(rev2 June 2016)

User manual for ThermalCapture 2.0

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Initial Operation

Before you can use ThermalCapture 2.0 the first time, take some time to learn more about the product and needed steps to a setup tailored to your needs. This guide assumes that

ThermalCapture 2.0 is already mounted to a TAU core. If this is not the case please follow the *ThermalCapture 2.0 Mounting Guide* first.

1.1 Wiring and Connectors

ThermalCapture 2.0 has the following connectors:

1	8-pin connector
2	Micro sd card slot
3	Mini-USB for configuration and 5V power supply

1.1.1 Mini-USB Connector

ThermalCapture 2.0 and the connected TAU core can be powered from the Mini-USB interface for configuration. This interface also allows the configuration of the TAU core via the FLIR TAU GUI.

To do TAU core configuration disconnect any memory devices, connect ThermalCapture 2.0 to your PC and execute steps described in chapter Configuration of the TAU Core of this guide.

Thermal Capture is intended to be used with small UAVs. Therefore you need an adapter cable from your 5V power supply to either Mini-USB or 8-pin connector. ThermalCapture 2.0 can work with a DC voltage from 4,5 to 5,5V. The source must be able to deliver at least 600mA continuous and peeks up to 1A.

1.1.2 Micro SD card slot

This is a slot for a micro sd card. ThermalCapture 2.0 stores the captured images on the memory

connected to this interface. The sd card must be formated with a FAT32 filesystem and support a minimum serial data writing speed of 10MB/s. We recommend a SDHC Class 10 for use with the ThermalCapture 2.0.

It is strongly recommended to use the SD Formatter 4.0 for SD/SDHAC/SDXC instead of formatting utilities provided with operating systems that format various types of storage media. Using generic formatting utilities may result in less than optimal performance for your memory cards.

It is necessary to format the sd card between uses with the SD Formatter to ensure an uninterrupted image stream to be saved to the sd card.

1.1.3 8-pin connector

The 8-pin connector has the following pin definition:

1	(reserved)
2	(reserved)
3	5V DC input
4	GND
5	TRIGGER_IN
6	SERIAL_IN
7	VIDEO GND
8	VIDEO OUT

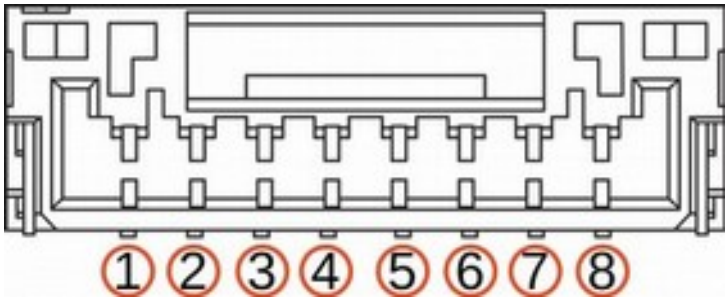


Image capture is triggered when the TRIGGER_IN pin is pulled to ground. It is connected to 3.3V internally via resistor. You can apply a switch or a transistor between TRIGGER_IN and GND. It is also possible to connect a digital signal (0-5V) to the trigger input.

Images are captured as long as TRIGGER_IN is at ground level. It is not possible to connect the trigger input permanently to GND, because in this case there would be no way to switch ThermalCapture 2.0 off or release the sd card, without potentially damaging its file-system.

SERIAL_IN is a UART interface. It supports inverted and not inverted signals (0-5V). The data received at this pin is continuously stored in an internal buffer. This buffer is added to any stored image. So it is possible to connect a GPS receiver or an IMU to ThermalCapture 2.0. Since the

data is only stored but not processed at ThermalCapture 2.0, any UART based protocol can be used as long the sensor begins with data output on its own. Interface settings (baud rate etc.) can be done with the serial configuration tool (see chapter 2.2).

VIDEO_OUT provides NTSC or PAL composite video out from the TAU core. The video standard and other video related settings can be configured with FLIR TAU GUI, see chapter 2.1.

2 Configuration

Before ThermalCapture 2.0 can be used in a specific setup, it is necessary to configure the TAU core correctly. Configuration of ThermalCapture 2.0 is only needed if the serial input (see chapter 1.1.3) is used to connect to a GPS receiver or a similar device.

