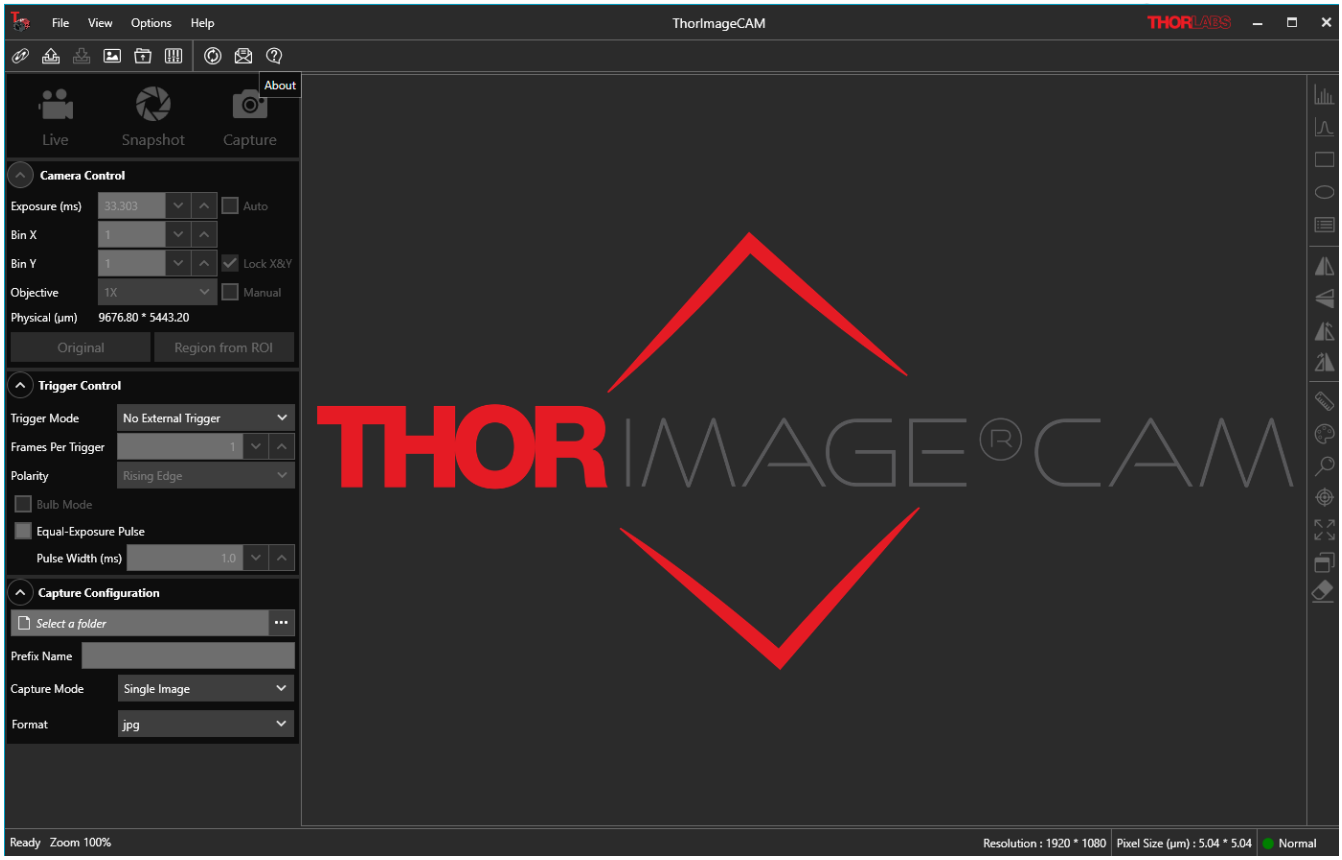
ThorImage®CAM

User Guide



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Chapter 1 Introduction

1.1 Intended Use

The ThorImage®CAM software is intended to be used as an image acquisition tool for Thorlabs' Scientific CMOS Cameras, such as the Zelux®, Kiralux®, and Quantalux® families of USB 3.0 cameras. The product may only be used in accordance with the instructions described in this manual. Any other use will invalidate the warranty.

ThorImageCAM does not support older Thorlabs' Scientific Cameras such as the DCx or CCD families and is not supported by 32-bit versions of Windows. Users operating these should use Thorlabs' legacy software, ThorCam®.

1.2 Explanation of Safety Warnings

Below is a list of warning symbols you may encounter in this manual.

Caution: Risk of data loss and damage to operating system

1.3 Description

ThorImageCAM is a powerful image acquisition software package that is designed for use with Thorlabs' Scientific CMOS Cameras on 64-bit Windows® 10 or 11 systems. The Graphical User Interface (GUI) communicates with the camera to provide system control, image acquisition, and image review. It also includes a selection of image analysis tools and statistics to assist users in their experiments.

1.4 Recommended System Requirements

Recommended System Requirements[a]	
Operating System[b]	Windows® 10 (64 Bit) or 11
Processor (CPU)	≥3.0 GHz Intel Core i5 or Higher
Memory (RAM)	≥8 GB
Hard Drive	NVMe Solid State Drive (SSD)
Graphics Card	Dedicated Adapter with ≥256 MB RAM
Connectivity	Internet Connectivity for Driver Installation
Motherboard	USB 3.0 (-USB) Cameras: Integrated Intel USB 3.0 Controller or One Unused PCIe x1 Slot (for Item # USB3-PCIE)
Additional Software	Visual C++ Redistributable for Visual Studio 2015 - 2022 (x64) and Microsoft .NET Desktop Runtime 6.0.4 (x64) or a later version are required. The installation program will check and download them from the internet if necessary.

a. ThorImageCAM does not support previous generation Thorlabs' cameras such as DCx or Thorlabs' Scientific camera (CCD) line. For those using Thorlabs CCD or DCx cameras, use the legacy software, ThorCam.

b. ThorImageCAM is only supported by 64-bit versions of Windows. For those operating 32-bit versions of Windows, use the legacy software, ThorCam.

Chapter 2 Safety

Please read the instruction manual for your Thorlabs cameras carefully before using them with ThorImageCAM. All statements regarding safety and technical specifications will only apply when the unit is operated correctly.

Chapter 3 Installation

3.1 Warranty Information

The system must meet the system requirements listed in Section 1.4 to achieve optimal performance. Only use accessories provided by Thorlabs to connect hardware to the system. Any modification or servicing by unqualified personnel renders the warranty null and void, leaving Thorlabs free of liability. Please contact techsupport@thorlabs.com for questions on customization.

3.2 Installation Instructions

***Note**: Please note that ThorImageCAM is only supported by 64-bit versions of Windows.*

Verify that you have the proper operating system prior to beginning the installation process.

1. Double click on the **Setup.exe** ThorImageCAM_V1.0.7_Setup.exe located in the folder where the software file was downloaded. Click **Yes** to begin the installation process.

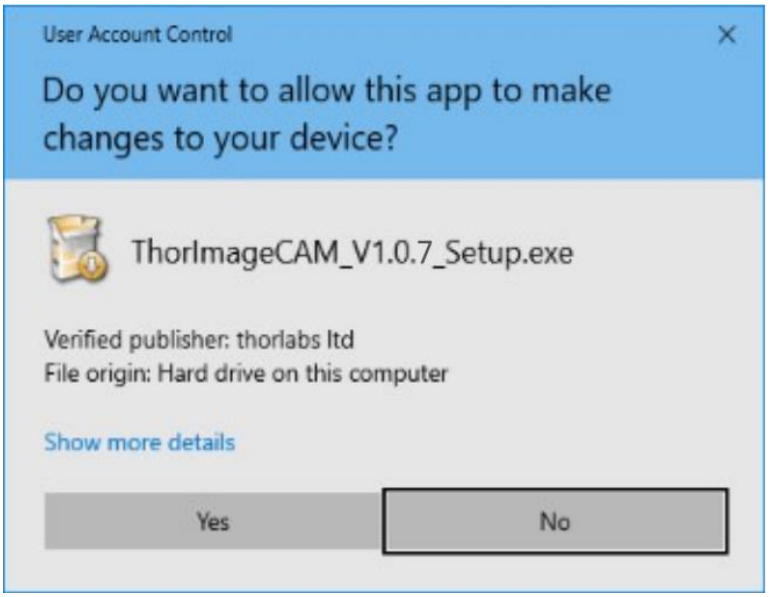


Figure 1 Start Installing

Please note the current software version may be different from the version in the screenshot.

2. Click **Next** to install the ThorImageCAM program.

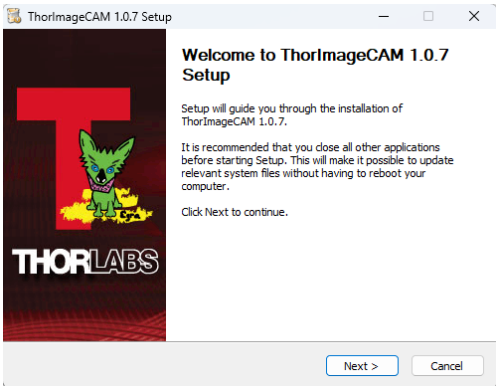


Figure 2 ThorImageCAM GUI Installation

3. Please read and agree to the License Agreement to continue.

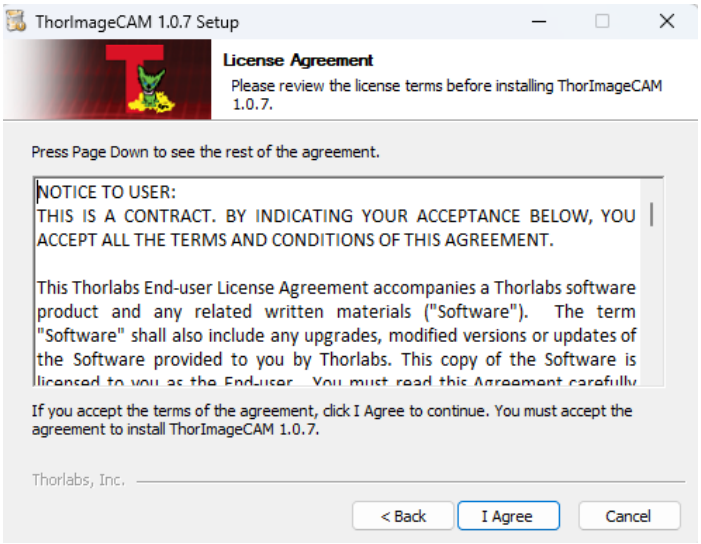


Figure 3 Thorlabs License Agreement

4. Choose a destination folder on your computer or use the default folder provided and click **Install** to install.

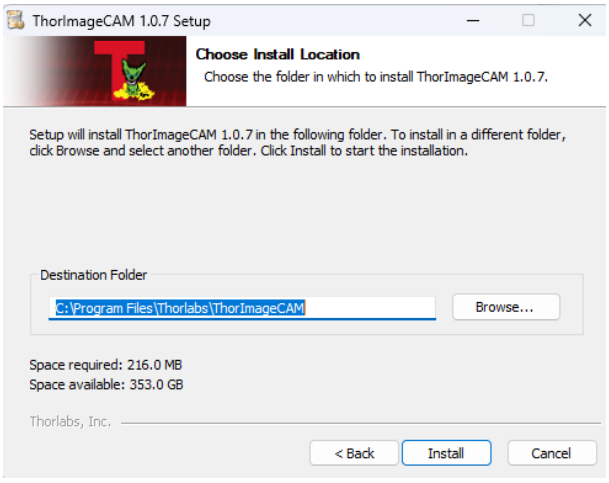


Figure 4 Select Destination for Installation

5. ThorImageCAM requests the .NET Windows Desktop Runtime 6.0.4 or higher and VC runtime 2019 X64 14.29.30133 or above. If they are not installed on your system, the ThorImageCAM installer will automatically install them.

