raytrix

RxLive user manual

Table of Contents

1   Introduction

Thank you for purchasing this Raytrix light field camera. Before enjoying the various advantages of your camera system, let us introduce you to the usage and capabilities of the RxLive software which came with your Raytrix camera.
Please follow our Getting Started guide, to install the software, connect the camera and do your first images.
Further Information are given in Using RxLive.

2   Getting Started

This section contains information about the following topics:

- System Requirements

- Software Installation

- Hardware Dongle

- Camera Setup

If you're using a Raytrix Camera for the first time, please follow these steps to set up your system and get your first images.

2.1   System Requirements

Operating System
- Windows 7 64-bit

Graphics
- NVIDIA CUDA 2.0 or higher

- OpenGL 3.0 or higher

- GTX 980 (recommended)

- GTX 780 Ti

- at least 2 GB Ram

Processor
- Intel i7

Ram

- 16 GB (recommended)

For Type A Cameras

- Intel USB 3.0 Controller or NEC/Renesas USB 3.0 Controller:

- supported Chipsets:

    - Intel 7 Series/C216 Series

    - Intel 8 Series/C220 Series

    - NEC/Renesas µPD720200

    - NEC/Renesas µPD720202

2.2   Software Installation

Our RxLive software is available on different media such as CD, USB flash drive or as several downloaded files. In any case, you have to perform the following actions to properly install RxLive on your system.
At first please remember to update your graphics driver to the latest version. To do so please visit www.nvidia.com/drivers and download the latest driver for your specific graphics card.

To install our software please follow these steps:
- Start the executable called Raytrix_RxLive_FullSetup_*.exe to install RxLive and follow the steps of the installation manager
- Start Raytrix_CameraType*_FullSetup_*.exe, depending on your camera type, to install your camera driver
- Start RxCalibData_*.exe, to install your camera calibration database (Please note: The database is usually installed very fast)

After successfully completing all 3 installer you're system is ready to use the camera.

The SDK files are automatically installed on your PC together with the RxLive installer. You can only use it with SDK dongle feature. More details here.

2.3   Hardware Dongle

The RxLive Software has different feature levels which are locked by a hardware USB Dongle. It depends on your dongle license which features are available.
To use RxLive, please make sure, that your Dongle is attached to your computer.

These are all available dongle features:

Multiview	Enables the creation of mutliview images (e.g. stereo image)

Focus+	Enables refocusing the image after the fact.
3D+	Enables depth estimations. Now you can also get a total focus image. (focus on depth)
Calibration	Enables the calibration of the camera
Metric Calibration	Enables the metric calibration of your camera to measure in metric units
SDK	Enables the access to the Software development kit to create a custom light field application
RxFlow	Enables our software tool RxFlow, to analyze particle movements.
Halcon	Enables the access of Raytrix camera directly from Halcon 12.

You can find the Dongle Dongle ID, the Dongle Serial as well as an expire date in the license Tab on the start page. The expire date is used for software updates. You're system can be updated up to this date.

To upgrade your dongle or to extend your expire date please contact info@raytrix.de and send your Dongle Serial.

2.4   Camera Setup

To connect your camera to your computer and configure properly, please follow the steps for your camera type:

- Type A USB 3.0

2.4.1 USB 3

To connect your TypeA USB3.0 camera, please make sure your computer meets our requirements and you have completed the software installation successfully.

Please connect your camera to the USB3.0 controller. You can identify a USB3.0 connector by it's blue color (usually) or the USB Super speed logo (common on Notebooks)
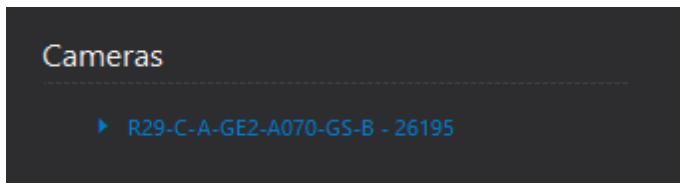
After connecting the camera please wait some seconds. Meanwhile your system will recognize the new hardware.
After waiting you can start RxLive and RxLive is looking for the camera.
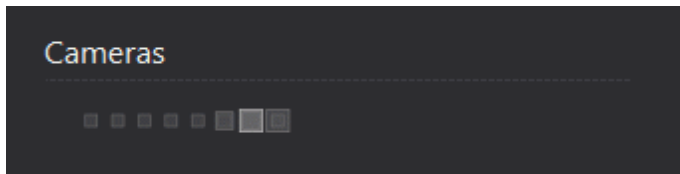
If the camera is found correctly, you can select the found camera:

If the camera was not found at first attempt, please try again by clicking on "Find".

2.5 Camera Calibration

Before using your camera it is necessary to calibrate your **MLA** (**M**icro **L**ens **A**rray).

It is very helpful to have the camera already running in RxLive. For the MLA Calibration you need a calibration filter and light source.
To calibrate your MLA, please start the MLA Calibration wizard.

If you have the Metric Calibration feature, you can calibrate your camera using your calibration target and the Metric Calibration wizard.
Please contact info@raytrix.de to order Metric Calibration, if you would like to get the

most out of your camera.

2.5.1   MLA Calibration

The MLA Calibration wizard will guide you through the calibration process.

The wizard contains five steps. Please read the description inside the wizard carefully and keep in mind to repeat the MLA Calibration after changing focus, aperture or main lens.

Main Lens Database

Here are some hints to add a new main lens in the second step of the wizard:

When adding a new main lens, please make sure to put in the right values for **Focal Length**. If you're using a **prime lens** (fixed focal length) please make sure to set your focal length for both values. If you're using a **zoom lens** (variable focal length), please set minimum and maximum focal length.

Focus Distance

In the third step, please make sure to set your **focus distance** correctly. It is the distance between the sensor and the focus plane of your main lens. (Often you can find the focus distance written on the focus ring of your main lens) This value is used for the metric calibration process.
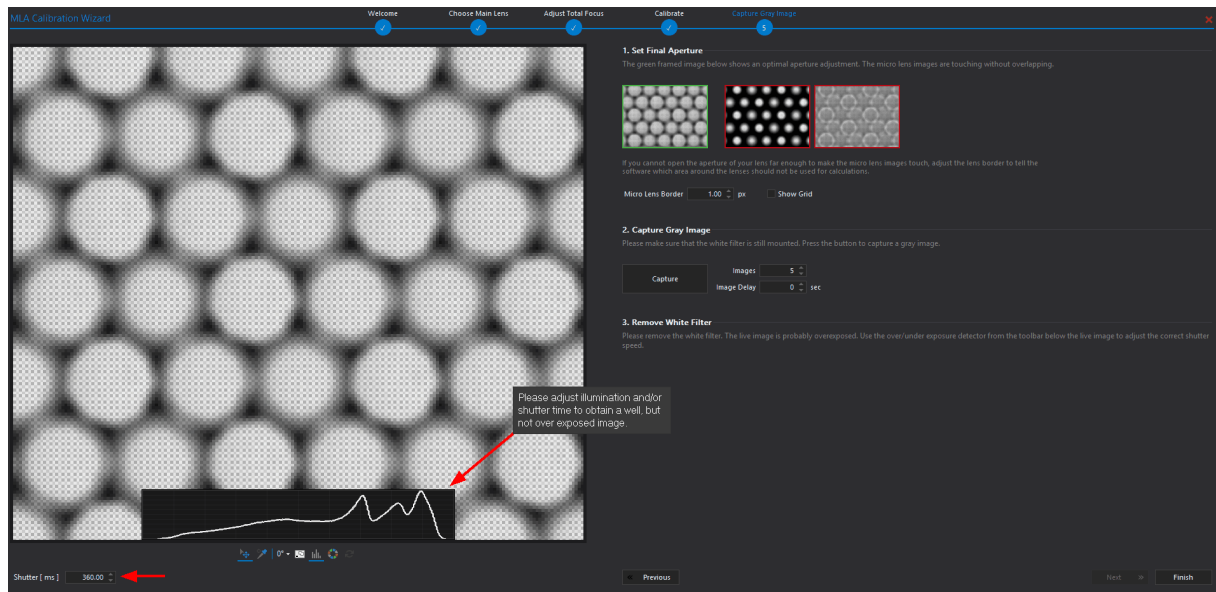

Grey Image

The grey image is used to eliminate the micro lens structure from your final images. Therefore it is very important to use a well illuminated image for this step.
You can obtain this by adjusting light intensity and/or changing the shutter time. Your histogram should not show overexposure, but you should reach at least 90 % illumination.

It is very important not to change your aperture after this step. If you change your main lens setting after this step, please repeat the MLA calibration.

2.5.2 Metric Calibration

The Metric Calibration wizard is only available after completing the MLA Calibration successfully and with the Metric Calibration dongle feature.
To purchase your dongle upgrade for metric calibration, please contact info@raytrix.de.

General Information

Your Raytrix camera system gives you the ability to do measurements in 3D. You can measure the distance between two points as euclidean distance or in z-direction (parallel to the optical axis). Area measurements or volume analysis are also available, using different File Export options. After calibrating the camera, following our Metric Calibration wizard, you're able to obtain all distances in millimeter.