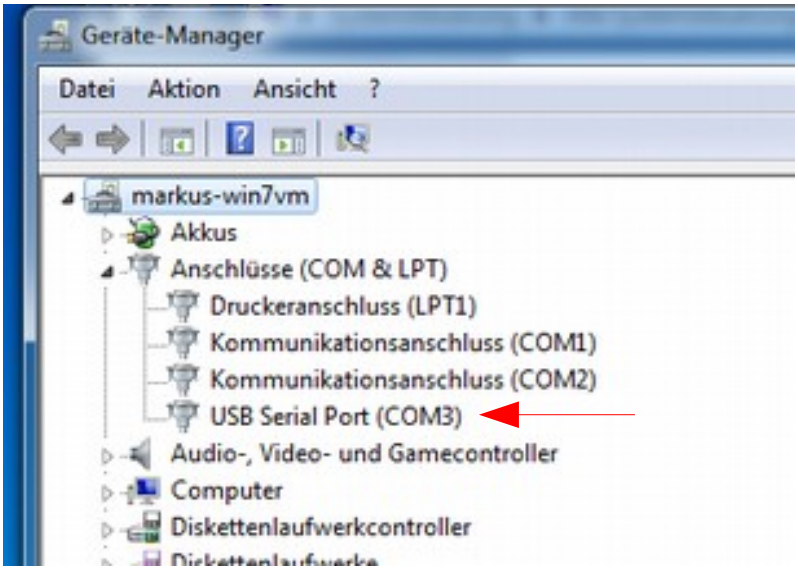
2.1 Configuration of the TAU Core

TAU core configuration is only necessary if you have mounted ThermalCapture 2.0 to a TAU core on your own, or if you want to change some core related settings. If this is not the case, please proceed with chapter 3.

2.1.1 Driver Install

ThermalCapture 2.0 uses a virtual COM port to connect the TAU core to the Mini-USB interface. To get access to the TAU core with your PC, you may need to download and install the STM32 virtual COM port driver from STM32 Virtual COM Port Driver

After installation the TAU core is connected to a virtual serial interface (COMX). Please open the device manager and look which COM – interface it has got.



2.1.2 Flir Software Installation

The configuration of the Tau core is done by software from FLIR.

You need the FLIR Camera Controller GUI for Tau and Quark:
http://www.flir.com/cvs/cores/view/?id=51880

and the FLIR GUI User Guide:
http://www.flir.com/uploadedFiles/OEM/Products/LWIR-Cameras/Vue/flir_gui_user_guide.pdf

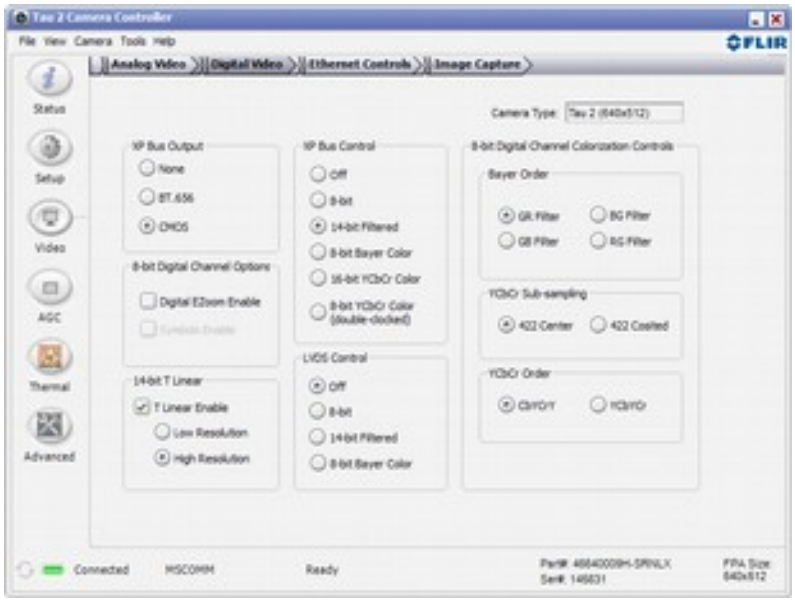
Connect the Mini-USB interface of ThermalCapture 2.0 to your PC and follow Chapter 4 of the FLIR GUI User Guide to connect to the camera.