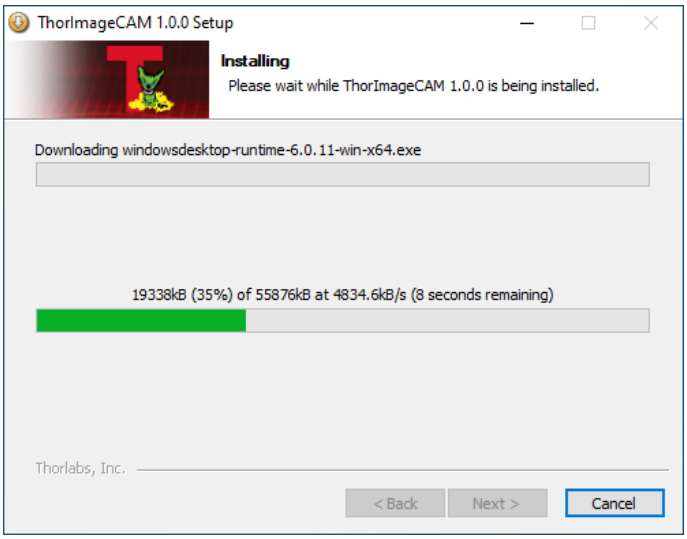


Figure 5 Install Shield Wizard

6. Click **Install** when the download is complete.

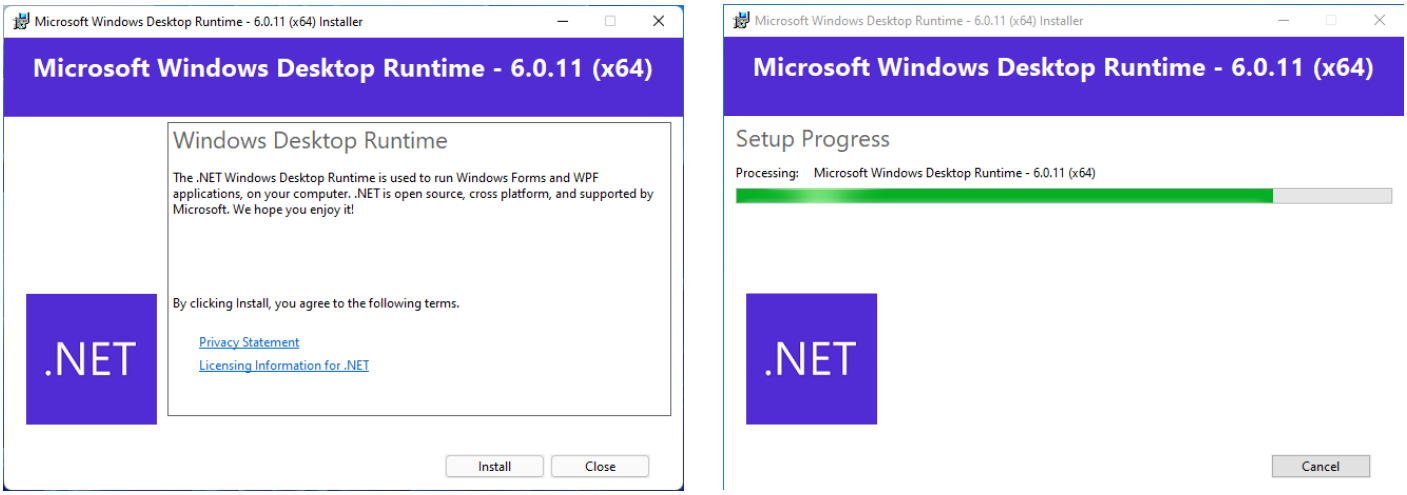


Figure 6 .NET Runtime Installation

7. Click **Close** once the installation of the .NET runtime has completed.

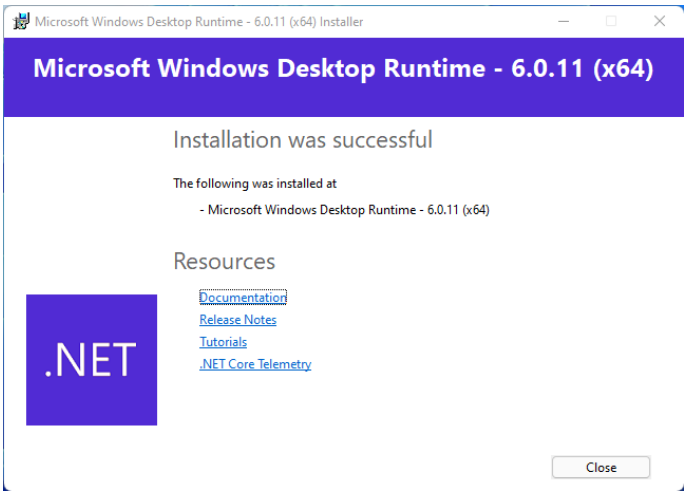


Figure 7 Successful .NET Runtime Installation

8. Follow the instructions to install VC Runtime.

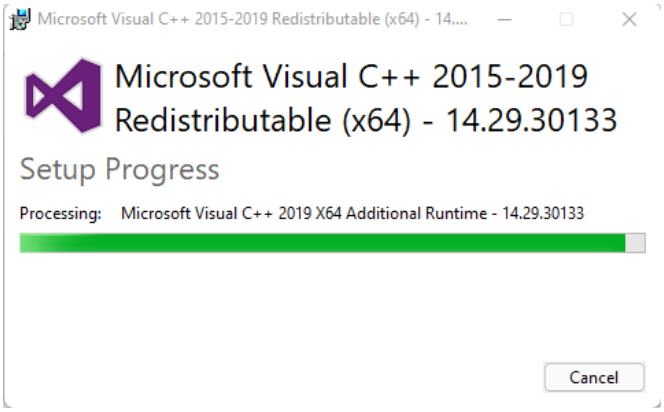


Figure 8 Visual C++ Installation

9. Click **Install** to install the camera drivers.

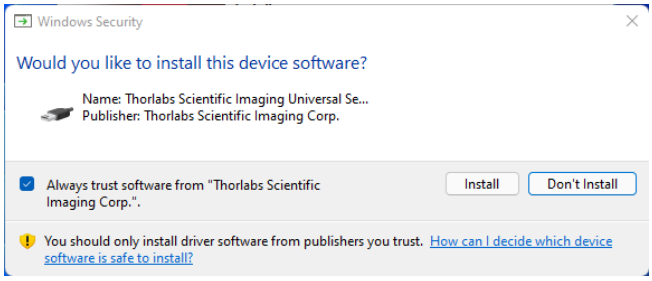


Figure 9 Camera Driver Installation

10. When successfully installed, click **Finish** to complete the installation process. ThorImageCAM is now ready to use.

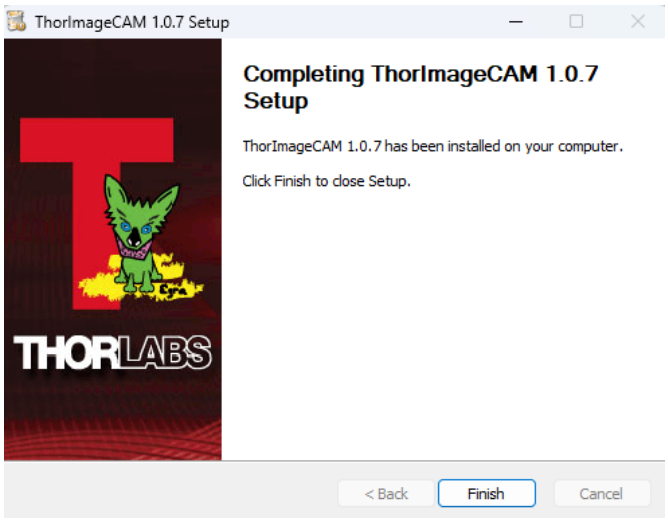


Figure 10 ThorImageCam Installation

Chapter 4 Operation

4.1 Launching the Application

To launch the ThorImageCAM application, select the icon from the desktop.

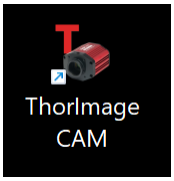


Figure 11 ThorImageCAM Application Icon

If multiple cameras are connected, the window shown in Figure 12 will appear prior to the main window opening. The camera highlighted in blue is the selected camera and pressing **OK** will open that camera in the main window.

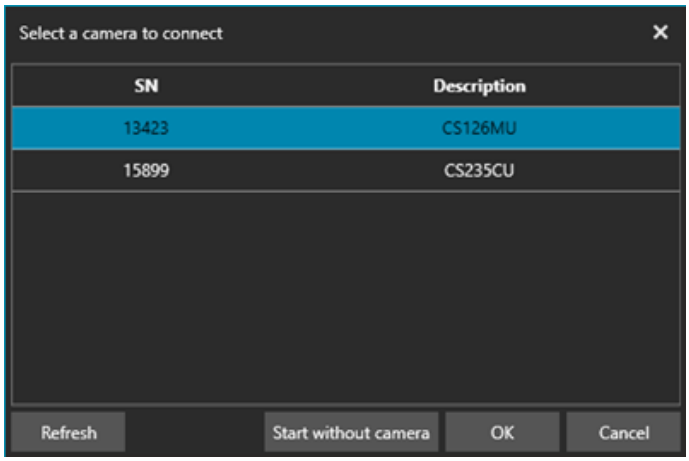


Figure 12 Connection Window with Two Cameras Detected

The user can switch the camera at any time from the Main Window (see Figure 17) by pressing the **Connect** button and reselecting from the available cameras. See Section 4.2 for more information on the features and operation using the Main Window.

When working with multiple cameras, the camera that is currently connected to the ThorImageCAM software will be shown in gray, see Figure 13. The camera that is chosen to be connected will be highlighted in blue. Selecting **OK** will connect the camera and open it in the Main Window. All other cameras will be displayed in white text. Selecting any camera in the list will highlight it blue enabling it to be connected.

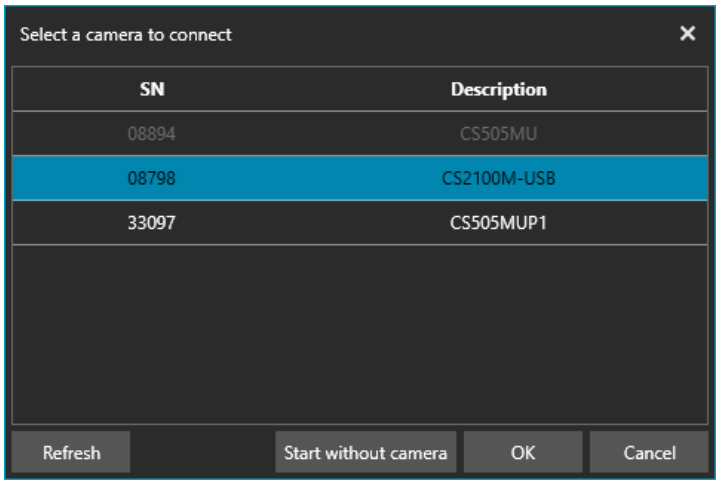


Figure 13 Selecting a Camera with Multiple Cameras Detected

If the camera does not appear in the list of cameras to select, check that the power supply is turned on and the camera is properly connected to the computer. The ThorImageCAM application can also be run without having a camera selected by selecting the **Start without camera** button shown in Figure 14.

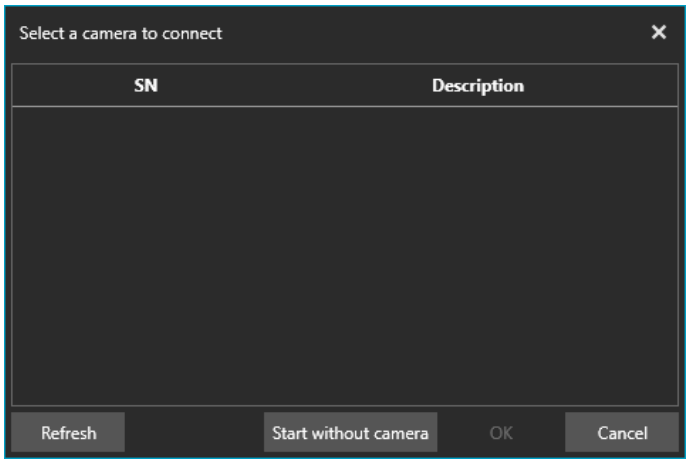


Figure 14 Connect Window with No Camera Detected

Select **Refresh** to check for the presence of the camera.

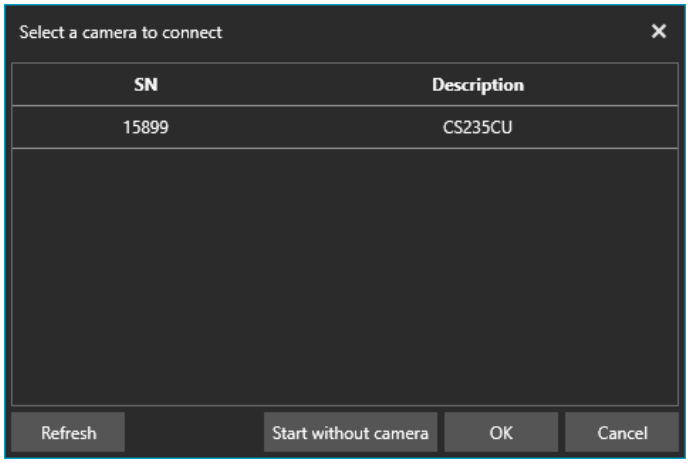


Figure 15 Connect Window with One Camera Detected

Once the camera is detected, the camera can be connected by selecting the camera and clicking **OK**. Any camera can be operated after connecting to it via this menu. Each time a camera is connected, the following image will appear for a moment:

Figure 16 Startup Splash Screen

Then the main window for the chosen camera will appear.