Capturing Calibration Target

Capturing the Calibration Target is the most important step of calibrating your camera. At first please set your Point Pitch in millimeter correctly! Please take a look at the back of your metric target. Here you should find a small sticker with the exact point pitch. If there is no sticker, or you're facing errors, please check the Point Pitch by measuring them. Best to measure the pitch of 10 points and divide the result by 10 to reduce parallax errors.
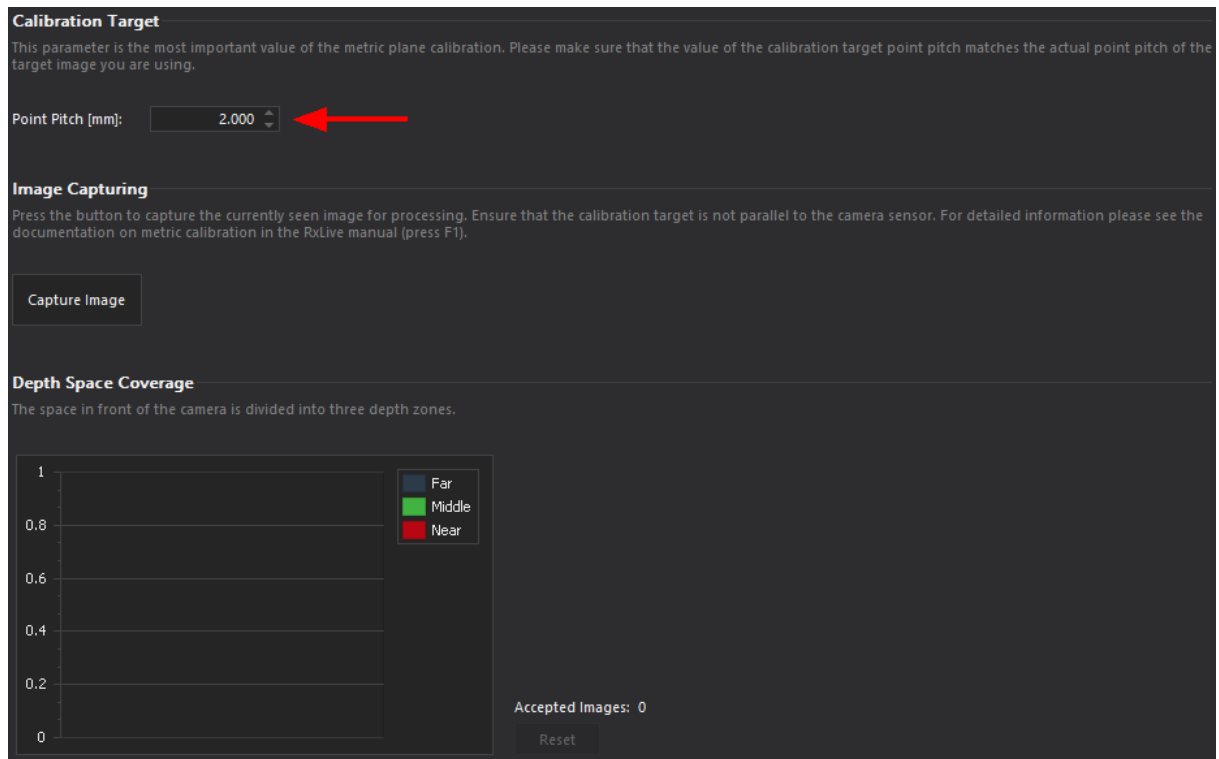
How to place the target

Our calibration target and software is designed to capture different depth values in one image. Best if you can get depth from blue to red range in one image without tilting the target more than 45°. To get a good result, you'll need at least two images. To improve your results the calibration images should have different target orientation for each image. For example upper end of the image blue range, lower end of the image red range for first image. Second image blue range on left side, red range on right side. Third image, blue range at the bottom, red range at the top.
The goal is to cover the whole depth space. You can find a "depth histogram" on the right side. You should have some measurement values in all three depth zones. It is normal, that there are much less Far points, than Middle ones, than Near ones.

Here is one example for a metric calibration, captured with our R29 color camera, 200mm focal length and 500 mm focus distance.

After completing the MLA calibration we start the Metric Calibration wizard. We read the first page carefully and go to the second page.
There we put in 2.000 mm Point pitch. (point pitch = distance between two points)
After that we place the target so that the blue depth range is at the bottom and the red range at the top.
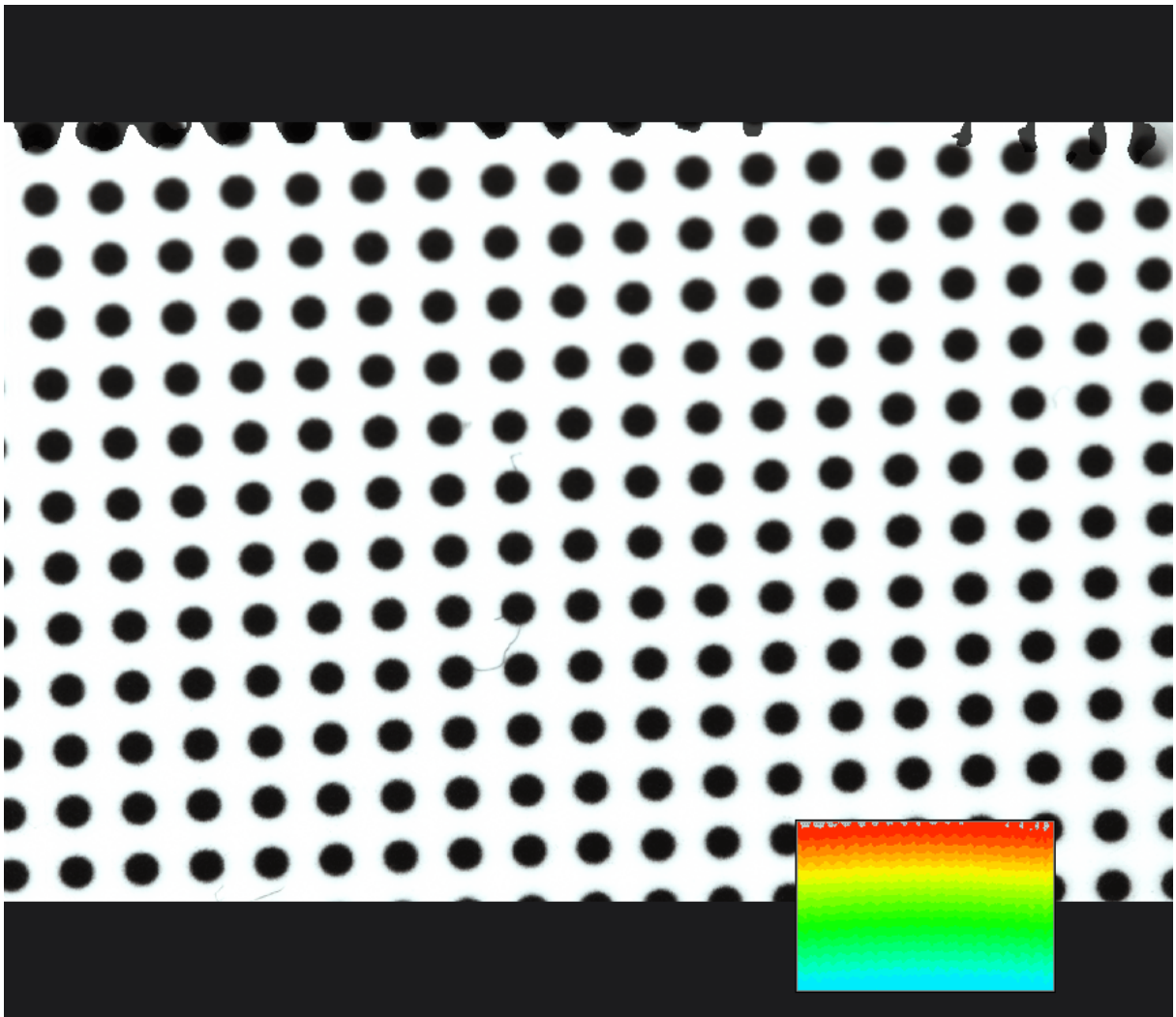
Now we click "Capture Image". We are asked whether to process this image. If you can see motion blur or bad depth preview you can reject the image here. If everything looks as above or similar, you can accept by clicking "Yes".
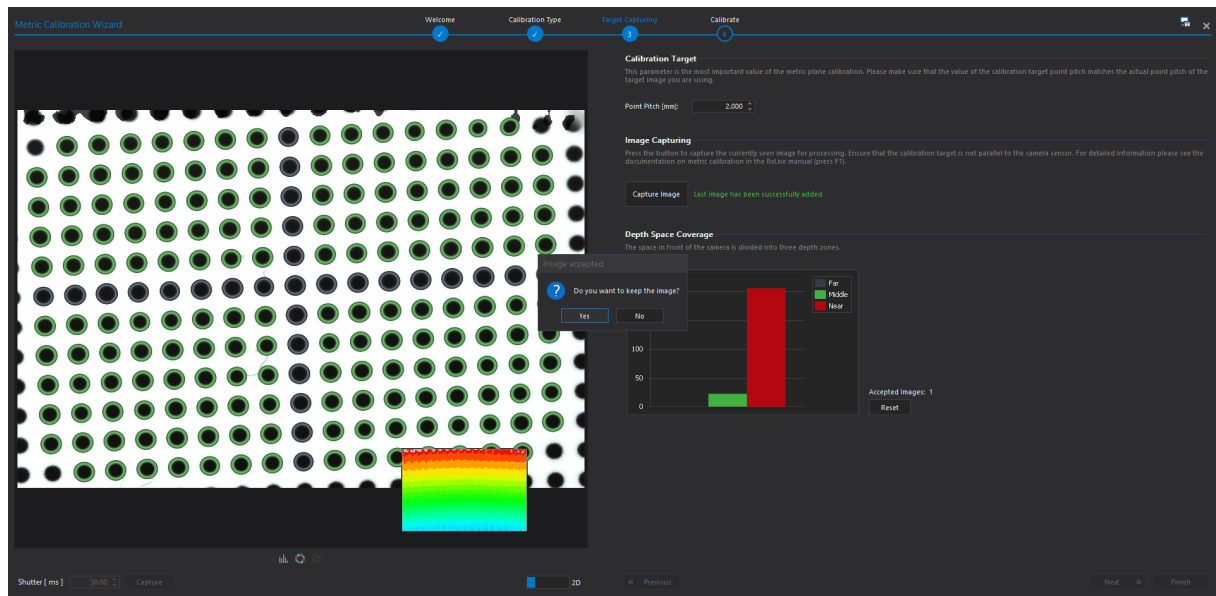
After the image is processed the result is shown as overlay. If the overlay matches the black dots on the target, you can keep the image. It is also no problem if there are some more red circels around the black dots.
This image is ok, so we'll keep this one.