2.1.3 TAU Configuration

ThermalCapture 2.0 gets the images from the digital output of the TAU core. This output is switched off by default. If the output is not enabled, ThermalCapture 2.0 cannot record images.

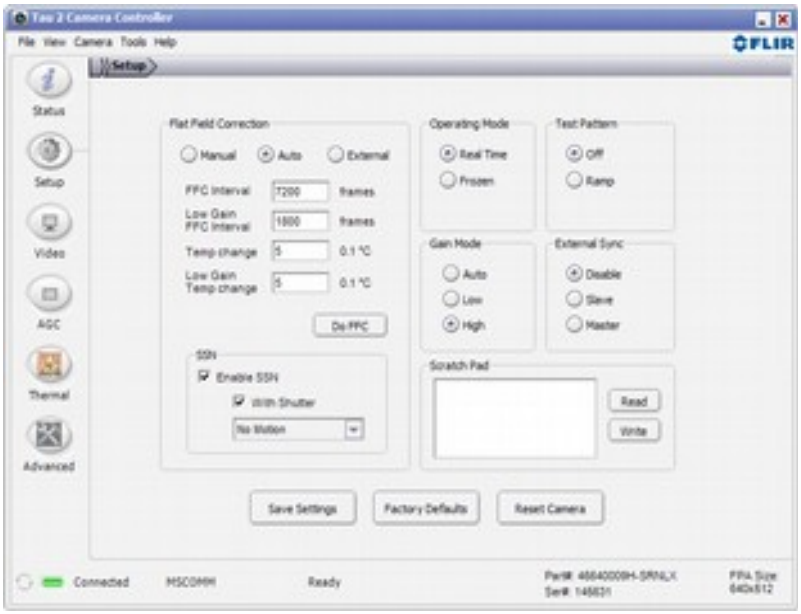
The digital output must be enabled with the Flir "Camera Controller GUI".

After the FLIR GUI has connected to the TAU core, go to the Digital Video Tab and select CMOS for XP Bus Output and 14-bit filtered output.



If your TAU core has the “advanced radiometry option”, TLinear should be enabled to have per pixel temperature measurement in ThermoViewer.

These settings must be saved permanently. To achieve this, go to the Setup tab and click to Save Settings.

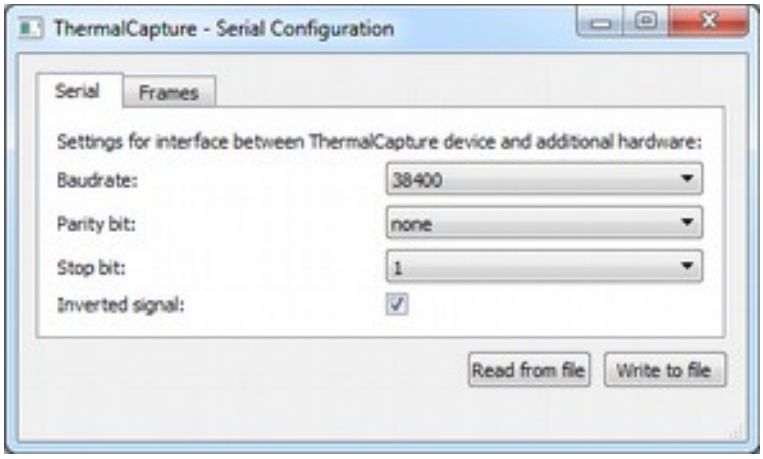


Without this, the settings will be lost with the next power cycle and recording cannot work. Now the TAU core is ready to be used with ThermalCapture 2.0.

2.2 Configuration of ThermalCapture 2.0

If the serial input (see chapter 1.1.3) is used, it needs to be configured for a specific data source. ThermalCapture 2.0 is delivered together with a configuration software to set up this serial interface. This chapter describes how to use the TC-Configurator software.