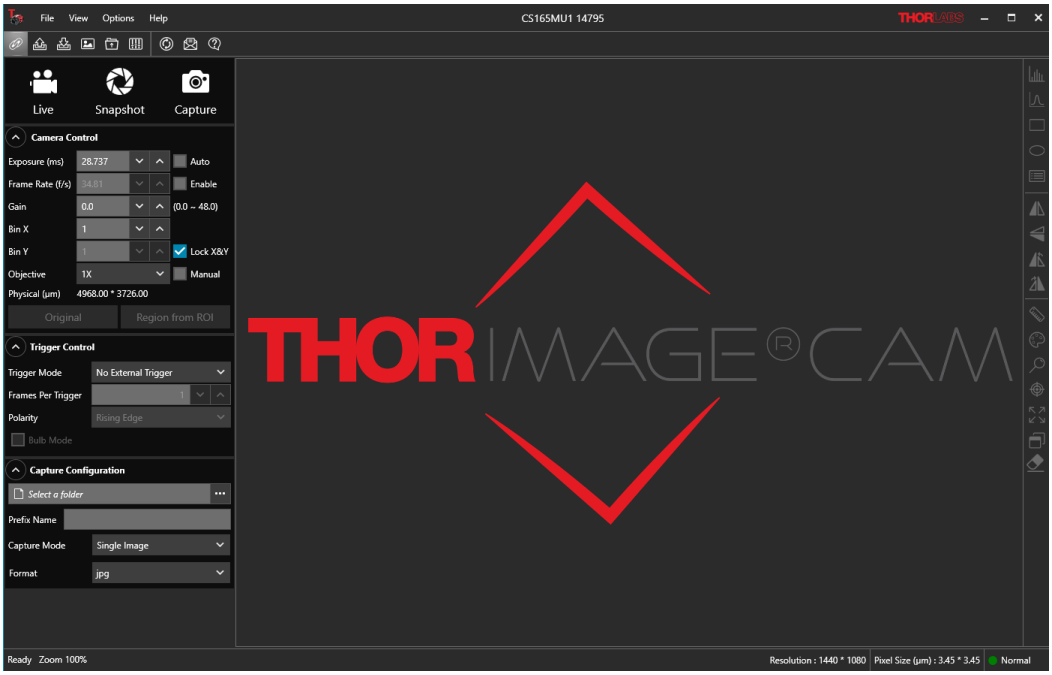


Figure 17 Main Window

When the **Start without camera** button is selected, the main window will be shown as displayed in Figure 18, but the camera functions will be disabled.

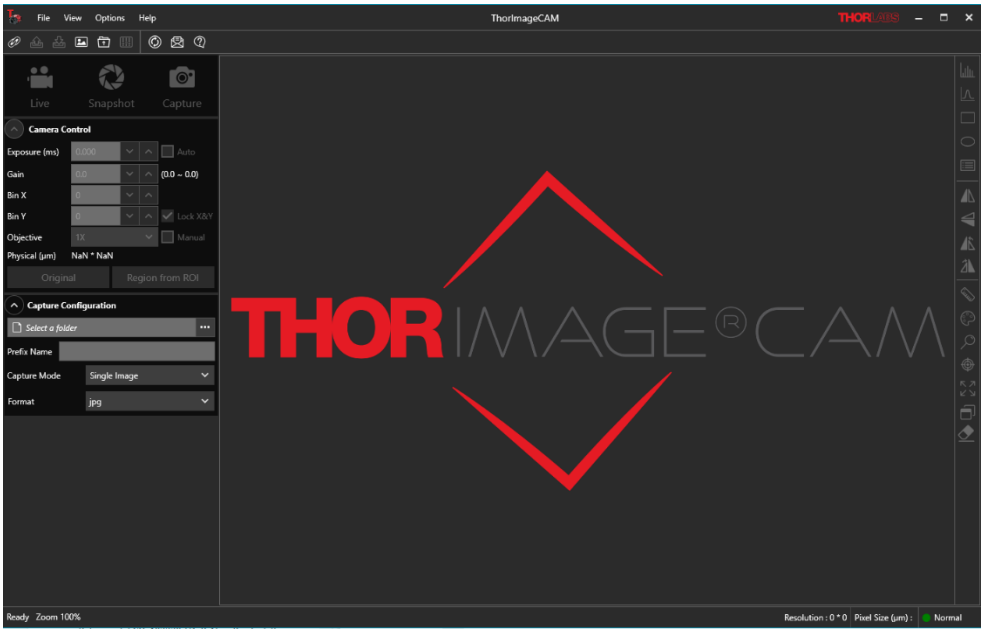


Figure 18 Main Window Without Camera

4.2 General Control

Figure 19 Title and Ribbon Bar

- A1 - **File** Menu: Includes basic file menus such as **Load Configuration**, **Save Configuration**, **Load Image**, **Load Experiment**, **Recent**, and **Close**. The secondary menu, **Recent**, contains a list of the 10 most recently opened images.

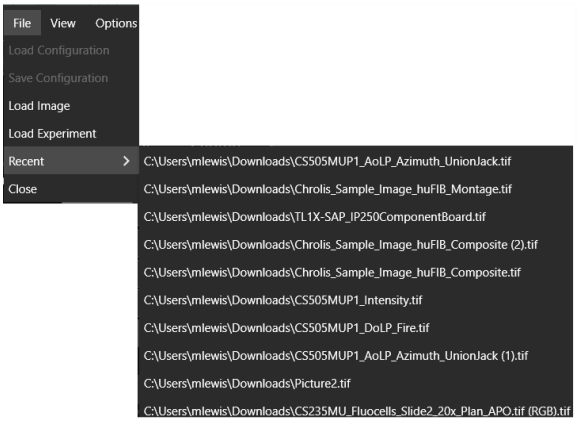
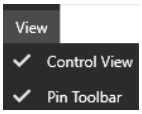


Figure 20 File Menu

- A2 - **View** Menu: Toggle the Visibility of the Control View Panel and the Pin Toolbar
- A3 - **Options** Menu: Includes the **Calibration**, **Settings**, **Language**, and **Theme** Items
- A4 - **Help** Menu: Includes the **Update**, **Support**, and **About** Items



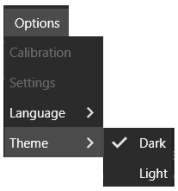


Figure 21 View Menu ***Figure 22 Options Menu*** ***Figure 23 Help Menu***

- A5 - Camera Model and Serial Number
- A6 - Thorlabs Logo: Click to Open Thorlabs' Website Homepage
- A7 - Minimize Window
- A8 - Maximize/Restore Window
- A9 - Close the Program

- B1 - **Connect** Button: Opens the Camera Connection Menu Described in Section 4.1
- B2 - **Load Configuration** Button: Opens the file explorer and allows all the saved configurations, saved as JSON files, to be quickly loaded.
- B3 - **Save Configuration** Button: Opens the file explorer and enables the user to save the configuration of the currently connected camera into a JSON file.
    - The configuration file includes all the current GUI parameters (Capture Configuration, Region Settings, Color Control settings, etc.), but does not contain specific camera settings. Camera specific settings are saved in the Experiment folder.
- B4 - **Load Image** Button: Opens the file explorer and allows access to view saved images in the ThorImageCAM GUI.
    - The Experiment.JSON file associated with the image must be loaded to perform accurate length measurements.
- B5 - **Load Experiment** Button: Opens the file explorer and allows saved experiments saved as folders to be quickly loaded. The folder being opened must contain an Experiment.JSON file and at least one image file to properly load the experiment.
    - The Experiment.JSON file only contains camera specific data (pixel size, objective setting, binning, exposure).
    - This is useful for when a user wants to load an image into the GUI and perform measurements with the correct pixel size to determine length values. This is also useful to recall the camera settings when an image was taken.
    - An Experiment.JSON file and image are created every time a “Capture” is performed.
- B6 - **Options** Button: Opens the Options Window Including the **Settings** and **Miscellaneous** tabs:

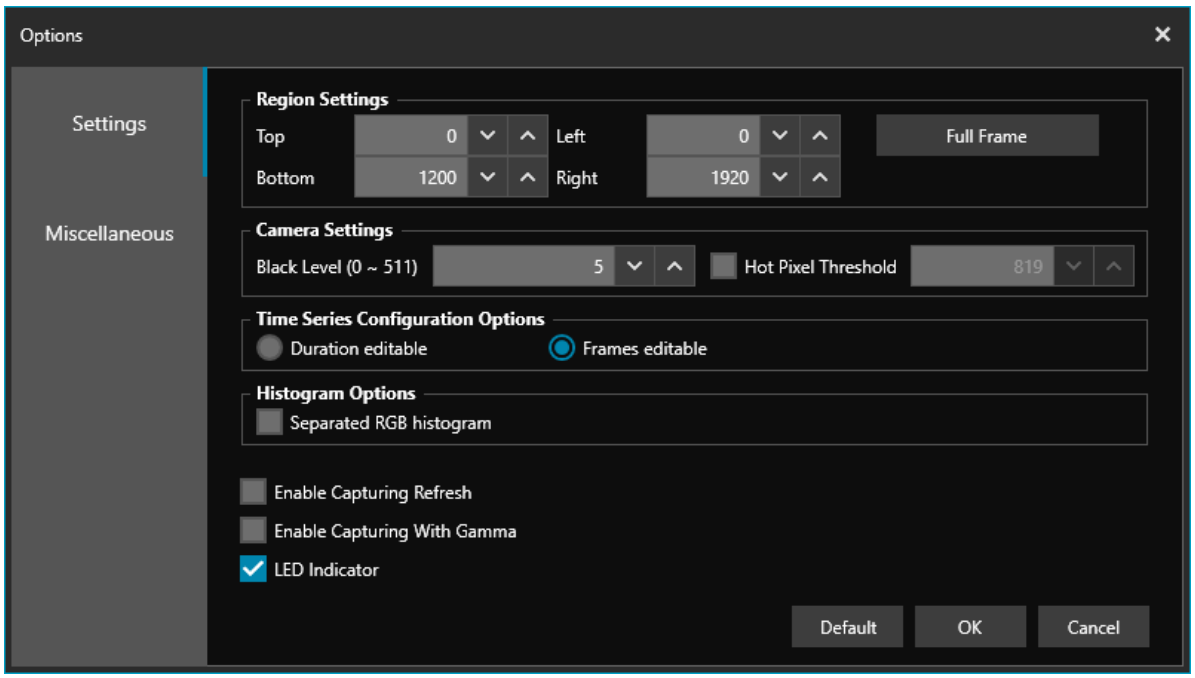


Figure 24 Settings in Options Tab

- **Settings**: Adjust the ThorImageCAM GUI Features and Camera Settings Shown in Figure 24.

- **Region Settings**: Provide pixel values for the Top, Bottom, Left, and Right to set a default rectangular area of the Region of Interest (ROI). The origin (0, 0) of the rectangular ROI is located in the top left corner. This ROI will then be the default ROI shown by the GUI. The **Full Frame** button resets the ROI to the maximum sensing area.
- **Camera Settings**:
    - **Black level** is the average image signal from the camera in the absence of light. Effectively, this adds an offset to pixel values. The black level control range depends on the camera model.
    - **Hot Pixel Threshold** is the parameter of the hot pixel correction function that identifies and corrects pixels that are much brighter than their surrounding pixels. Hot pixels are visible as very bright pixels regardless of the scene being imaged and are unavoidable by-products of the sensor manufacturing process.

      By checking this box, the hot pixel correction will be activated, and the threshold can then be adjusted using the numeric input box. The Hot Pixel Threshold box can only be checked and unchecked when the camera is stopped. Once it is checked however, the threshold adjustment can be made on a live image.

      A hot pixel is identified by comparing the value of a pixel to the median value of the surrounding 8 pixels out of a 3 x 3 neighborhood. If the difference between the pixel value and the median value is larger than a specified threshold value, then this pixel is considered a hot pixel and will be replaced with the median value of those pixels in the neighborhood. As the correction value is increased towards the maximum value allowed by the camera, the threshold is reduced in a linear fashion. The minimum threshold value, corresponding to the upper limit, has been selected to provide users with the ability to correct hot pixels having a deviation of only a few hundred counts. At this most aggressive value, it is likely that the image content near the maximum pixel values (full scale) will be altered by the hot pixel correction algorithm.
- **Time Series Configuration Options**: The user may specify whether they want a Timed Series captured for a set period of time (**Duration editable**) or a set number of frames (**Frames editable**). When Duration editable is selected, the Timed Series will capture an image at each interval until the duration has ended. When Frames editable is selected, Timed Series will capture an image at each interval until the desired number of frames has been acquired.
- **Histogram Options**: This option is only meaningful for color cameras; by checking this box, the histogram of each R, G, and B channel will display separately in its own chart. By default, the histograms of RGB channels are displayed together in one chart.
- **Enable Capturing Refresh**: By checking this box, you can enable the live image while a capture is being made. Not enabling this will reduce the instances of dropped frames while capturing.

- **Enable Capturing With Gamma**: By checking this box, the captured image will retain the effects of the user's gamma settings when it is saved.
- **LED Indicator**: USB 3.0 series cameras provide a special function to enable control of the LED indicator on the rear panel of the camera. If the box is checked, the LED will be turned on. If the LED Indicator box is unchecked and power is cycled to the camera, the LED indicator will return to being checked, by default, and the LEDs will be turned on again.

- **Miscellaneous**: Users can customize their themes and languages here.