Next step is to change the target orientation. We will bring the blue range to the left and red range to the right.
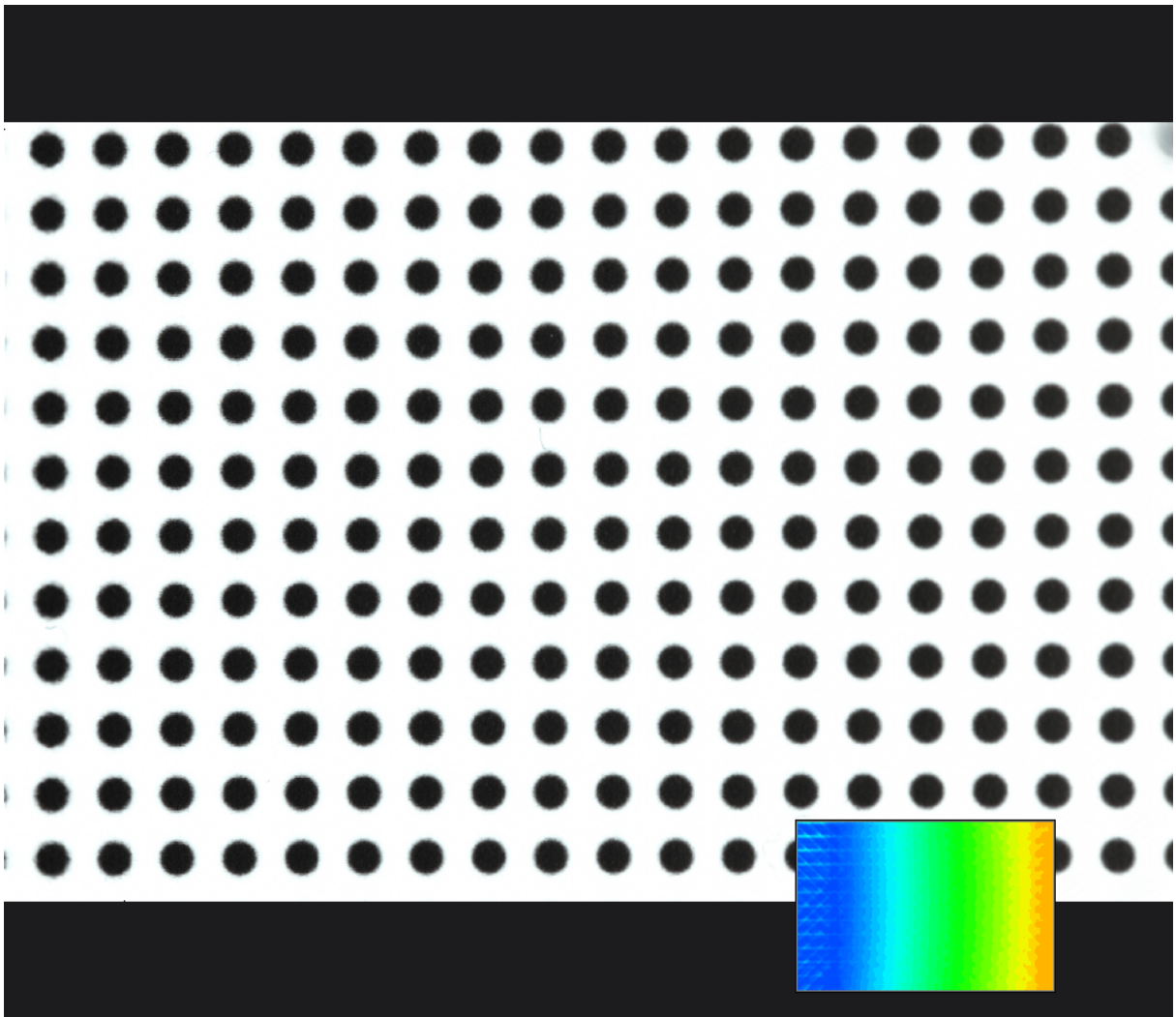
We capture this image, process it and keep the result. (it looked like the result above)
Then we have this situation:
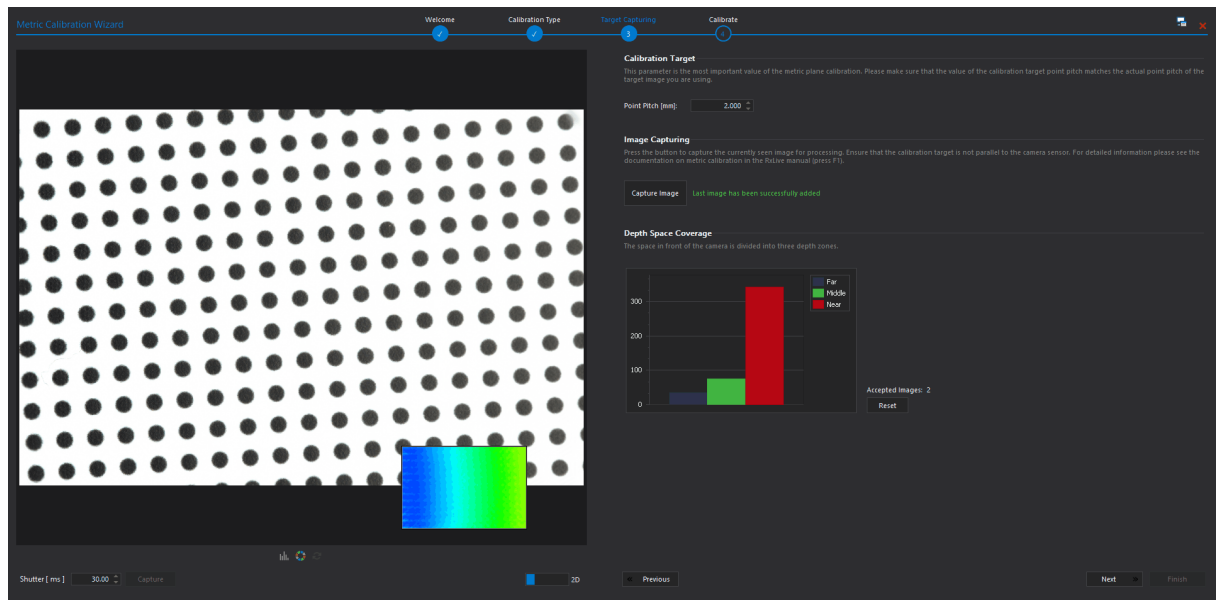
Now, we have collected some measured points in all three depth zones. If you have not reached this situation please capture another image. To do so, change the target orientation once again, capture the image and process it.
Then we can proceed to the next wizard page.