2.2.1 Serial interface



Settings for the serial interface are communicated to ThermalCapture 2.0 by generating a configuration file and saving it onto the sd card, which is used for picture storage. This file contains information about the Baudrate, Parity Bit-, Stop Bit- and Inversion-settings. These settings must match with the settings of the connected hardware.

- Supported Baudrates range from 1200 to 115200
- Parity can be set to “none”, “odd”, or “even”
- 1 or 2 Stop bits
- Inverted signal check box determines, if inversion is active or not

The button “Write to file” opens a file dialog in which the root directory of the sd card should be selected as target. The supposed filename “TCCONFIG.BIN” must be used to allow ThermalCapture 2.0 to read it. The file can also be saved to a different destination and copied to the sd card manually later on.

2.2.2 Frame skip

For some applications it may not be necessary to record all frames coming from the Tau Core in order to reduce the amount of data in post-processing steps. Therefore it is possible to chose the amount of frames that should be skipped between each recording.

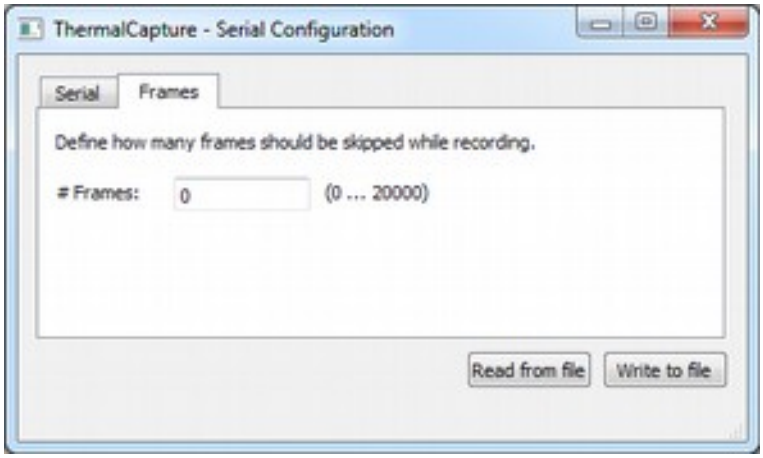


Figure 1: TC Configurator, Frame Skip

The Tau Core delivers frames with 8.33Hz in the not export restricted versions. If a recording frame rate of approximately 1Hz is desired a value of 7 skipped frames does exactly this. The result is 1 frame gets recorded; the next 7 frames are discarded; 1 frame is recorded; and so on.

This parameter is also useful if only one frame should be recorded with each trigger event. If for example the trigger is activated automatically by the waypoint functionality of the UAV, this parameter should be set to a number > 10. That ensures that even, if the UAV activates the trigger for 1 second, only one frame is stored. The number can be set even higher, because the counter is reset with every new trigger event.

3 ThermalCapture 2.0 Usage

ThermalCapture 2.0 was designed to be used with UAVs. Its task is to store thermal image data from the TAU core, when the trigger signal occurs. So there is only limited human intervention necessary to operate ThermalCapture 2.0. In the following the complete process from power up through data recording to power down is described.

3.1 Power On

You can power on with or without a connected sd card. ThermalCapture 2.0 begins to boot immediately when 5V is supplied to the MINI-USB connector or to the 8-pin connector. During boot up the LED on the back side glows red. This will take one or two seconds. After boot up ThermalCapture 2.0 waits for the sd card and the LED glows green. When the sd card was found and ThermalCapture 2.0 is ready to work, this LED will start blinking green.

3.2 Data Recording

When the trigger input is pulled to ground images from the TAU core are captured and stored to the sd card. The LED on the back side will flicker red and the letters “REC” are shown in the analog video output. Do not power off ThermalCapture 2.0 or release the sd card when the red LED is flickering. The file-system of the sd card may get damaged. If an error occurred while writing the data to the sd card the LED will blink green and red alternately. This will also happen if the sd card is full.

3.3 Power Off

Every time the LED does not flicker red, it is safe to remove the sd card or to power off ThermalCapture 2.0. Power off can only be done by turning off the power supply which is connected to the MINI-USB connector or 8-pin connector.