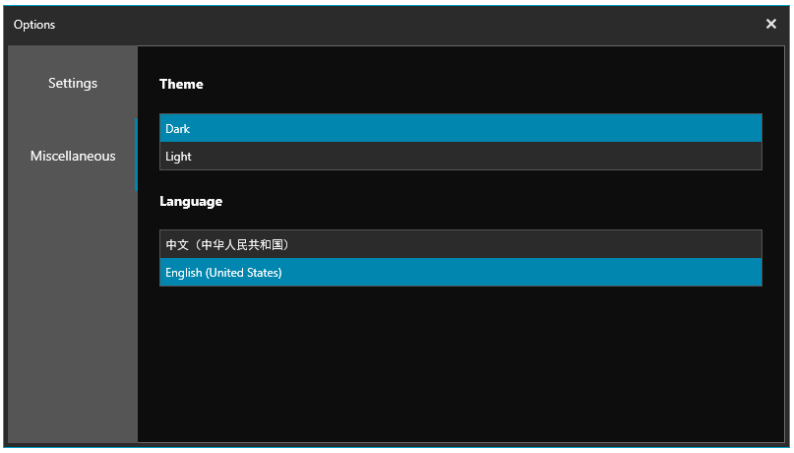


Figure 25 Themes and Languages in Options

- B7 - **Update** Button: Brings up the update window which allows the user to upgrade the program by checking the website to see if a newer version has been released.

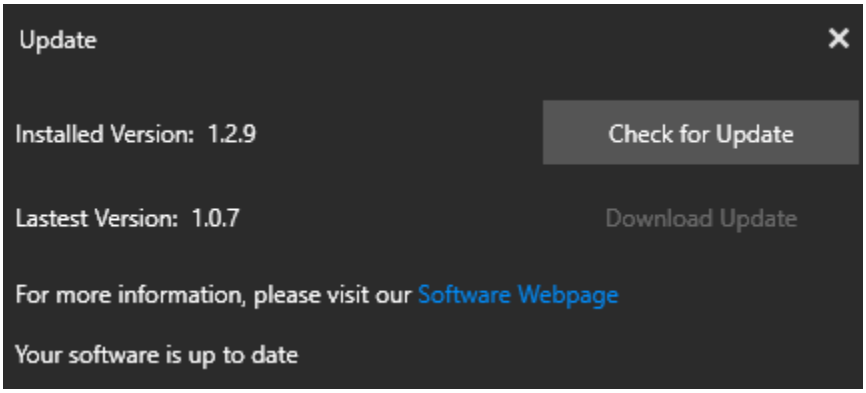


Figure 26 Update Window

- B8 - **Support** Button: Displays a log of information. Please include this information when contacting Thorlabs' technical support (techsupport@thorlabs.com) in the event an issue arises.

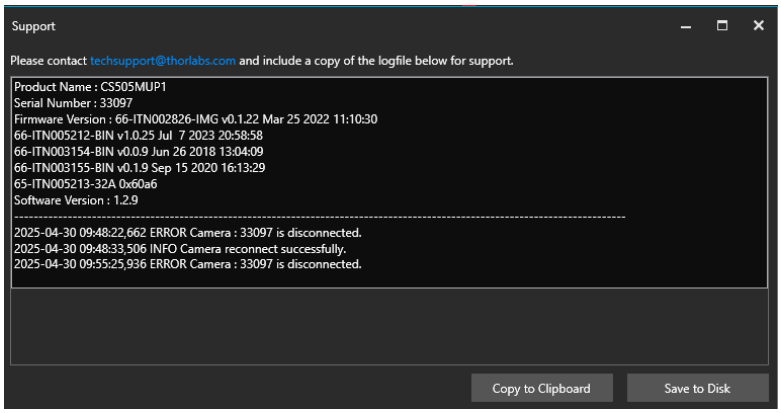


Figure 27 Support Window

- B9 - **About** Button: This will display the basic information about the program and cameras.

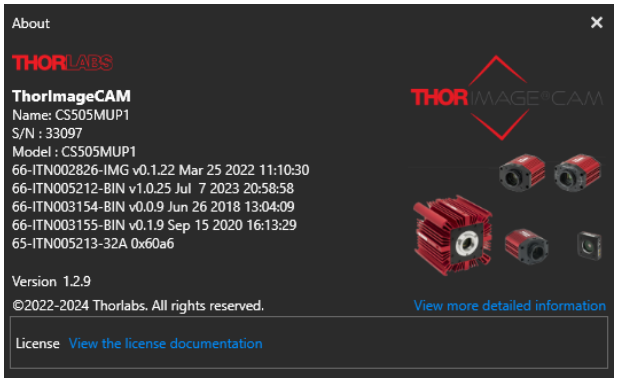


Figure 28 About Window

4.3 Operation

The main ThorImageCAM window, shown in Figure 17, is the main area of control, capture configuration, and image display. There are a few differences between the window tool icons and functions for monochrome cameras and color cameras.

4.3.1 Common Control

Start/Stop Live

Commences live view according to the camera settings. When clicked, the button turns blue. Clicking again stops the live view.

Snapshot

Takes a single frame capture according to the current camera settings. This saves an image in the format selected in the Capture Configuration window.

Start/Stop Capture

Commences saving an image to a JPG or single-frame TIFF file in the case of a single image capture, or capturing a timed series as a multi-frame TIFF or MP4 file. The MP4 and the TIFF files are saved in a variety of formats (bit depth and grayscale/color depends on camera model). When clicked, the capture button turns blue. Clicking again

stops capturing before it is completed. The image will then be saved in the location specified in the Capture Configuration section (see Figure 34). After the image capture is stopped, the image or images will be saved in the corresponding folder along with an Experiment file with a JSON file format. This Experiment file contains all the camera settings (Exposure, Frame Rate, Binning, Pixel Size, etc.) at the time the images were taken. The Experiment file does not save the GUI settings (Region Settings, Color Control settings, etc.) at the time of the image capture.

Note: In order to analyze images from a particular experiment without having the camera connected, the associated Experiment file will need to be loaded. See Section 4.2 for details on loading an experiment.

Unattended recording can result in excessive use of file storage space and ultimately result in operating system malfunction and/or loss of data.

Camera Control

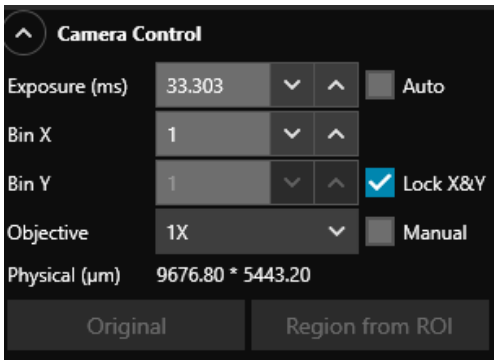


Figure 29 Standard Camera Control Settings

Figure 30 Camera Control Settings for Frame Rate Control Compatible Cameras

Exposure

Sets the amount of time that each frame is exposed to light. Units are in milliseconds (ms).

The camera exposure time is very stable, but the exact exposure accuracy and increment depends on the readout speed as well as the Binning and ROI settings. Therefore, the actual exposure time of the camera will be the closest possible value to the value entered in the GUI.

By checking the **Auto** box, the camera will adjust the exposure and the gain, for most models that support gain, in order to achieve a reasonable overall exposure. A percentage of the highest and lowest pixel values are ignored so that they do not have undue influence over the algorithm. For example, a small number of defective or saturated pixels will not affect the exposure.

Meanwhile, when auto exposure is enabled, the time series capture will be disabled since the interval of frames will not be determined.

Frame Rate (Kiralux®, Zelux®, and Quantalux® Cameras)

If frame rate control is supported on a camera, the camera control window will display the frame rate of the current set-up in frames per second (FPS) in units displayed as f/s. When the **Enable** box is checked, the Frame Rate control box is enabled allowing the frame rate to be adjusted manually. **Note: Frame Rate control is only available on Kiralux, Zelux, and Quantalux cameras.** The minimum and maximum frame rates allowed depend on the sensor readout region of interest. Very small readout ROIs will allow much faster frame rates, because less

data is transferred from the sensor, but also higher minimum frame rates. Some PCs have limitations that result in image frames not being delivered to the host computer. There are many factors, from the brand of USB chipset on the host to an abundance of USB devices on a single host controller to heavy CPU utilization that can result in dropped frames. Reducing the frame rate increases the time interval between the rows of the image as it is being read out. This allows the host more time to acquire the data and can reduce the number of dropped frames.

When the **Enable** box is unchecked the camera will operate at its maximum FPS for the given settings of Exposure, ROI, and Binning. For Kiralux and Zelux cameras, when the box is checked the numeric input field and increment/decrement arrows will be enabled. For Quantalux cameras, when the box is checked a drop-down menu will be enabled that has two options: 30 fps or 50 fps. Standard external hardware triggering with frame rate control is only allowed when frames per trigger is set to 0 (continuous) - allowing a continuous video stream to start with a single external trigger event. Single frame triggered acquisition is not allowed. Bulb, Pulse Driven Exposure (PDX), mode triggering is not allowed when using frame rate control.

Gain

To increase image brightness, the signal can be amplified by an analog gain before the digitizing process. The results of analog signal processing are usually better than the results of digital post-processing. Gain refers to the scaling of pixel values up or down for a given amount of light. This scaling is applied prior to digitization.

Note: Signal gain will also result in a noise gain. High gain settings are therefore not recommended.

Bin X

Horizontal binning factor. Horizontal binning is accomplished in the software and has no impact on readout rate. Horizontal binning will increase the offset level and noise floor commensurate with the binning factor selected. The offset level increases as the sum of the offset of individual pixels binned. The noise floor standard deviation increases as the root sum square of the standard deviation of the pixels binned. The Bin X control is disabled when the camera is acquiring frames. Binning may be done in the software and not result in increased frame rates depending on the camera model.

Bin Y

Vertical binning factor. For scientific cameras other than the Zelux series, vertical binning is done on the camera's sensor and will produce increased frame rates as the binning factor is increased. In general, vertical binning has little effect on offset level or noise floor. The Bin Y control is disabled when the camera is acquiring frames. For Zelux series cameras, vertical binning is done in the software and does not result in increased frame rate.

Note: Color capable cameras can only operate at 1 x 1 binning, so the Bin X / Bin Y controls are not available for color camera settings.

Lock X&Y

The option to lock X and Y for binning. When the box is checked, changing Bin X will also change Bin Y.

Objective

When an objective is integrated into the system, it may be selected from a limited list of preprogrammed objectives via the Objective drop down menu. This enables the ThorImageCAM program to convert the physical size and pixel size according to the scale rate. If the scale rate is uncertain, it can be set manually by clicking the **Manual** box.

Trigger Control

Figure 31 Standard Camera Trigger Control

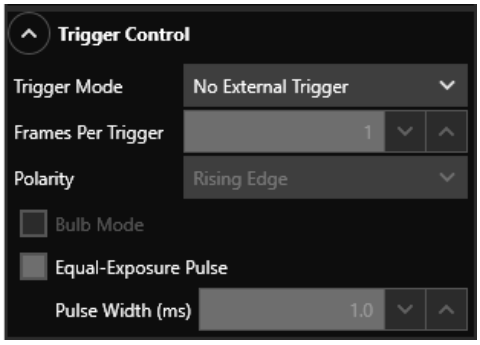


Figure 32 Camera Trigger Control of EEP Compatible Cameras (Quantalux® Cameras)

ThorImageCAM has three options for Trigger Mode.

- **No External Trigger**: Trigger is generated by ThorImageCAM (e.g. Pressing the Capture Button will Capture the Requested Number of Frames Per Trigger).
- **Hardware Trigger First**: Capture of all frames is triggered by the first rising or falling edge of the trigger signal according to the Hardware Trigger Polarity setting, with the exposure value given according to the Exposure setting.
- **Hardware Trigger Each**: Capture of each frame is triggered by a rising or falling edge of the trigger signal according to the Hardware Trigger Polarity setting, with the exposure value according to the Exposure setting.

Bulb Mode Check Box: If enabled, the trigger is provided through the camera hardware auxiliary connector. Capture is triggered by the rising or falling edge of the trigger signal according to the Hardware Trigger Polarity setting, with an exposure dependent on the trigger pulse width.

Equal-Exposure Pulse (CS2100M-USB and CC215M Only):

When a compatible camera is in use, the **Equal-Exposure Pulse (EEP)** checkbox and **Pulse Width** field will be displayed. The Equal-Exposure Pulse is an output signal available on the Quantalux sCMOS camera's I/O connector (refer to the Camera User Manuals for details on this connector). When the Equal-Exposure Pulse box is checked, the Strobe Out signal on the I/O connector is reconfigured to be active only after the sensor's "Rolling Reset" function has completed. The signal will remain active (logical high) until the sensor's "Rolling Readout" function begins. This means that the EEP signal is high only during the time when all the sensor's pixels are simultaneously integrating.

The Equal-Exposure Pulse can only be produced when the exposure time is greater than the frame period, defined as 1/fps. Exposure time and ROI determine the final fps, so varying combinations of all will determine when the signal can be produced.

When the Equal-Exposure Pulse (EEP) box is selected, all camera settings parameters are grayed out and held in their current state. Based on these parameters AND the value in the EEP Pulse Width (ms) input box, ThorImageCAM calculates the exposure setting required to produce an Equal-Exposure Pulse of the duration entered into the EEP Pulse Width (ms) input box. This new total exposure value will be shown in the grayed-out Exposure (ms) box.

The EEP Pulse Width (ms) value is the only parameter that can be changed when the Equal-Exposure Pulse box is checked. To make adjustments to other parameters, the Equal-Exposure Pulse box must be unchecked.