Calibrating
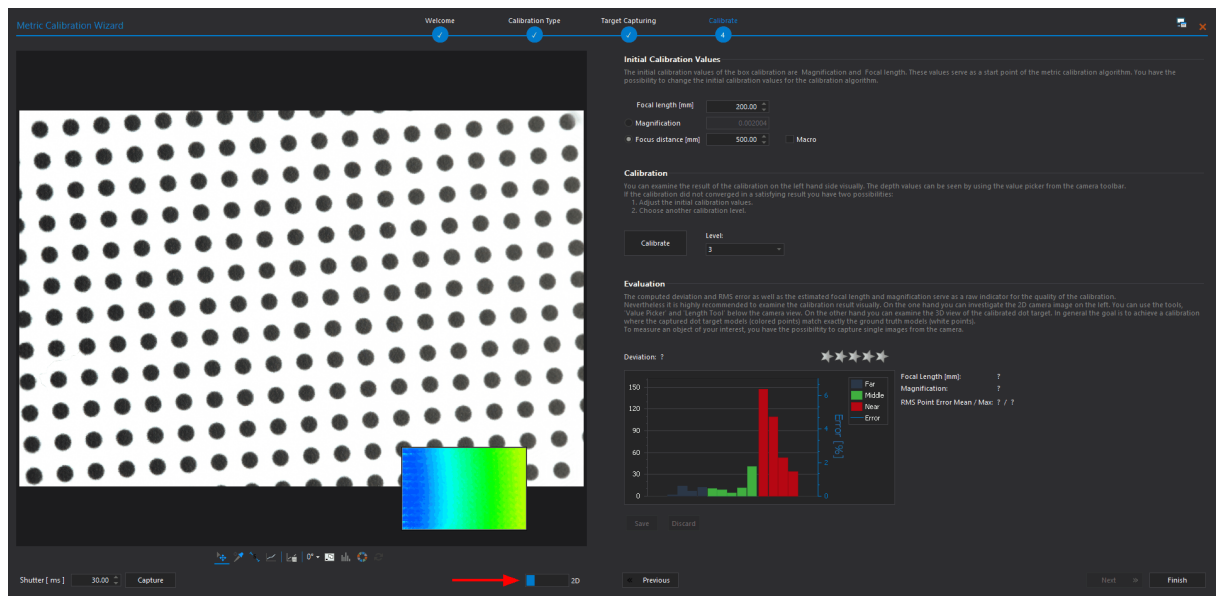
By changing from 2D to 3D mode you can have a look at the measured points (colored) and model points (grey). Our goal is that corresponding model points and measured points come as close together as possible. If you take a look at the upper left corner, you can see some grey model points far away from any colored point.
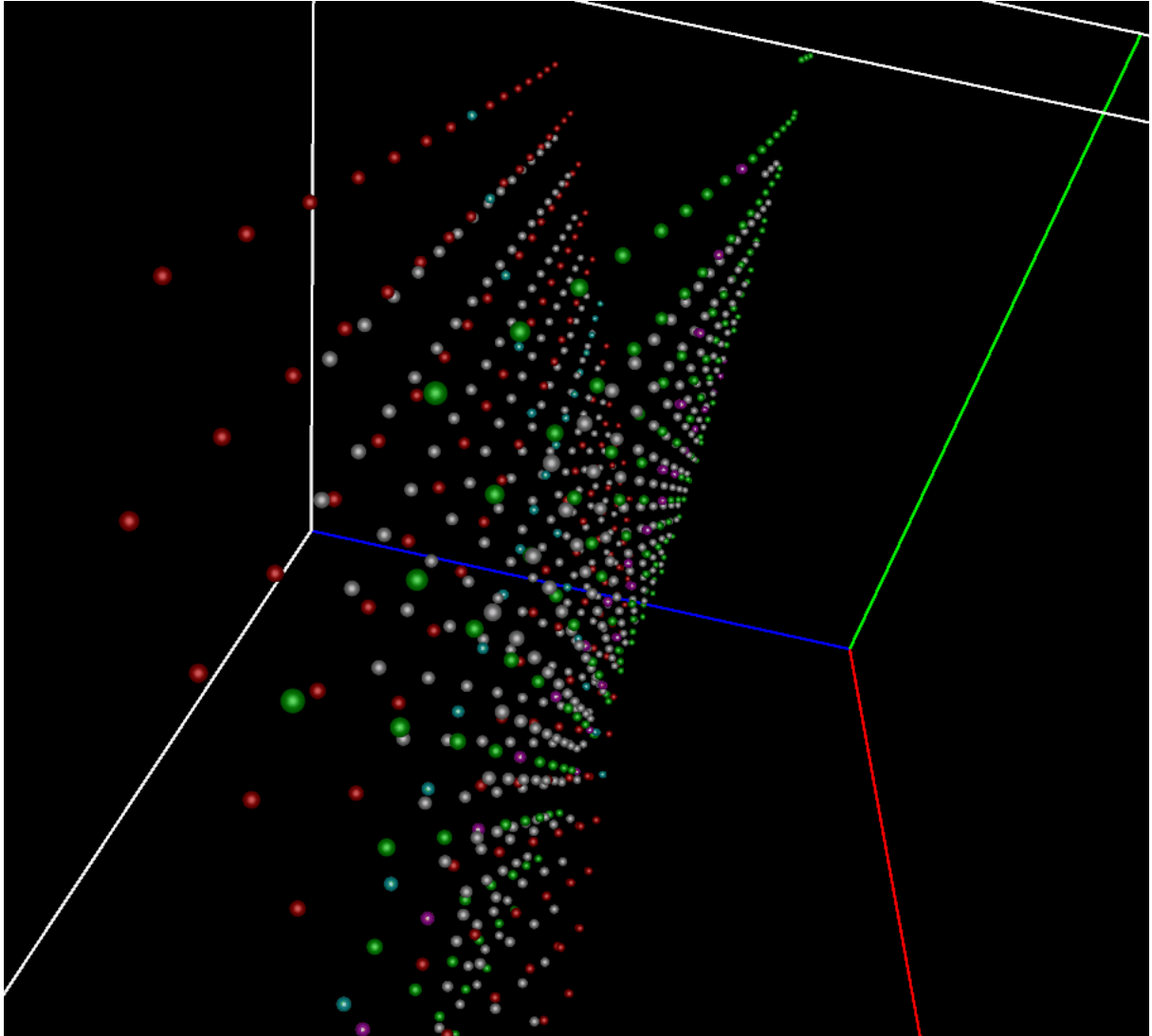
We have five different calibration level, that you can try at this point. Our standard choice is Level 3, because this one works with most optics in the best way. A detailed description of the 5 different level is given by a tool tip text you can find by clicking on this icon:

We keep "Level 3" for this case and click "Calibrate" and in the next step, we check our calibration result.

The Evaluation section gives you a first impression about the accuracy:

The Deviation 0,204% and the 5 stars indicate that the result is very good and you reached a very high accuracy.

Although the Calibration process finishes with success, there might be situations where the result is not good. So please take a close look at the following three parts, to verify, if the calibration is a good one:

1. What is the max. euclidean Distance between model and target points? (RMS Point Error Max) It should be less than 10 times the mean euclidean distance. Here it is 149,90 μm, which is a good result!

2. Does the 3D view look good? Do all model points match corresponding measured points?

Here is our example (you can change the point of view, by left click and moving the mouse. You can zoom in and out by right mouse click and moving the mouse back or forward):
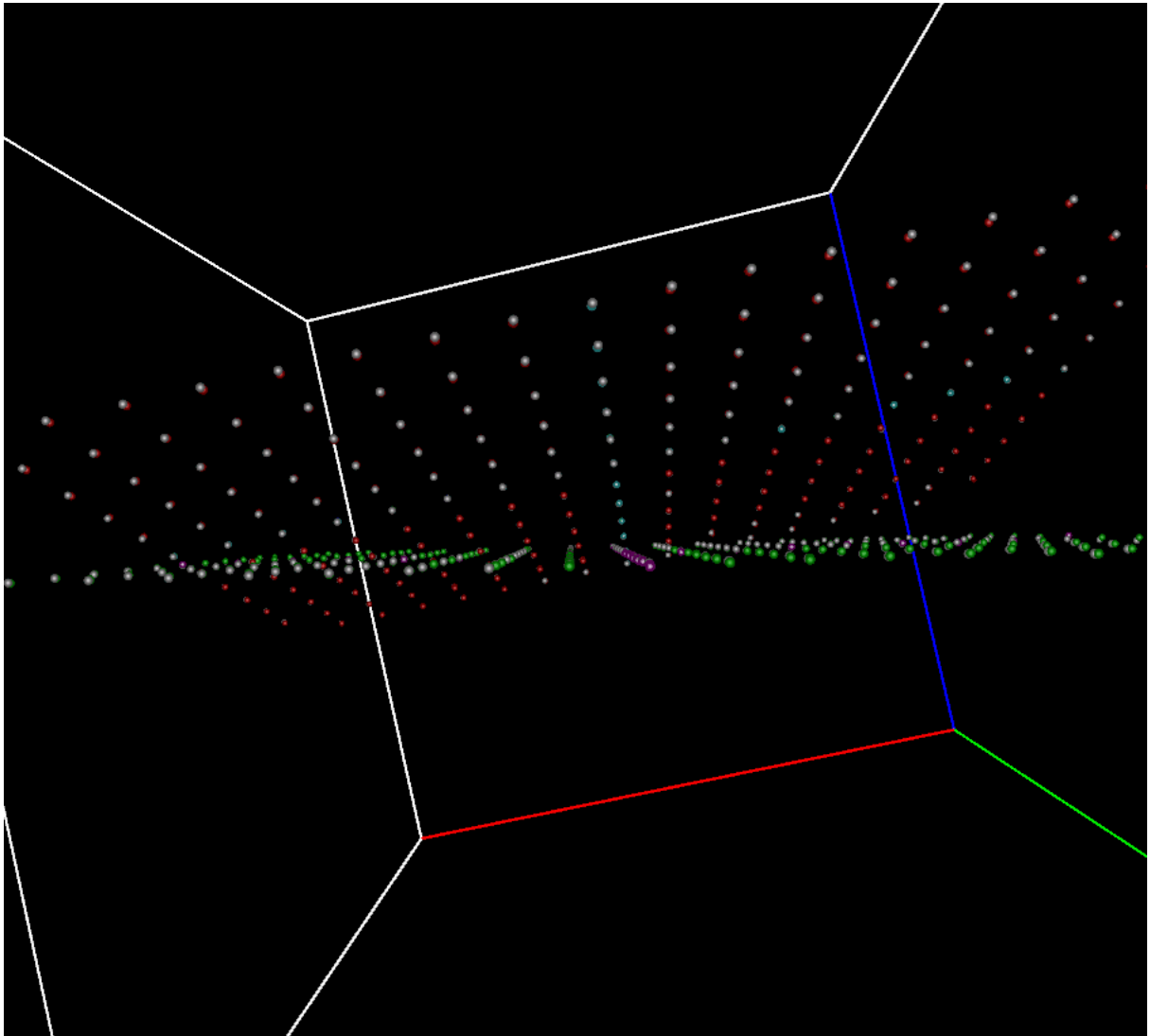
Colored (measured) and grey (model) points are very close together. Most of them even intersect each other, which is good.

