, W = structure width, T = step height)

Figure 27 on the following page shows an example of a step height measurement.

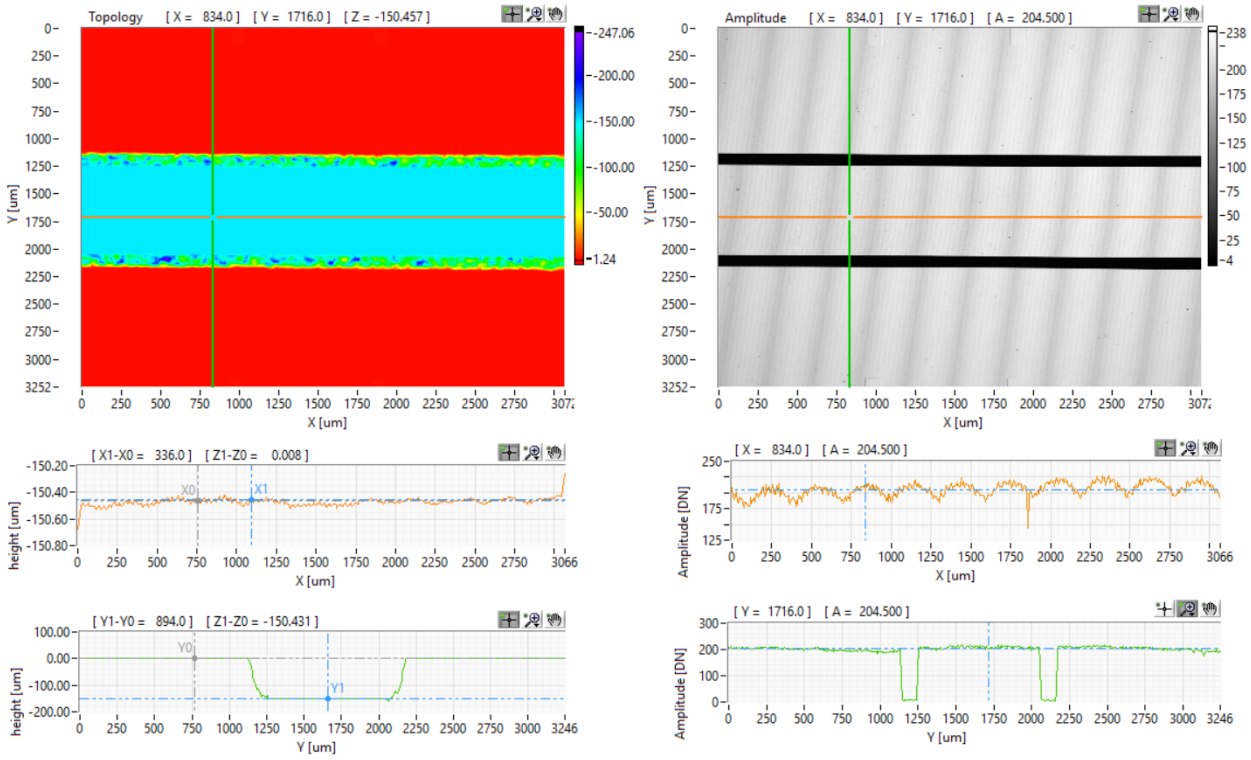


Figure 27: Colour scaled height image of a representative example measurement - steps normal with heliInspect™ H8. The step height is calculated in compliance with DIN EN ISO 5436-1 (see above=. The upper reference level is calculated after application of the algorithm "levelSURF (type= gradient) left and right of the grove. Determination of the depth/height value is effected as a subtraction from the mean values of the upper and lower level (Z_1-Z_0 in ZY-section (green cursor)).

Capability of test processes and measurement equipment

Objective:	A test device with a sufficiently small uncertainty is used at the place of operation for evaluating a test statistic
Criterion:	Uncertainty of the test results in relation to the tolerance of the test statistic
Procedure*:	Procedure 1: Verification of the capability of a the test device; Procedure 2: Verification of the capability of a the test device with operator influence

* The procedure follows “Bosch Booklet 10 Capability of Measurement and Test Processes”.