The Equal-Exposure Pulse is primarily meant to be used to control a light source that will expose a scene for a precise duration only when all pixels are integrating charge. The result is a more consistent exposure across the entire sensor. The user must keep in mind that the Exposure (ms) setting in the Camera Settings dialog will not be the effective exposure produced from the external light source. The effective exposure will be the value in the EEP Pulse Width (ms) setting.

For example, a Quantalux camera at full frame ROI, with a Frame Rate setting of 30 fps, and the EEP Pulse Width (ms) time in the Setting window set to 10.0 ms, will have an effective exposure of 10 ms, even though the adjusted Exposure (ms) setting will be 43.3 ms.

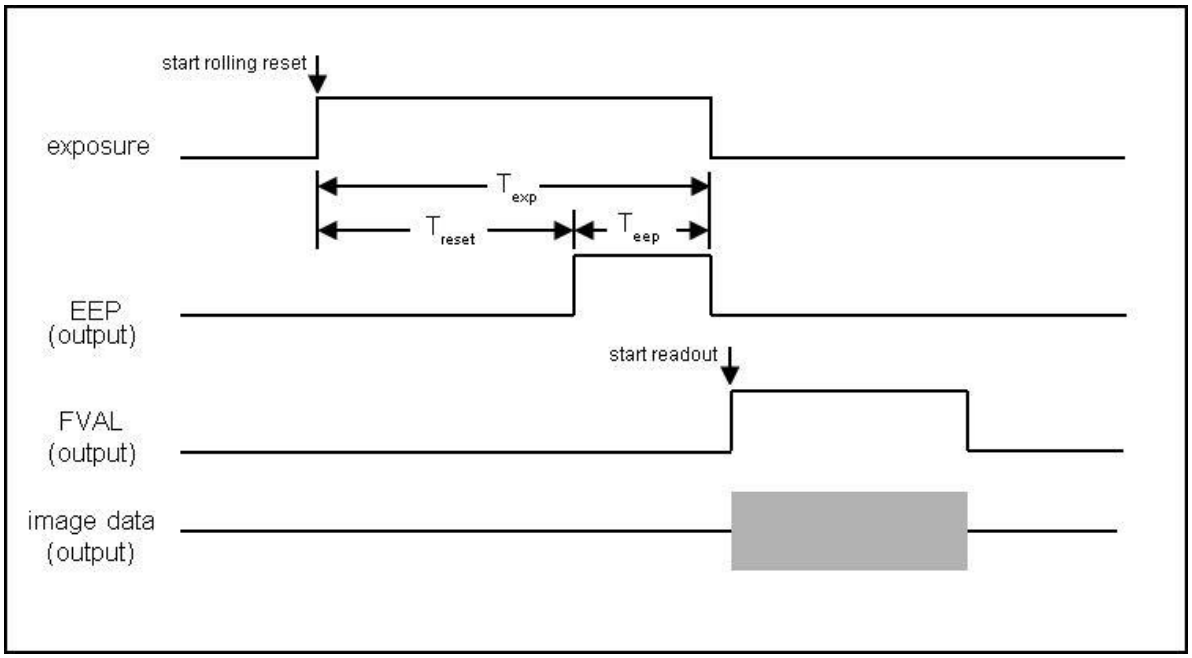


Figure 33 EEP Schematic

Be aware that the Equal-Exposure Pulse has no bearing on continuously illuminated scenes, and the resulting exposure will be whatever the actual Exposure (ms) time is set to. Please refer to the Compact Camera User Manual for additional timing diagrams and related information. The minimum EEP Pulse Width is 1 ms, with increments of 0.1 ms thereafter. This function is only available on Quantalux sCMOS models.

Capture Configuration

The stored path, prefix name, time series information, trigger mode, and format of the stored image can be viewed or changed here.

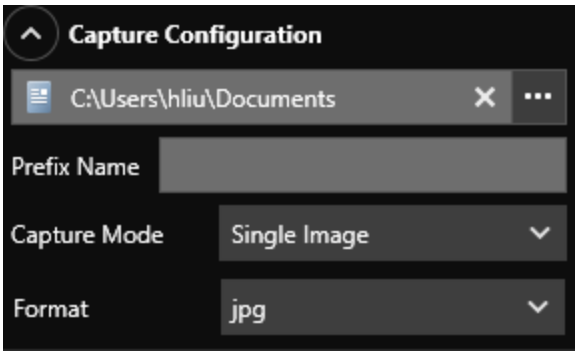


Figure 34 Capture Configuration

The default path is the Windows User's Documents folder with a default image name (yymmdd_hhmmss_num) without prefix. By clicking the button ··· the user can browse and change the path to any desired file path, provided that the user has write-access privileges.

The image name (Image Prefix) can be customized by filling the **Prefix Name** input box.

The first file captured will have a file name consisting of the Image Prefix appended with "_0001". As additional files are captured and saved, they will be automatically appended with a numerical suffix _0002, _0003, and so on.

The drop-down list of Capture Mode includes 3 items: **Single Image**, **Timed Series**, and **Streaming**.

You can capture a single image by selecting **Single Image**.

You can capture a time series of images by selecting **Timed Series** at which point the following options will appear in the Capture Configuration window below the **Timed Series** field: **Interval (ms)**, **Duration (s)**, and **Frames**. The Timed Series option chosen in the Timed Series Configuration Settings (See Figure 24) will be editable along with the Interval, while the other will be grayed out.

Selecting **Streaming** will allow you to capture multiple frames as a multi-frame TIFF or an MP4 format video.

ThorImageCAM supports the following file formats:

- Single-Frame Images: JPEG and Single-Frame TIFF
- Multiple-Frame Images: MP4 or Multi-Frame TIFF

Additionally, each time the Capture icon is selected, the processing information will be displayed along the bottom status bar until the acquisition is successfully completed and saved.

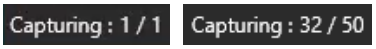


Figure 35 Image Capture Status

Color Control

The Color Control window is only available when a Color Camera is connected. The Color Control window enables adjustment of the gain values for the individual R, G, and B pixel values. The White Balance control feature uses the RGB gain settings of the camera to correct the white level. This is achieved by adjusting the gain controls within the 0 - 100% range until the red or blue channel matches the average brightness of the green channel.

Different light sources can have different spectra, sometimes characterized as "color temperature" which can result in color casts in the captured images. Sources with low color temperatures (e.g. incandescent lamps), the white point is offset towards a red hue. Sources with high color temperatures (e.g. cool-white fluorescent lamps), the white content is offset towards a blue hue. The **White Balance** tool can aid in correcting for these differences.

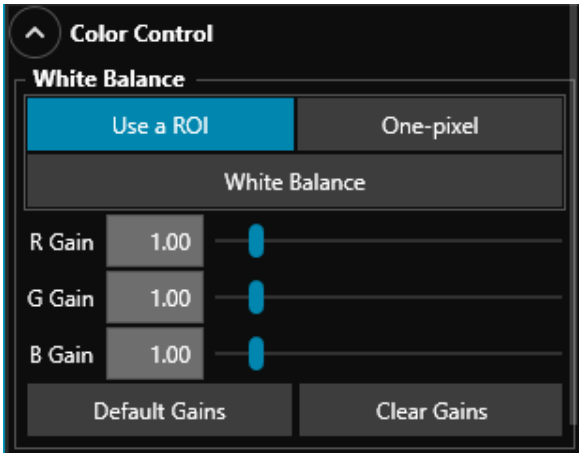


Figure 36 Color Control Window

The white balance corrections can be used while considering the entire image, a selected ROI, or a specific pixel. A rectangular ROI can be used as the white balance region by selecting the desired ROI, clicking on the Use a ROI button, and then clicking the White Balance button. Additionally, a specific pixel can be used by selecting the One-pixel button and then clicking the White Balance button. A crosshair will appear in the center of the image denoting the selected pixel location. The marker can be moved by clicking on the crosshair and dragging it to the desired location.

Show Scaler

Right click on the image area to set the display scaler. The scaler displays at the bottom-right corner of the image by default.

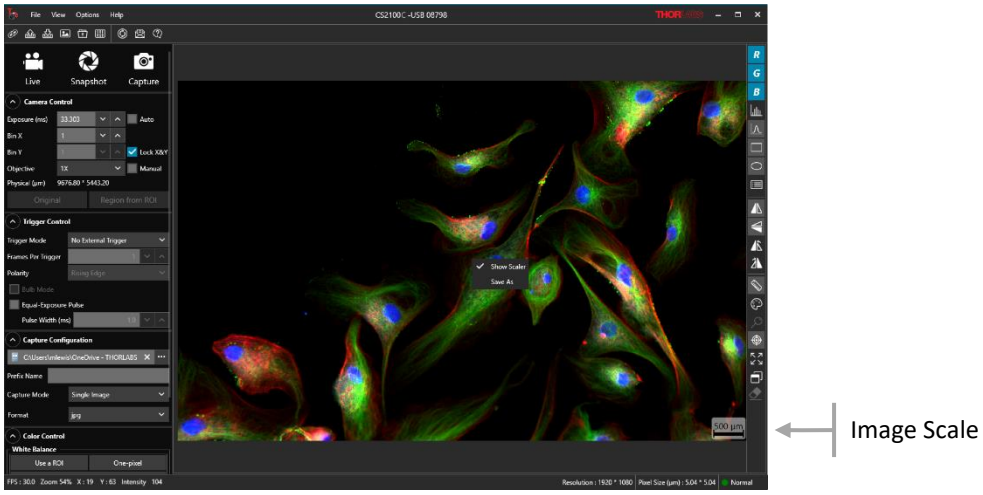


Figure 37 Image Scale

The style and location of the image scaler can be changed by clicking on it.

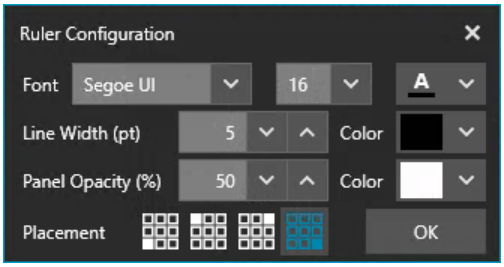


Figure 38 Edit the Style of the Scale

Save as

Right clicking on an image will produce a menu with a **Save as** option which enables the current single image to be saved to the target folder as a JPEG or TIFF file format.

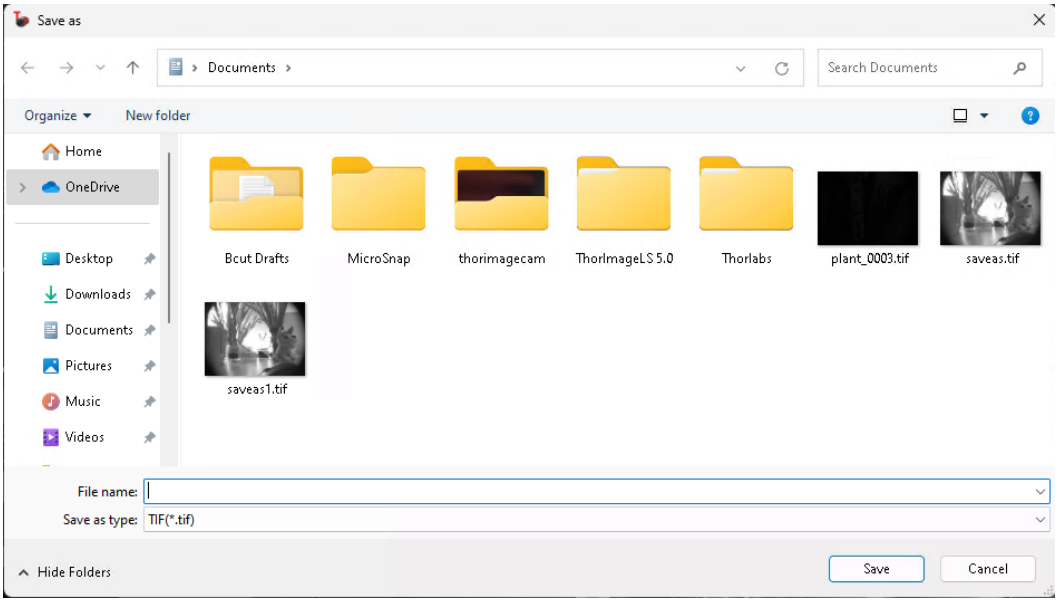


Figure 39 Save as Image

4.3.2 Analysis Tools

The following controls pertain to the image view and are not available during the image capture process.

Red, Green, Blue Channels (Color Cameras Only)

The Red (R), Green (G), and Blue (B) icons allow each of the R, G, and B channels to be turned on/off in the display of the GUI. By default, all the RGB channels are turned on. These display features will **not** apply when saving images and videos.