3. As a last step, please go back to 2D view, to check your image and whether it looks distorted or not.
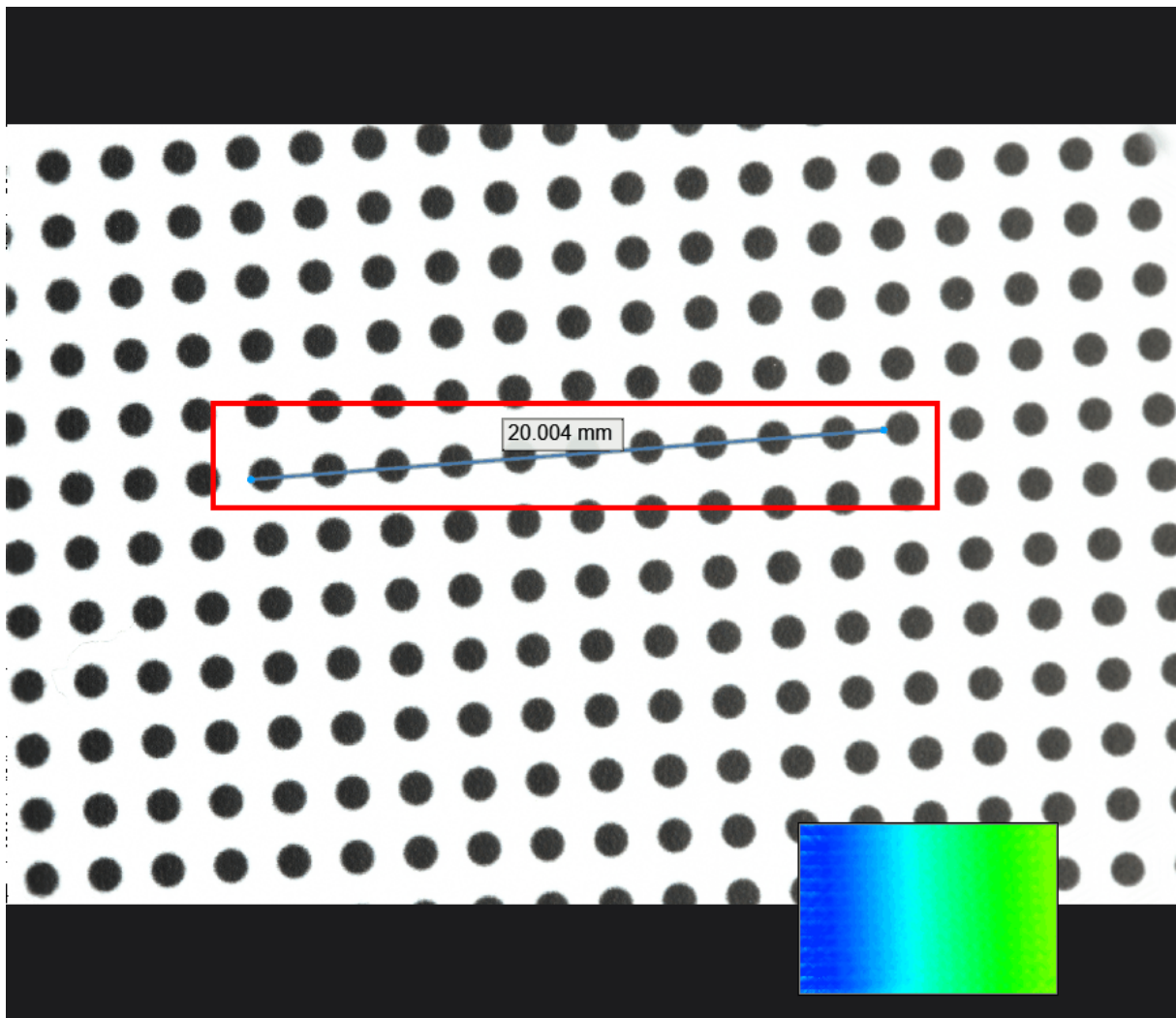
Here is our example:
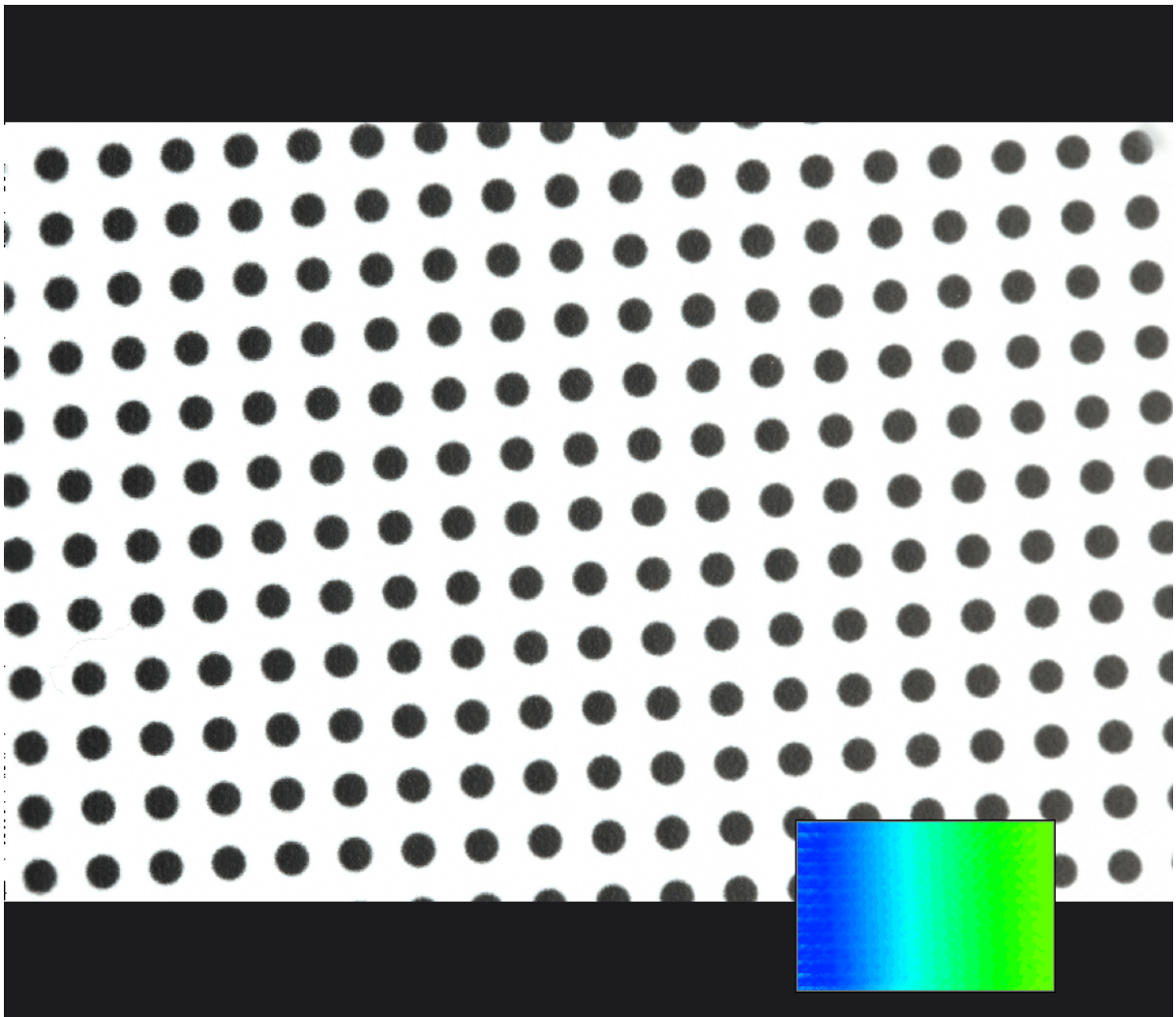
You can see, that the black dots are located on straight lines, so it doesn't look distorted. You can also check the distance, by measuring with our length tool.

Best to measure 10 points and divide the result by 10. The result should match your model point pitch.

The used model pitch was 2,000 mm and that's perfectly our measured result of 2,0004 mm (20,004 mm /10 points). So we can finish our metric calibration. To do so, we click "save" and afterward we finish the wizard.
Now your camera and main lens is fully calibrated for the current setting. If you change focus or aperture now, you have to repeat MLA calibration and metric calibration.

3   Using RxLive

RxLive is designed to control your camera, capture images, process them and save your results. It also allows you to change preprocessing and post processing parameters for specific images, to get the best quality.
To use RxLive, you always need your hardware dongle attached to your PC. For camera usage, please make sure, you've installed all necessary drivers and your system meets the requirements. If you like to develop your own software package, you can use our light field SDK. Furthermore, you can use our Halcon Plug-in, to use your light field system integrated to Halcon.