Procedure 1

Assessment of systematic measurement error and variation of the measurement device without operator influence based on a standard:

1. Record the resolution of the measurement device (< 5% of the tolerance)
2. Carry out repeat measurements n >25 under identical conditions
3. Calculate the mean value ($\bar{x}$) and the standard deviation (s_g) from x_i (i = 1 . . . n) of this measurement series
4. Compare s_g with tolerance T:

   $$Cg = \frac{0.2*T}{6*sg} \geq 1,33$$

   $$Cgk = \frac{0.1*T-|\bar{x}-xr|}{3*sg} \geq 1,33$$

   ⇒ Measuring device is capable according to procedure 1 if both capability indexes C_g und C_{gk} achieve at least the value 1.33

Procedure 2

Study of the measuring process taking into consideration operator influences and numerical analysis of the results according to ANOVA, ARM or difference methods.

1. Calculate GR&R key figure

   $GRR = \sqrt{EV^2 * AV^2}$ (according to ARM)

2. Set key figure GRR in relation to the tolerance

   $$\%GRR = \frac{6*RR}{processvariation} * 100$$

> Calculation procedures differ. Indicate calculation basis.

> The procedures described assume normally distributed measured values.

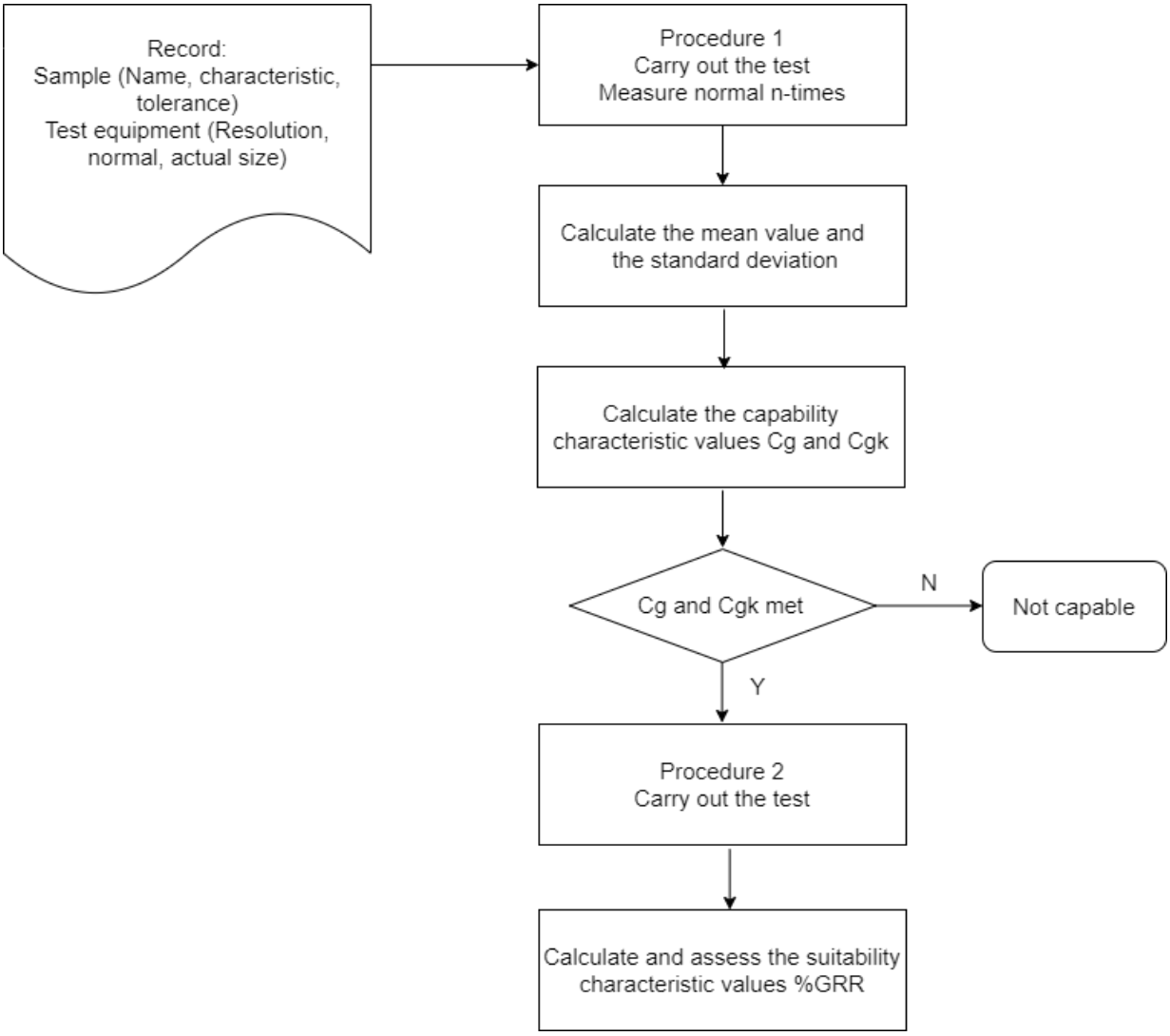


Figure 28: Schematised process- phases of the measurement device and test process assessment

References to standards

Standards for the dimensional evaluation of structured surfaces:

- ISO 5436-1:2000
- ISO 25178-70:2014

Overview of 2D and 3D surface parameters:

- ISO 4287:2010
- ISO 225178-2:2012

Correct functional characterisation of many surface structures by international standardised surface parameters not fully covered. Specific applications within the scope of factory standards have been standardised in-house.

DEBUGGING

Error table

Error description	Possible cause	Remedy
Connectivity		
Network status LED does not light up	Booting not initiated	Check the connection of the power and signal cable (see Chapter "Installation")
heliInspect™ H8 is not found in the network	Error during configuration	Check and implement the procedure described in the Chapter "Configuring the interfaces " on page 31
	Firewall active	Check and implement the procedure described in the Chapter "Configuring the Windows Firewall" on page 32
	Connection to the host computer lost	1. Check the settings of the power management on the host computer (Option "Power save & sleep" must be deactivated) 2. Restart the PC
Longer latency time	Image processing filters are active in the settings for the network adapter	Check the settings for the network adapter and deactivate all unnecessary image processing filters