Figure 40 Red, Green, Blue (R, G, B) Control Button Icons

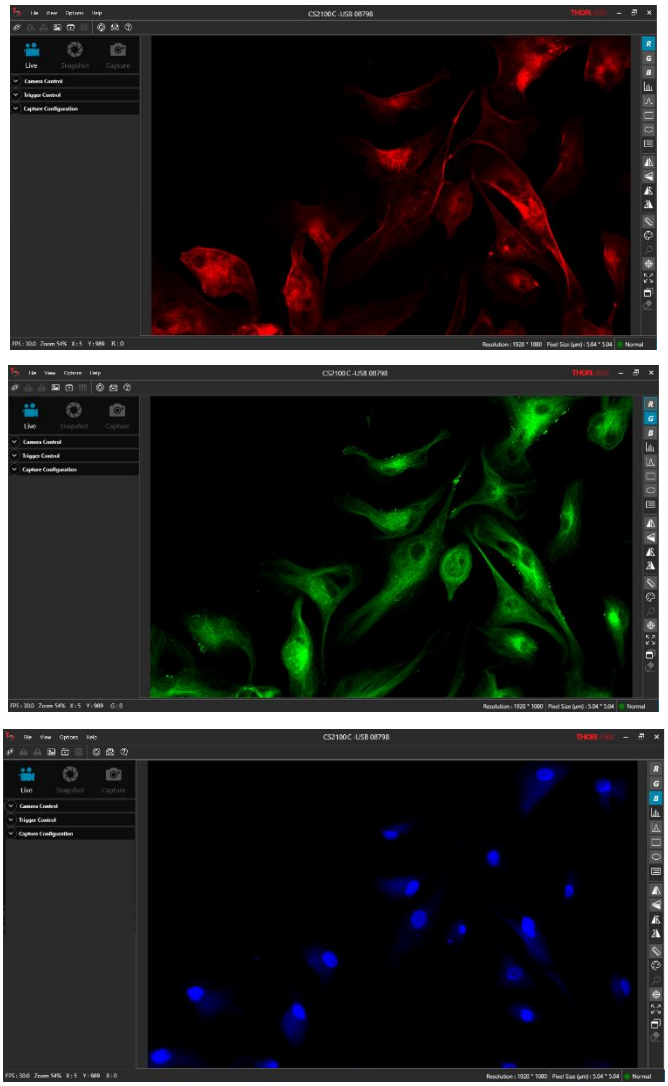


Figure 41 RGB Channel Control Windows

Histogram

Displays the histogram of the captured image values.

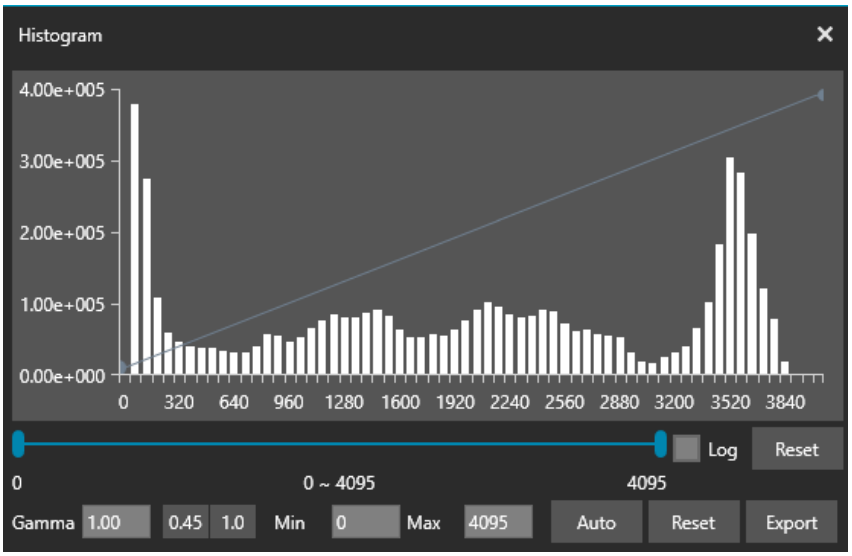


Figure 42 Histogram While Using a Monochrome Camera

For color images each of the R, G, and B waveforms can be displayed in a separate chart by selecting the **Separated RGB histogram** box in the **Options** menu (See Figure 24).

Figure 43 Histograms for a Color Camera (Combined and Separated RGB)

The Range Slider can be dragged to adjust the view scope to adjust the details that are visible in the histogram.

Close inspection of histogram values can be accomplished by changing the **Min**/**Max** values. The **Min** and **Max** controls set the contrast of the image. Pixel values equal to or less than the Min intensity level are set to a display

value of 0, or black. Pixel values greater than or equal to the Max Intensity level are set to a display value of 255, or white. Pixel values in between are mapped to display linearly from 0 to 255.

The histogram can also be viewed in a log-linear fashion by selecting the **Log** check box.

Entering a gamma value in the gamma field or dragging the gamma line in the histogram applies a digital gamma correction to the image. The limits for the gamma values are determined by the camera and are displayed to the right of the gamma input field.

Pressing **Auto** sets the Min Intensity and Max Intensity according to the image data captured at the time the button is clicked. Auto ignores extreme outlying values so that the values are not influenced by one or a small number of pixels.

The **Reset** button resets the Min Intensity and Max Intensity to their default values based on the camera's native bits/pixel.

The histogram data can be saved to a csv file using the **Export** button for further evaluation. Hovering the mouse cursor over the Histogram allows individual bin values to be inspected.

Line Profile 

Draws a line across the image and displays the values of the pixels along the line in a separate window. Once the line profile is active, the cursor changes to  . The position of the line profile can be chosen by left-clicking anywhere in the image and dragging to draw the line, then releasing to stop drawing. Hovering the mouse cursor over the line profile graph will allow you to inspect the intensity of specific pixels along the line. The line width can be set from 1 to 20 pixels, and the **XCoordinate** display value can be switched by selecting **Pixel** or **Micron** from the drop list. If a picture is loaded into the GUI for analysis, the Pixel value will be the only option for the XCoordinate unit as the software does not have scale for the pixel size. If an experiment file is loaded, both Pixel and Micron options will be available as the JSON file saved in the experiment folder contains a pixel scale for the software to reference. The line profile data can be saved as a csv file using the **Export** button.

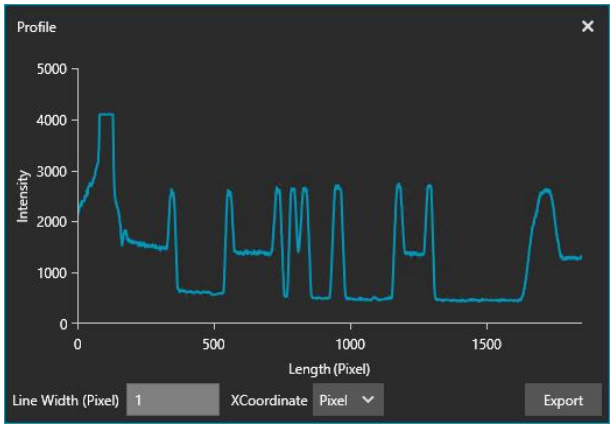


Figure 44 Line Profile of Monochrome Camera

For color cameras, individual R, G, and B line profiles can be viewed.

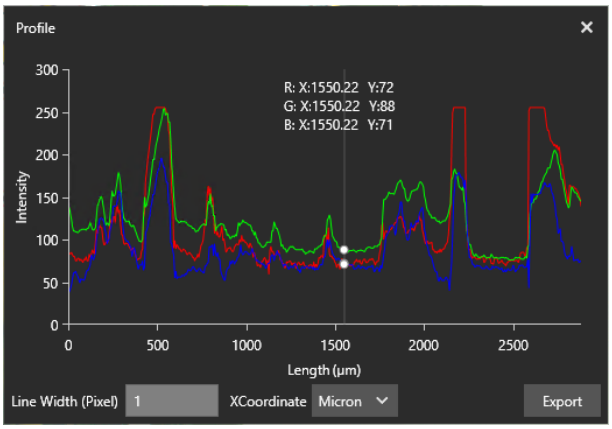


Figure 45 Line Profile for a Color Camera

Draw a Rectangular or Oval ROI

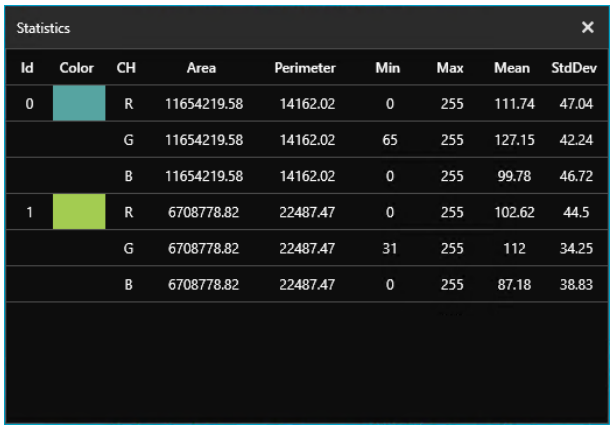
Clicking on the Rectangle or Oval symbol allows a rectangular or oval shaped ROI to be drawn in the image for analysis or scaling for image display. Once the button is pressed, the cursor changes to or for rectangular or oval ROIs, respectively, until an ROI is drawn.

During a live capture, the selected ROI can be set to the display region. The **Region from ROI** button, found in the camera control panel, is only available during live capture mode when an ROI is selected.

The **Original** button in the camera control section is only available after a ROI is set as the display region using the Region from ROI button. Clicking the Original button will restore the ROI to the region defined in the **Options** → **Settings** → **Region Settings**.

Statistics

A separate window displays the statistical results of all current ROIs. For a color camera, this tool will calculate individual R, G, and B data for each ROI.



Id	Color	CH	Area	Perimeter	Min	Max	Mean	StdDev
0		R	11654219.58	14162.02	0	255	111.74	47.04
		G	11654219.58	14162.02	65	255	127.15	42.24
		B	11654219.58	14162.02	0	255	99.78	46.72
1		R	6708778.82	22487.47	0	255	102.62	44.5
		G	6708778.82	22487.47	31	255	112	34.25
		B	6708778.82	22487.47	0	255	87.18	38.83

Figure 46 Statistics of All ROI

Mirror Flip Horizontal or Vertical

The mirror icons will mirror the current image from left to right (Horizontal Flip) or from top to bottom (Vertical Flip). This feature will **not** apply when saving images or videos.

Rotate Left or Right 90°

These two icons will rotate the current image either 90° to the left or right. This feature will **not** apply when saving images and videos.

Ruler

Clicking on the ruler icon will enter measurement mode. When in this mode, the cursor will change to until measurement mode is ended.

Once in measurement mode, take a measurement by clicking on an image location, dragging to draw a line, then releasing to end the measurement. If analysis is being performed on a loaded image, the result is displayed in units of pixels. If analysis is being performed on an experiment, whether active or previously saved and reloaded, the result is displayed in units of physical size. To perform multiple measurements, the Ruler tool must be reselected for each measurement.

Color Image

Color Image provides a means of visualizing subtle intensity differences in a grayscale image. Selecting one of the options from the drop-down menu will colorize a monochrome image by substituting a unique color for each intensity level. This function is also available for each channel (R, G, or B) of a color camera. See Section 4.5 for details.

Set Region to Window

Fits the selected region to the image window. The full frame view can be restored by pressing the **Fit image to window** button or by left-clicking twice on the mouse.

Reticle

Places a reticle crosshair target in the center of the image for visual reference.

Fit Image to Window

Fit the entire image to the window.

Restore all Window Positions

If the pop-up windows cannot be found, click this button to restore all pop-ups to the default location. It is useful when switching from multiple monitors to a single monitor.

Clear ROIs

Deletes all drawn ROIs and measurements made with the ruler function. To delete a single ROI or measurement, select the desired feature in the GUI and then click delete on the keyboard.

4.3.3 Reading Saved Images

Saved images can be viewed in ThorImageCAM by loading them using the **File** → **Load Image** or **File** → **Recent** commands in the main ThorImageCAM window. The quick load icon in the ribbon bar can also be used. The ThorImageCAM software can load saved .tif, .jpg, .png, and .bmp image file formats.

Analysis of Saved Images

ThorImageCAM offers the same analysis functionality for loaded images that it has for live images. However, if an image is loaded without a camera connected to the ThorImageCAM software, some features, such as the settings window and calibration window, will be unavailable. Additionally, if an image is loaded without a corresponding Experiment .JSON file, the Line Profile and the Ruler tool will only display measurements in units of Pixels.

Multi-Frame TIFF Playback

Time series images are stored in a multi-frame TIFF format to preserve high-precision, unaltered image data. A multi-frame TIFF file is a single file that contains multiple images. ThorImageCAM will read back the multi-frame TIFF files it generates during the **Timed Series** mode and provide a set of simple controls to play the images.

Use the control buttons to **Start** or **Stop** playback (See Figure 47). Drag the slide to a specific position to view that frame image. Modify the playback frame rate by changing the **Frame Rate** value.