You can find detailed information in the following sections:

- Home Menu

- Main Page

- Parameter Settings

- Loading images

- File Export

3.1   Home menu

The home menu is the start page of RxLive. You can access this page with the home button. ![home] Here you can decide to open a camera or to Open File. If your PC is connected to the internet, the News Tab will give you our latest news. Documentation opens this user manual.
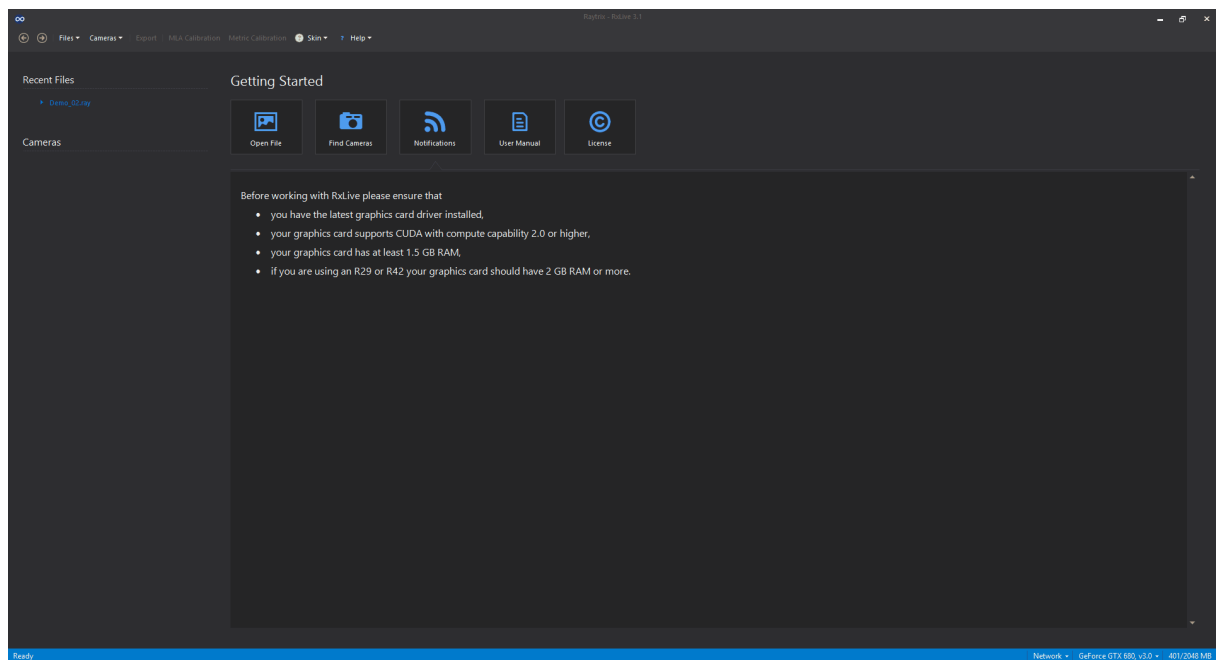
There is a status bar at the bottom where you can find information about your network settings and graphics card.

3.2   Main Page

The main page is the most important page in RxLive. Here you can control your camera, optimize your settings and from here you can access the MLA Calibration, Metric Calibration as well as the File Export.

In this section we will explain the view tabs, tool bars and menu bar.

View Tabs

Inside the View Tabs you can always zoom in and out by pressing the right mouse button and move the mouse back and forward.

Refocus

This is your standard view, when you open an image or camera. In this section we'll show screen shots with our Demo_02.ray. After opening an image you see the image in the "Refocus" tab. Here you can Refocus manually, using the focus slider.
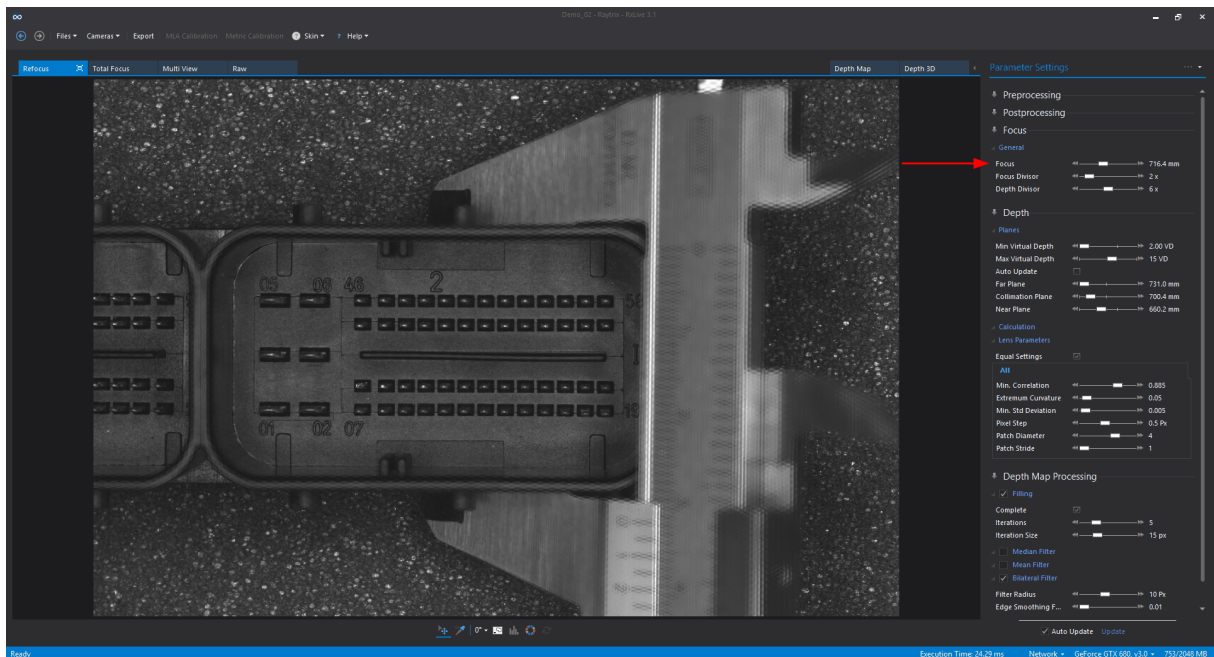
Total Focus

The Total Focus Tab shows your image focused on the calculated depth map. Therefore your Total Focus image is depended to your Depth Map. Only good Depth Maps can give you a nice Total Focus image.

Multi View

Multi View shows your image from different views. You can use this Tab together with anaglyph glasses for example to get a 3D impression. You can modify the views changing the Multi View Settings.

Raw

The Raw Tab shows the original image the camera captured. You can see the Micro
Lenses and if you're using a color camera, you can also see the bayer pattern.
In the drop down menu, you can switch to:
Gray, showing your gray image. The gray image is captured during MLA calibration.
Processed, showing your Raw image devided by the gray image and debayered (if
color is used)
Ray Depth, showing the Depth points calculated for each micro lens.
Raw Grid, showing the Processed image with the MLA grid overlay. The overlay is
calculated during MLA calibration process and should match the real micro lens images.
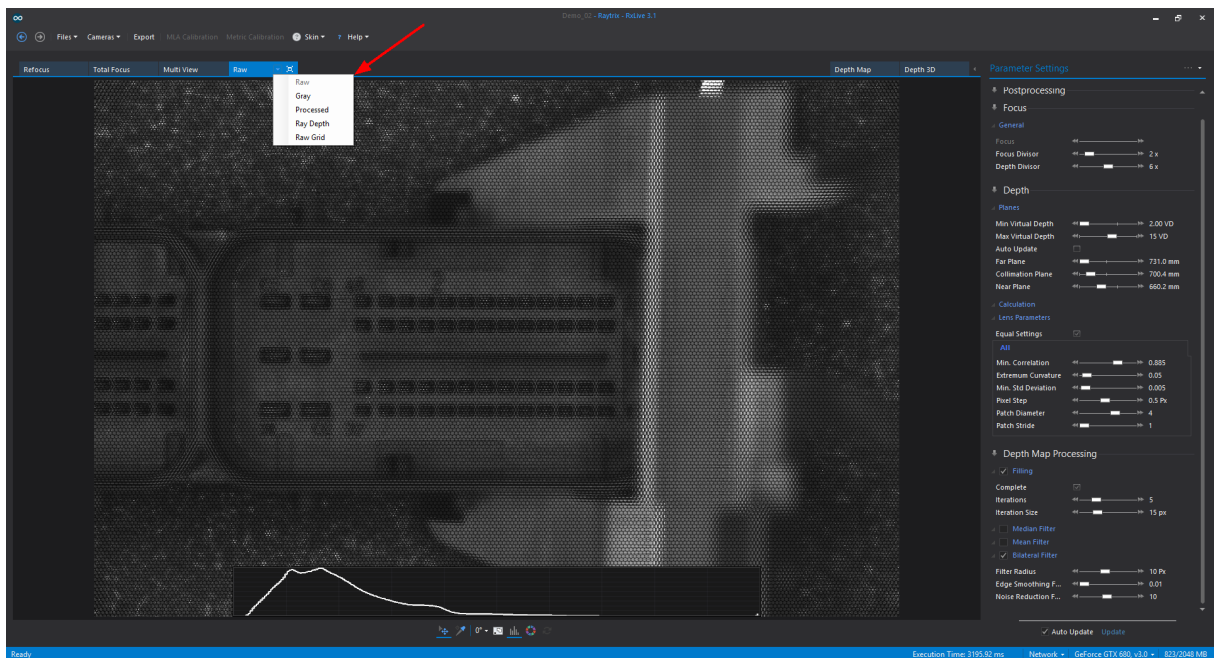