Data acquisition		
No data acquisition	Settings for "3D-heliCam" and/or "Optics" incorrect	Select "Menu bar > 3D heliCam > Select Configuration > H8default" (Select settings for your optics under the "Menu bar > Optics > Select Configuration")
Delayed image display	Bandwidth of the network/ network card throttled	Check the settings of the network/ network card
Data contain noise and no surface information	Light is switched off	Click the button "Toolbar > Light"
	Surface outside of the measuring range	Adjust scan parameter "rangeZ" ("Toolbar > Settings

Error description	Possible cause	Remedy
		> Wizard H8 > scan range") Adjust scan parameter "CenterZ"
Data quality		
Data quality unsatisfactory	Signal-to-noise ratio too low ("Signal quality" on page 17)	Optimise acquisition parameter under "Toolbar > Settings > Wizard H8" (» "Carrying out first measurements" on page 46)
	Wavelength in the selected optics configuration does not match the wavelength of the installed light	Check optics configuration (» select, duplicate and edit Menu bar > Optics > Manage Configuration" (Values for "heliOptics_3D > illumination > wavelength": LED red = 625nm; LED blue = 475nm)

ANNEX

Dimensions and weight

Specification	Value	Unit
Length	254	mm
Height	58	mm
Width	100	mm
Weight (without heliOptics™ WLI8)	2465	g

Electrical specifications

Specification	Value	Unit
Supply voltage	24	VDC
Current consumption	1.5	A
Power consumption	36	W
Protection class	III	-
Protection type	EN 60529: 2000-09	-
Degree of contamination	2	-

Environmental conditions

Specification	Value	Unit
Permissible ambient temperature	0-40	°C
Permissible relative humidity (non-condensing)	65	%
Height of the area of application	2000	m
Base point acceleration	VDI 2627-1, -2	-

CE

heliotis
advancing 3D metrology

EC-Declaration of Incorporation of Partly Completed Machinery

(original document)

In accordance with the EC machine directive 2006/42/EG of 09.06.2006, appendix II B

We hereby declare that the following described partly completed machine in its conception, construction and form put by us on the market, is in conformity with all the relevant essential health and safety requirements of the EC machinery directive 2006/42/EEC, the low voltage directive 2014/35/EU and the EMC directive 2014/30/EU as amended and the national laws and regulations adopting this directive. In case of alteration of the Partly Completed machine, not agreed upon by us, this declaration will lose its validity.