Figure 47 Multi-Frame TIFF Playback Control Bar

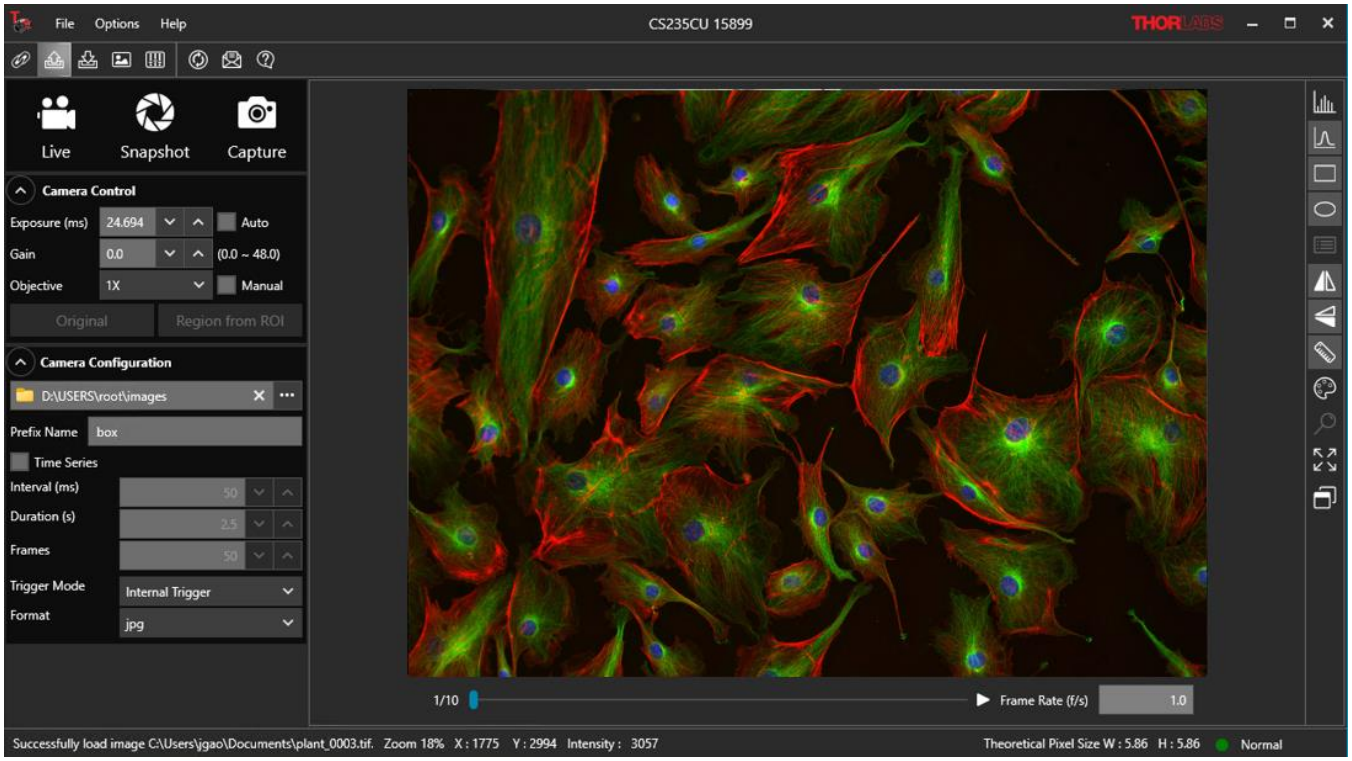


Figure 48 Main Window View of a Multi-Frame TIFF Playback

4.4 Additional Information

Additional information regarding zoom level, frame rate, cursor position, and more is displayed on the status bar at the bottom of the display. See Figure 49 for more details.

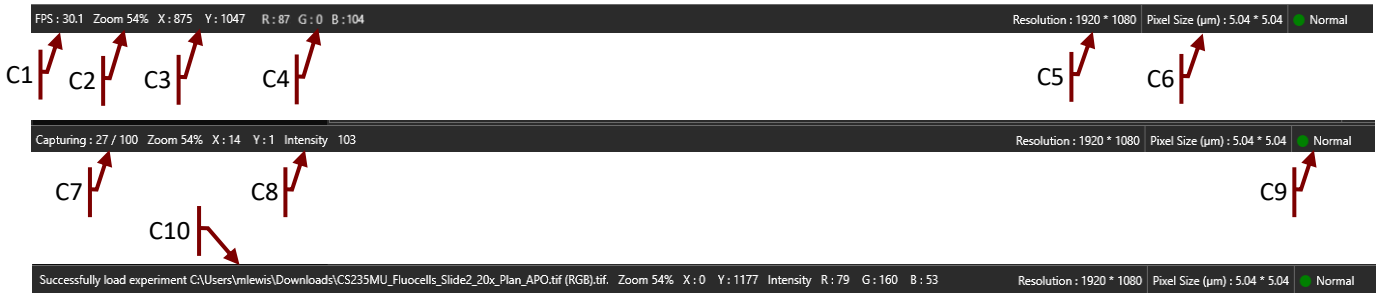


Figure 49 Status Bar Details

- C1 - Frame Rate While in Live Capture View
- C2 - Zoom Level of Current Image View
- C3 - X and Y Pixel Position of the Cursor
- C4 - Color Camera: RGB Values at the Cursor Location on the Image

  Monochrome Camera: Pixel Intensity is Given, See C8
- C5 - Resolution
- C6 - Pixel Size
- C7 - Capturing Progress

- C8 - Pixel Intensity at the Cursor Location for Monochrome Cameras
- C9 - Status Indicator of the ThorImageCAM Program:
  One of Three Indicators Will be Displayed to Alert the User of the Current Status:
  ●Normal ●Warning ●Error

  For more information, see Figure 49.
- C10 - Status of File Loading Operation

4.5 Color Image

By clicking **Color Image** icon you will find the color selections. **Color Image** provides a means of visualizing subtle intensity differences in a grayscale image. Selecting one of the options from the drop-down menu will colorize a monochrome image by substituting a unique color for each intensity level. This feature is also available for color cameras, substituting a unique color for each intensity level of each individual color channel.

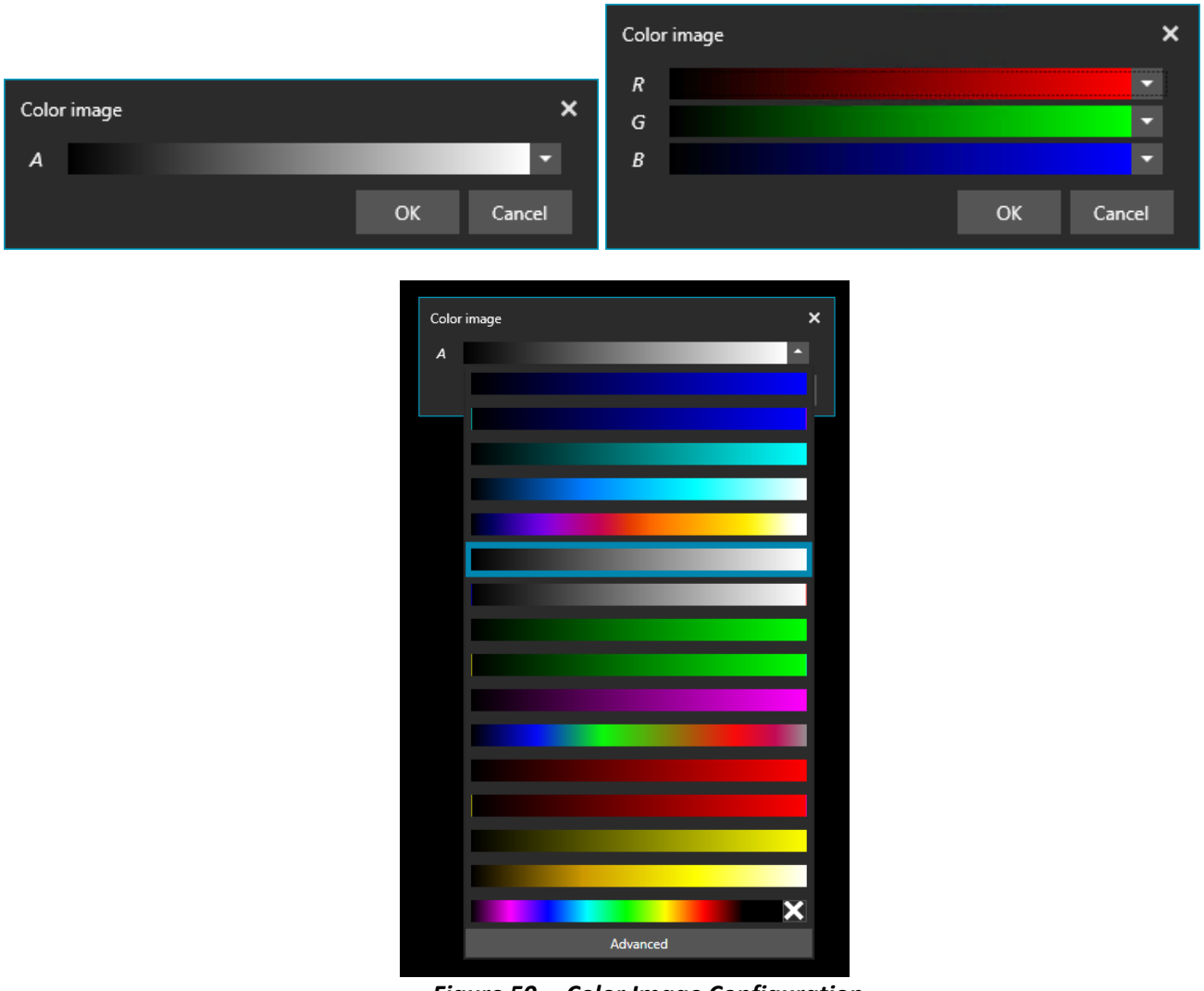


Figure 50 Color Image Configuration

A few examples of colorized monochrome images are shown in Figure 51.

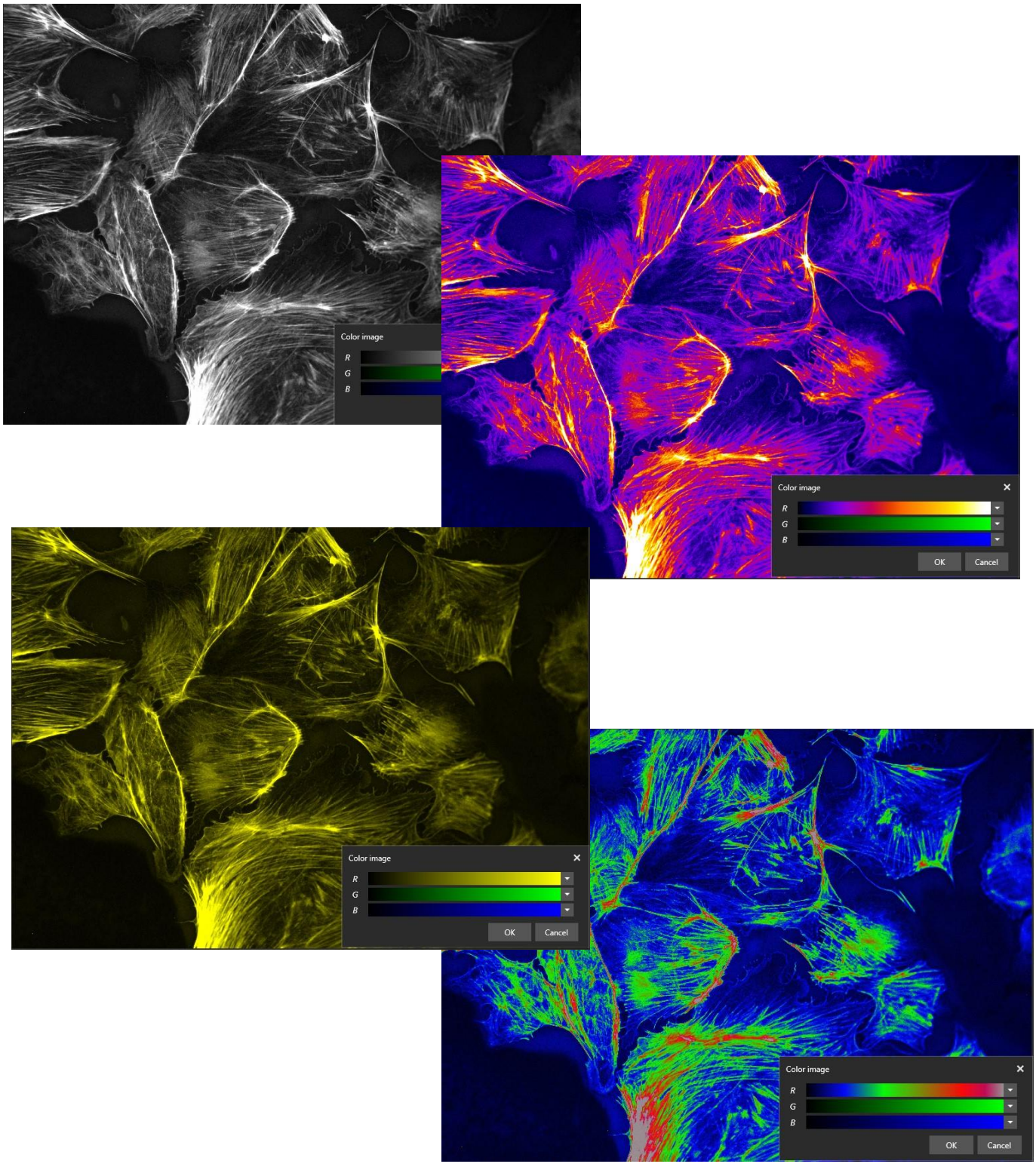


Figure 51 Examples of Colorized Monochrome Images

The colorization of a monochrome image utilizes a pseudo color look-up-table (LUT) to convert the grayscale values into the corresponding RGB values. The LUT is a table of red, green, and blue values from 0 - 255 that correspond to the gray intensity values of the image.