Depth Map

The Depth Map is shows the distance between camera and object as color coded
image. Blue is far away, red is close, green in the middle. You can adjust the colored
depth range by changing the settings for Depth Planes.
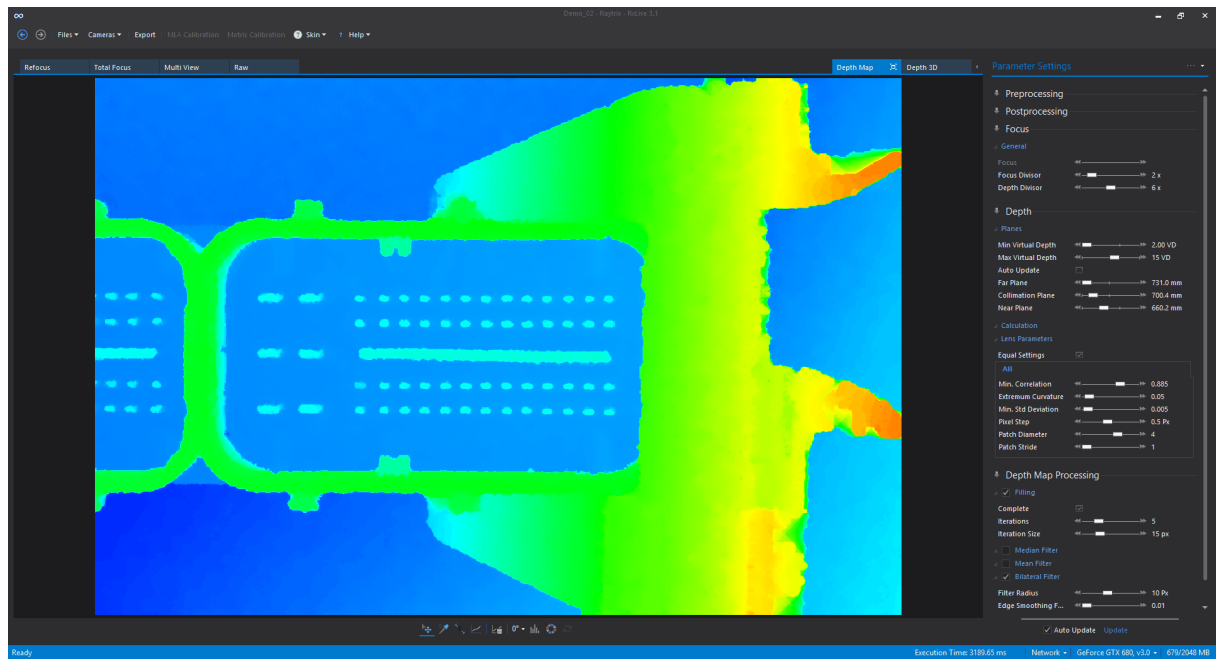
Depth 3D

Depth 3D shows you the 3D model. It combines the total focus image with the Depth Map and your metric calibration. If you have no metric calibration your Depth 3D and Depth Map is not to scale and distorted. Our Demo_02 image was captured with a fully calibrated R29 mono camera.

In Depth 3D Tab, you can move the model by holding Shift + right mouse button and mouse movement. Left mouse button and mouse movement rotates the model. Shift + left mouse button rotates around the z axis.
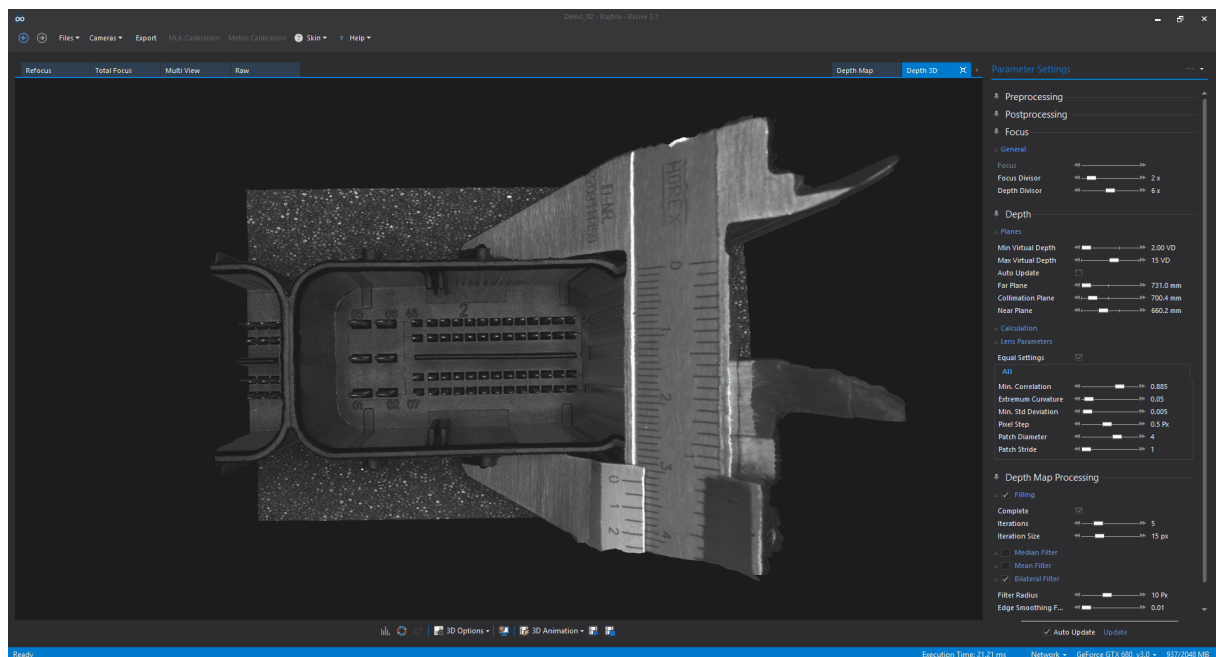
Tool Bars

RxLive provides different tool bars to measure inside the images, or to adapt the view settings. The Tool Bar can be found below the image.

Attention: The shown results depend on the View Tabs. Furthermore some tools can return values in mm. They are only accurate if you have a Metric Calibration. Their accuracy depends on a good 3D estimation as well as on the accuracy of your metric calibration.

Refocus, Multiview, Raw, Grey, Processed, Raw Depth, Raw Grid have this tool bar:

Icon	Feature
	Moving the image. By left mouse click you can move the image.
	Value Picker. Returns RGB or Luminance value of the picked point normalized to 0-100.
0° ▾	Rotating image clockwise in 90° steps. The drop down menu gives you a short cut to all available orientation.
	Blinking. Enables overexposure blinking in red and underexposure blinking in blue.
	Histogram. Gives you a RBG or Luminance histogram. A histogram shows the global distribution of values, here brightness. Left dark, right bright.
	Background color. Here you can choose your preferred background color.
	Reset view. Resets movement and zoom.

Total Focus has this tool bar: (**differences marked bold**)

Icon	Feature
	Moving the image. By left mouse click you can move the image.

	Value Picker. **Returns distance from focal plane parallel to optical axis in mm or virtual depth (VD).**
	Length measurement. Returns euclidean distance between start and end point in mm or virtual depth.
	Cross section line. Gives you difference to end value as well as a cross section line.
	Saving current cross section line. You can save the values of current cross section line as comma separated value.
	Rotating image clockwise in 90° steps. The drop down menu gives you a short cut to all available orientation.
	Blinking. Enables overexposure blinking in red and underexposure blinking in blue.
	Histogram. Gives you a RBG or Luminance histogram. A histogram shows the global distribution of values, here brightness. Left dark, right bright.
	Background color. Here you can choose your preferred background color.
	Reset view. Resets movement and zoom

Depth Map has this tool bar: (**differences marked bold**)

Icon	Feature
	Moving the image. By left mouse click you can move the image.
	Value Picker. **Returns distance from focal plane parallel to optical axis in mm or virtual depth (VD).**
	Length measurement. Returns euclidean distance between start and end point in mm or virtual depth.
	Cross section line. Gives you difference to end value as well as a cross section line.
	Saving current cross section line. You can save the values of current cross section line as comma seperated value.
	Rotating image clockwise in 90° steps. The drop down menu gives you

	a short cut to all available orientation.
	Histogram. **Gives you a distance histogram. A histogram shows the global distribution of values, here distance. Left close to focal plane, right close to the camera.**
	Background color. Here you can choose your preferred background color.
	Reset view. Resets movement and zoom

Depth 3D has this tool bar:

Icon	Feature
	Histogram. Gives you a distance histogram. A histogram shows the global distribution of values, here distance. Left far away, right close to the camera.
	Background color. Here you can choose your preferred background color.
	Reset view. Resets movement, rotation, depth scale and zoom
3D Options	Resolution ▶ Structure ▶ Texture ▶ Depth Scale ▶ Planes ▶ Projection ▶ Here you can change the appearance of the model.
	Saves the current view as picture.
3D Animation	✓ Ping-Pong Animation / 360° Rotation / Continuous Rotation / Half-Sphere Here you can select different animation modes.

	Starts the selected animation.
	Stops the current animation.

At the bottom of RxLive there is a Status Bar, giving you some information about your system:
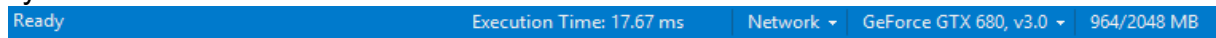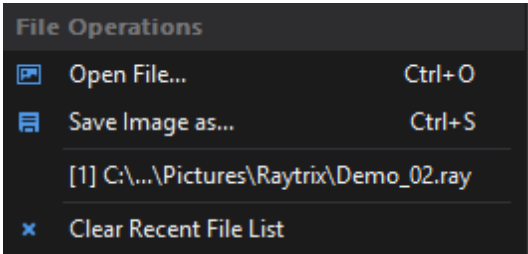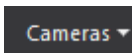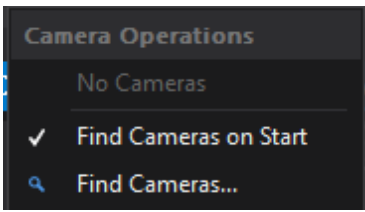
The Dongle gives shows your available hardware dongle features, the Network section shows your network card settings. This is very helpful for gigabyte ethernet cameras. The next part gives you information about your graphics card used in your PC. The fourth one shows your used and available graphics card memory. At the very right you can see the current camera capture frame rate, if a camera is attached.
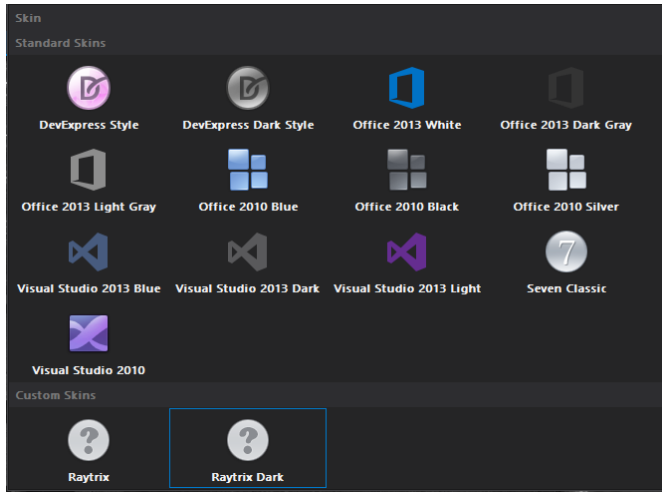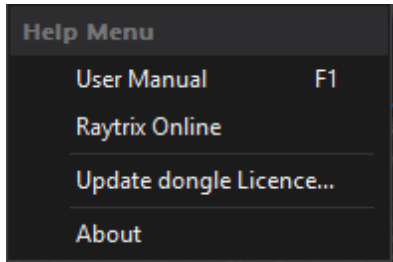
Menu Bar