Furthermore, we declare that the relevant technical documentation according to Appendix VII, Part B, have been issued and we commit ourselves to forward the documents on request to the market regulators as written documents or electronically.

manufacturer	Heliotis AG Längenbold 5 CH-6037 Root
authorized representative of technical documents	Heliotis AG Längenbold 5 CH-6037 Root
designation of the machine **commercial designation**	measuring head for 3D inline-inspection heliInspect H8 including heliDriver D3, heliCable HI-CC8-Lx, heliOptics WLI8
model or type of machine	H8-S4-LR1
year of manufacture	2021

guideline	**date**	**requirements**
2006/42/EG	09.06.2006	1.2.6/1.3.4/1.3.7/1.5.2/1.5.4/1.7.4
2014/30/EU	26.02.2014	Appendix 1 1. a), appendix 1. b)
2014/35/EU	29.03.2014	

harmonized standards	**date**	**remarks**
EN 60204-1	10.2014	Safety of machinery - Electrical equipment of machines (partly)
EN 62471	2009	Photobiological safety of lamps and lamp systems
EN 61000-4-2c		Electromagnetic compatibility (EMC) - Part 4-2
EN 55011		Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics

The commissioning of the incomplete machine is prohibited until the incomplete machine has been installed in a machine which then meets the requirements of the EC machinery directive 2006/42/EC, the low voltage directive 2014/35/EU and the EMC directive 2014/30/EU.

Root, May 10 2021

CEO

Distributors

Authorised distributors:

Japan
LinX Corporation
IK Building, 4F, 2-24-9, Kamiosaki
Shinagawa-ku, Tokyo, 141-0021
T: +81-3-6417-3371
E: info@linx.jp
I: www.linx.jp

South Korea
IOVIS Co. Ltd.
1305, Hyundai Knowledge Center, C-dong 7
Beobwon-ro 11-gil, Songpa-gu, Seoul, 05836
T: +82-2-424-8832
E: sales@iovis.co.kr
I: www.iovis.co.kr

People's Republic of China
Shanghai Nanvin Electro-Mechanical Technology Co. Ltd.
Golden Bridge Commercial Plaza No 255, RM 628
New Golden Bridge Road, Pu Dong, Shanghai, 201206
T: +86-21-6888-8372
E: andersonyan@nanvin.com

Other countries and regions
Heliotis AG
Längenbold 5
6037 Root
T: +41-41-455-6700
E: support@heliotis.ch
I: www.heliotis.com

GLOSSARY

A

API

Application Program Interface (interface to application programming). Program interface that provides the applications for connection of the system. Defines the use of interfaces on a source code level.

C

Coherence

Synonym for interference capability. Two (or also more) light bundles are coherent (to each other), if they interfere with each other when superimposed (» interference). If the visibility of the interference pattern is as large as possible, we speak of completely coherent bundles. Smaller, different values from zero, are the result of partially coherent bundles. Bundles emitted from different sources are incoherent.

Correlogram

Intensity distribution of a white light interferogram in dependence on the difference of the path length between object and reference beam.

F

Filter core

Defines the neighbourhood and the weights of the neighbour pixels.

G

GenICam

EMVA Standard for the control of cameras via a generic programming interface.

I

Interference

Interaction by the superimposition of two or more waves of the same frequency. Results in amplitude and phase-dependent intensity distribution, the interferograms.

K

Kernel

see filter core

L

Light-emitting diode

Semi-conductor element that has a p-n junction, that supplies an incoherent radiation when current passes through it, so-called luminescent radiation.

N

Neighbourhood

Defines the image region around a pixel. In the case of the 4-neighbourhood each pixel P of an image has two horizontal, two vertical and four diagonal neighbours.

P

Pixel

Made-up word from "picture" and "element". Designates an image point on an image sensor. Each pixel has row and column coordinates x,y.

R

Resolution

Value represented by the pixel raster distance. 100x: Optical resolution is diffraction-limited higher.

S

SNR

Ratio of the useful signal to the noise.

T

Threshold

The threshold value is the criterion for the partitioning of the value range into two subsets (e.g. grey values, colour values).

W

Working distance

Distance between the sample and the nearest face of the optical system.

INDEX

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