As a part of the ThorImageCAM installation, a folder for storing pseudo color look-up tables (LUTs) is located at the typical path C:\Program Files\Thorlabs\ThorImageCAM\Bin\ComputeColor\. To create new and custom LUTs, users can add .txt files to this folder in the same format as the default LUTs. The custom LUTs will then automatically be added to the pseudo color drop-down menu in the GUI.

An easy way to add a custom LUT is by clicking the **Advanced** button on the bottom of the color image drop-down list. After clicking, the **Colormap Editor** window will open allowing customization of colors in the LUT.

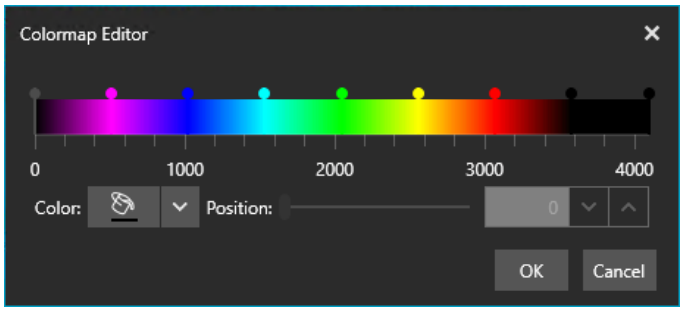


Figure 52 Colormap Editor

A color point can be added or removed by left or right clicking on the color bar, respectively. The color of the currently selected point can be modified by selecting a new color in the color palate. The position of the color point can be modified by dragging the point on the color bar or by inputting the position manually.

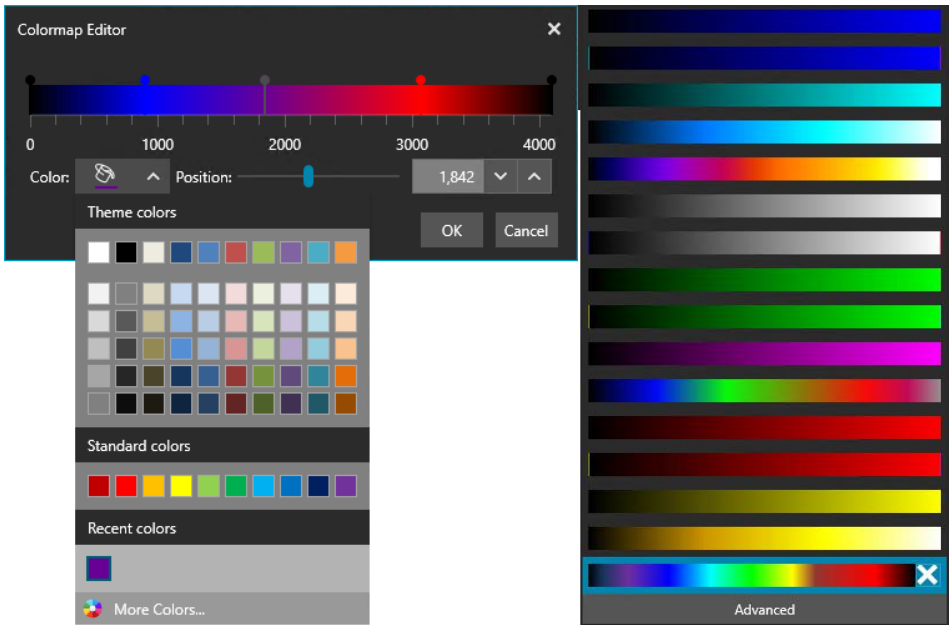


Figure 53 Customize an LUT Using the Colormap Editor

Click the **OK** button to save the custom LUT to the drop-down list. For any additional questions regarding Custom LUTs and their corresponding files please contact **techsupport@thorlabs.com**.

4.6 Polarization

ThorImageCAM provides several useful analytic and visualization tools for use with Thorlabs' CS505MUP1 polarization camera. The CS505MUP1 camera's image sensor incorporates an integrated, linear micropolarizer array to detect the linear polarization states within an image. Each pixel is covered with one of four linear polarizers with orientations of -45°, 0°, 45°, or 90°. The pixel values are then used to compute the three polarization parameters for the light incident at every pixel: intensity, degree of linear polarization, and azimuth.

- Intensity: Total Optical Power in Percent and Stokes Parameter S_0: Intensity = S_0, 0 ≤ Intensity ≤ 100
- Degree of Linear Polarization (DoLP) in Percent:

$$DoLP = \frac{\sqrt{s_1^2 + s_2^2}}{s_0}, 0 \leq DoLP \leq 100$$

- Azimuth: $\theta = \frac{1}{2} arctan\left(\frac{s_1}{s_2}\right), -90^\circ \leq Azimuth \leq 90^\circ$

When a polarization compatible camera (CS505MUP1) is connected, the **Camera Control** panel shows a selection field for five polar image types: **Unprocessed**, **Intensity**, **Azimuth**, Degrees of Linear Polarization (**DoLP**), and **Quad View**. Each polar image type will affect how the image is rendered as well as how the histogram tool will be presented, resulting in each tool representing the appropriate unit of measure of the image type selected.

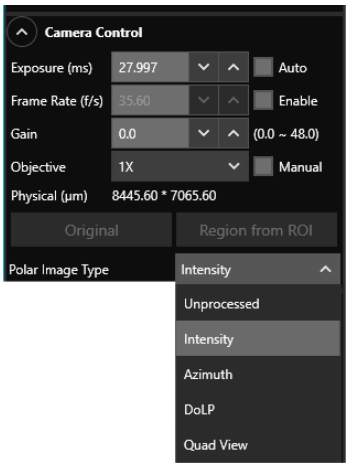


Figure 54 Camera Control Panel Displaying Options for Polar Image Type

The unprocessed polar image type will display the raw image from the camera. Selecting one of the four polar image types will change the image display to show the image using the selected **Polar Image Type**. In the bottom left of the status bar, a value corresponding to the selected image type will be shown according to the cursor location on the image. Selecting **Intensity** will display the total optical power as a percentage, the **Azimuth** image type setting will display an azimuth angular value in degrees, and the **DoLP** image setting will display the degree of linear polarization as a percentage. Selecting the **Quad View** image type will produce a four-quadrant image which displays the raw 0°, -45°, 90°, and 45° polarization azimuth angles detected by the image sensor. The image data is the same as the unprocessed image data but reorganized from the raw mosaic to a 4-quadrant image. The four quadrants will be preserved when saving the Quad View image to either TIFF or JPG file formats.

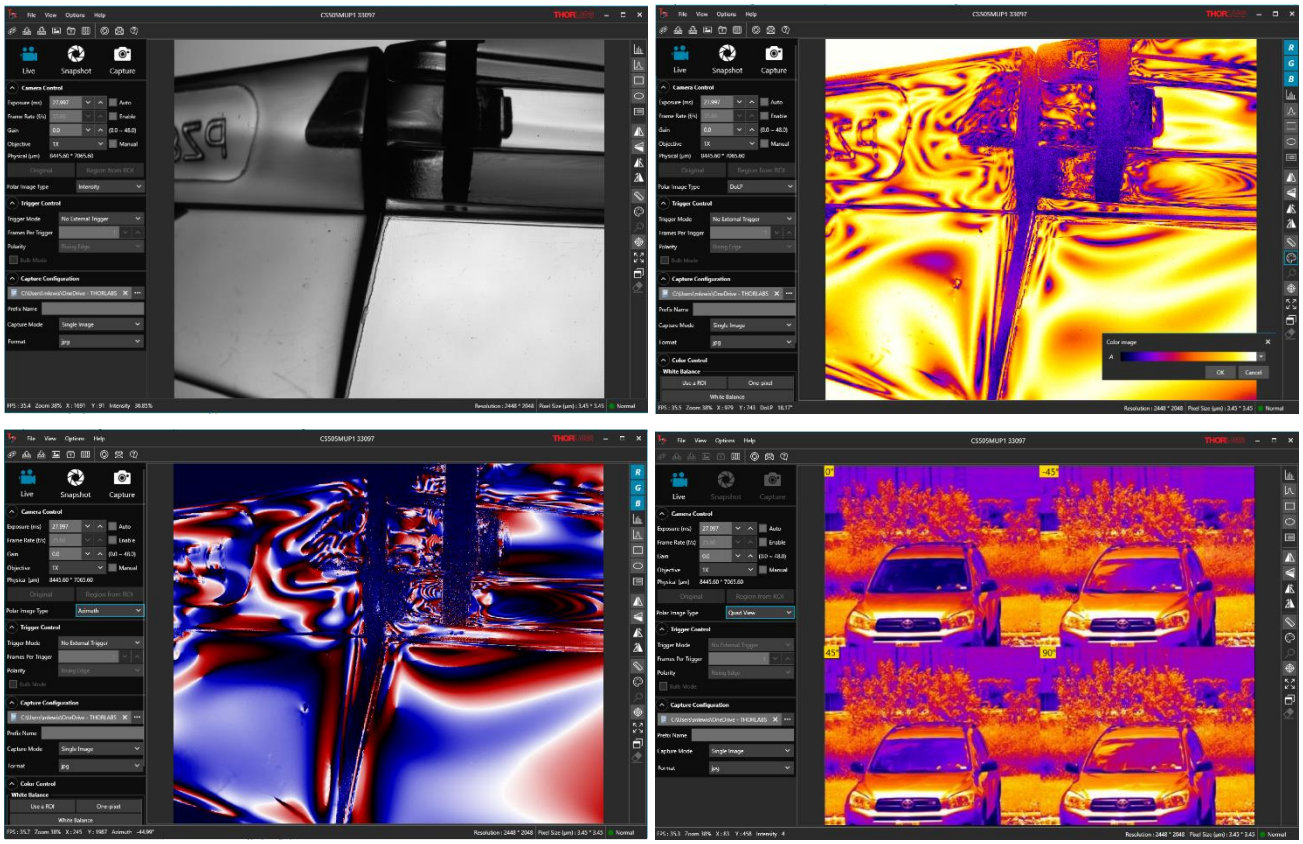


Figure 55 Polarization views for a given image type. Counterclockwise starting at the top left shows the Intensity, Degree of Linear Polarization (DoLP), Azimuth, and Quad View image types.

Chapter 5 Troubleshooting

Problem	Error Message	Cause
Export Failed	Export (…) to file (…) failed.	Occurs when Histogram or Profile is unable to create or write to a new file. Check Windows permissions and available disk space.
File Occupied	File (…) is occupied by another process, please close the file and try again.	Occurs when Histogram or Profile is unable to access the file to export to because another process has opened the file.
Memory Overflow	The memory is about to run out, do you want to stop capturing?	Occurs during Capture when RAM usage reaches an upper threshold. Press Yes to keep capturing to No to stop. Once RAM usage reaches 95% Capture will stop.
Load Experiment Failed	The specified directory must contain Experiment.JSON and a readable image file.	Occurs when the folder does not contain an Experiment.JSON file or has 0 image files. This can also occur when one or more of the image files in the experiment are corrupt, not following JSON syntax, or encounters an unknown exception.
Load Image Failed	Load image failed / The specified image must be readable and use one of the following file formats: .tif, .jpg, .png, .bmp.	Occurs when an invalid image format is provided, or if the image file could not be loaded.
Load Empty Path	Cannot find '(…)'. Please check spelling and try again	Occurs when the file specified to load was not found.
Camera Type Not Matched	The camera type of the configuration being loaded is: (…), which does not match the current camera type: (…).	Occurs when loading a camera configuration from a different camera model. Some cameras have parameters which do not apply to others, which can cause the settings to be mismatched after loading the configuration.
Camera Open Failed	Open camera (…) (SN:(…)) failed.	Occurs when the camera could not be opened. This may be due to the camera becoming disconnected or having an unstable connection. Try reseating the camera USB connectors on both ends and try different USB ports.
Auto Exposure Failed	Set auto exposure failed.	Occurs when an unknown issue occurs during the Auto Exposure routine. This may be caused by incompatible camera parameters.
Start Preview Failed	Start preview failed.	Occurs when Live mode could not start. Try unplugging the camera and plugging it back in.
Stop Preview Failed	Stop preview failed.	Occurs when Live mode could not stop. Try unplugging the camera and plugging it back in.

Problem	Error Message	Cause
Interval Error	When using Capture with Time Series, Interval (ms) must be greater than the exposure time (…) ms.	Occurs when Exposure is longer than the Interval for Time Series Capture, or when Auto Exposure is running during a Timed Series.
Internal Trigger Error	When using Capture with Time Series and Internal Trigger mode, Interval (ms) must be between (…) ms and (…) ms.	This can occur when the Calibration routine fails, the Live mode fails, or the Snapshot routine fails due to the camera being unable to start.
Save Path Error	You do not have permission to save in location (…). Please select another one.	This occurs when the program does not have permission to write to the file specified in the Capture control. This can also occur when the file name is empty.
Load Profile Failed	Failed to load the profile.	This occurs when the program is unable to load the specified Configuration. This can happen if the specified Configuration is inaccessible or does not meet the expected JSON format.

Chapter 6 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at www.thorlabs.com/contact for our most up-to-date contact information.

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