The Menu Bar can always be found at the top of RxLive.
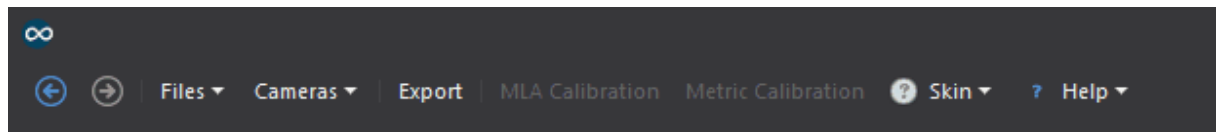
Icon	Feature	
	Back to Main Page	
	Back to Home Menu	
		Loading images or recent files ([1], [2]). Close closes RxLive.
		Here you can find and select attached cameras.

Export	<u>Exports</u> data from current image.
MLA Calibration	Starts the <u>MLA Calibration</u> wizard.
Metric Calibration	Starts the <u>Metric Calibration</u> wizard.
? Skin ▾	Here you can choose your preferred Skin.
? Help ▾	Here you can find Infromation about the Software, Update your dongle, visit <u>www.raytrix.de</u> or open this manual.

3.3   Parameter Settings

The Parameter Settings can be found at the right side of RxLive. Setting the parameters is a very important step to get good results. In the following section we'll describe each setting.
At the bottom of the Parameter Settings you can find "Auto Update" and "Update". If auto update is active, every change of settings will be calculated directly. This might take some time. If you disable auto update new calculations can be forced by clicking "Update".

Preprocessing

The preprocessing parameters are used to calculate the <u>Processed</u> image from Raw and Grey image.

Gradiation Line	Here you can adjust the contrast
Denoise	Denoise algorithm which might improve your results
Sharpening	Sharpens the image. Very helpful for depth calculation. Per default it is only used for calculation of depth.
Color	Adjusting the color channels of your camera. (Only color cameras)

Postprocessing

Here you can crop down your image, by simply moving the four borders.
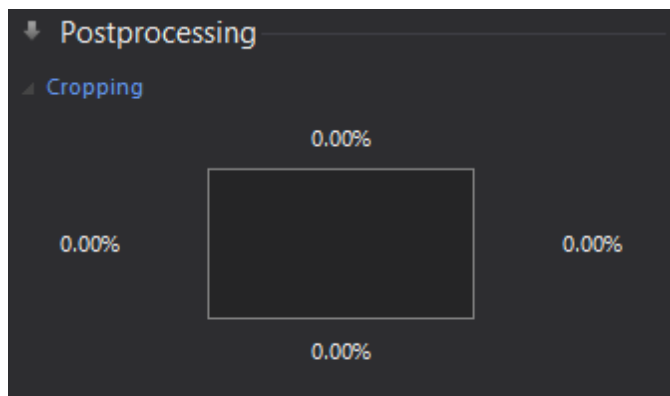
Focus

Focus	In Refocus Tab you can refocus manually
Resolution Deivisor	Divides the image resolution to generate lower resolution images
Auto Update	Updates the Depth Planes automatically. The depth planes are used for coloring your depth map and adjust the view parameters for Depth 3D and Multi View
Far Plane	Furthest away plane, from camera. Only objects between far and near plane will be shown in Depth Map, Total Focus and Depth 3D
Collimation Plane	Only for Multi View. Sets the "Monitor Plane". Everything further away from camera than the collimation plane appears inside the monitor. Everything between collimation plane and camera appears in front of the monitor.
Near Plane	Nearest plane to camera. Only objects between far and near plane will be shown in Depth Map, Total Focus and Depth 3D

Multi View

Eye Separation (only in Multi View Tab)	Sets the distance between your eyes.
Stereo Mode	Sets your type of stereo.

Depth

Calculation

Max Virtual Depth	Sets the closest plane, which can be calculated.
Near Resolution	Sets the effort made for close objects. The higher the value, the more calculations will be made for calculating depth of close objects. High values increase the processing time.
Sparse Lenses	Disables half of the near lenses. Reduces number of depth estimations and processing time.
Micro Lens Border	You can adjust the Micro Lens Border. The micro lens border is initially set during MLA Calibration.

Lens Parameters

Min. Correlation	This parameter indicates how good the correlation between two patches has to be to be considered as a correspondence. It is a value between 0 and 1, where 1 means that only perfect correlations are considered as correspondence and 0 would yield in each patch corresponding to every other patch.
Extremum Curvature	As the algorithm always searches for extrema in the correlations of several patches, it is important that the found extremum is rather significant. If the extremum curvature is high, this means only large peaks are accepted as extremum. On the other hand, if the extremum curvature is low, small elevations already are considered an extremum.
Min. Standard Deviation	It is not useful for the evaluations to calculate correlations of homogeneous areas as they cannot be distinguished. The minimum standard deviation refers to the standard deviation within a correlation patch. An image patch should provide a minimum amount of structure to obtain a reliable result when looking for correspondences. When increasing this value, less patches are

	considered for evaluations, correspondingly when decreasing the minimum standard deviation, you gain more data but the additional data is less trustworthy.
Correlation Patch Diameter	In the depth estimation algorithm, parts of the micro lens images, so called patches, are examined. The goal is to determine where a patch of one micro lens can be found in the neighboring micro lens. The size of these patches is adjusted by the "Correlation Patch Diameter" parameter.
Pixel Step	The pixel step defines the overall depth resolution and is between 0 and 1. The lower this value is set the finer the resolutionbecomes but again with more computing time.
Correlation Patch Stride	This value defines the distance between two observed correlation patches. Setting the parameter to 1 yields in a lot of data to be processed with possibly good results. Setting it to the same value as the correlation patch diameter yields in no overlap of considered correlation patches and low computing time.

Depth Map Processing

Complete Fill	Enables complete depth map filling.
Number of Iterations	Sets how often the fill algorithm will be aplied. (Number of iterations = 0 and NO "complete fill" can be used as consistency check)
Iteration Size	Sets the fill size for each iteration.
Median Filter	Applies a median filter, using the set median filter radius.
Mean Filter	Applies a mean filter (averaging), using the set mean filter radius.
Filter Radius	Sets the Bilateral filter Radius. A bilateral filter is a smart filter reducing noise and keeping edges sharp.
Edge Smoothing Factor	Threshold to distinguish between real edges and noise. The higher the value, the bigger edges will be smoothed.
Noise Reduction Factor	Sets the strength of Bilateral Filter.

3.4 Loading Images

You can open .ray files, or .rays sequences, which were saved with RxLive, or via the SDK.

The open file menu can be found in the Menu Bar or on the Start Page.

.ray file is a single image. Inside the .ray you have all image information including the grey and raw image, as well as all settings.
.rays are multiple images, like a video, where you also have all image information including the grey image, all raw images, as well as the parameter settings.

3.5 File Export

The file export Tab is structured in 4 sections:

- Lightfield
- Image
- Depth
- Data

Lightfield

Ray File	Save the Ray image including all data in the intern ray image format. This allows later refocusing and depth estimation with RxLive.
Sequence	Save some images as sequence including all data in the intern rays format. This allows later refocusing and depth estimation with RxLive.
Trix	3D Image container file for Raytrix Viewer App.

Image

Raw Image	Save the Raw image containing the unprocessed micro lens images.
Processed Image	The processed image is the processed raw image. Depending on your settings, image enhancements filters and the white image is applied.
Multiview Image	The stereo image is a red/cyan false color image.
Calibration Grid	The raw image and a virtual mla grid painted on it
Grey Image	The gray image used to eliminate vignetting in the preprocessing step
Total focus	A depth estimation is applied, and the focus is set on a per pixel basis. As a result this is an image with max. focus on every surface

Colored Depth Map	This is a false color coded depth map
Basic Refocus	An image where a specific plane is in focus, while areas outside that plane are defocused

Depth

Depth 3D Image	.tiff file where for each pixel you can find x (mm) in Red channel, y (mm) in Green channel and z (mm) in blue channel.
Depth Map	.tiff file, where for each pixel you can find z (mm) as 16 bit value.
Raw Depth Map	Raw depth estimation after estimation without fuse

Data

3D Mesh (PLY)	Builds a mesh from 3D map containing color information from your Total Focus image.
3D Mesh (STL)	Builds a mesh from 3D map.
3D Points (XYZ)	Exports the estimated depth values in a text file. This files can be viewed with external tools (e.g. Meshlab)
3D Points (PCD)	Exports the estimated depth values in a .PCD File (Point Cloud Data). This files can be viewed with external tools (e.g. Meshlab)
Calibration File	XML File containing the camera calibration.