4 Post Processing with ThermoViewer Software

ThermoViewer is the post-processing software provided by TeAx Technology to process RAW data captured with ThermalCapture 2.0. It allows the user to quickly browse through recorded data and tune every single frame into the perfect result. For further usage of the data it can be exported into images like JPG and PNG, videos and CSV data. CSV is especially useful, if further automatic data processing follows. There is also the option to export data into radiometric JPGs. Those files can be opened with powerful FLIR tools for deeper analysis, or automatic report generation.

4.1 Overview

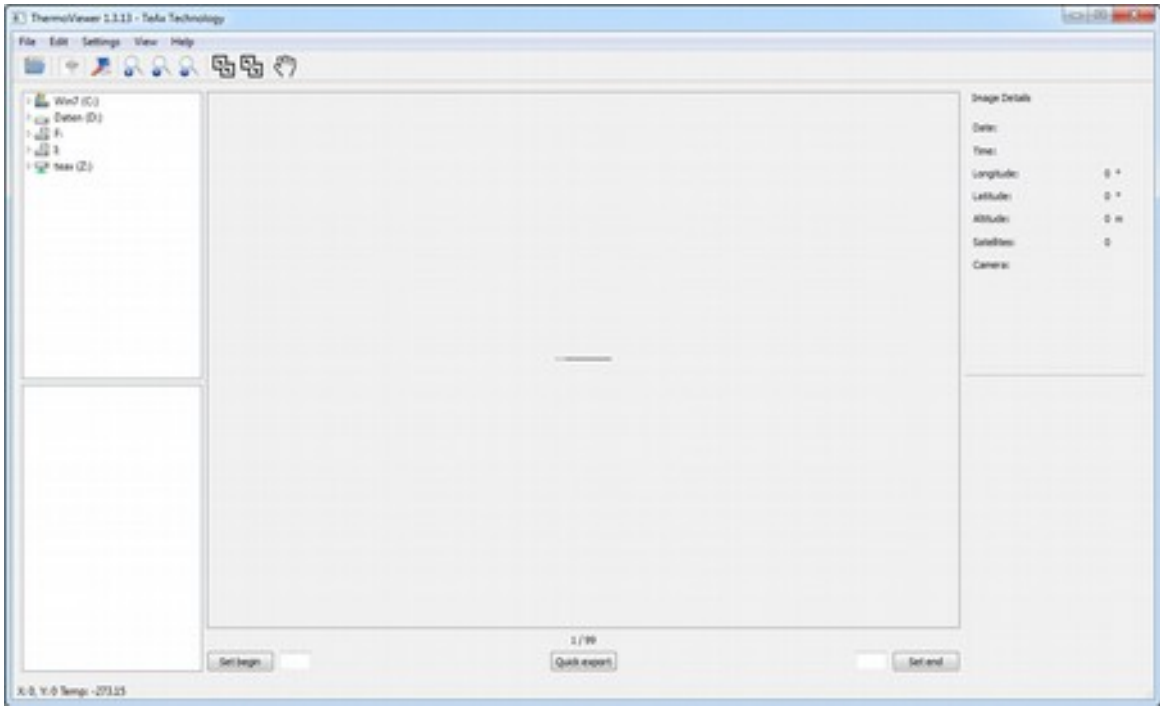


Figure 2: ThermoViewer after loading

Once you open up ThermoViewer you will see a window like shown above. On the top there are menu- and tool bar. The main window part below is split into three areas:

On the left side there are folder and file browsing areas (see 4.2.1). In the middle is the canvas for images. Underneath are the video control elements. On the right side additional image properties are displayed.

4.2 File handling

This section describes everything about opening and viewing of data, recorded with ThermalCapture 2.0.

4.2.1 Open and browse files

Opening files can be done in three different ways:

1. Select the folder directly in the directory tree on the left side of the window. Once you select the desired directory, the file list underneath will show all compatible files within it.
2. Use the toolbar button: 
3. Use the corresponding menu item within the “File” menu.

Either way the first image is loaded and shown in the center area of ThermoViewer. All parameters needed for conversion from RAW into a user friendly representation are determined automatically, if this feature is not disabled by the user.

4.2.2 Playback

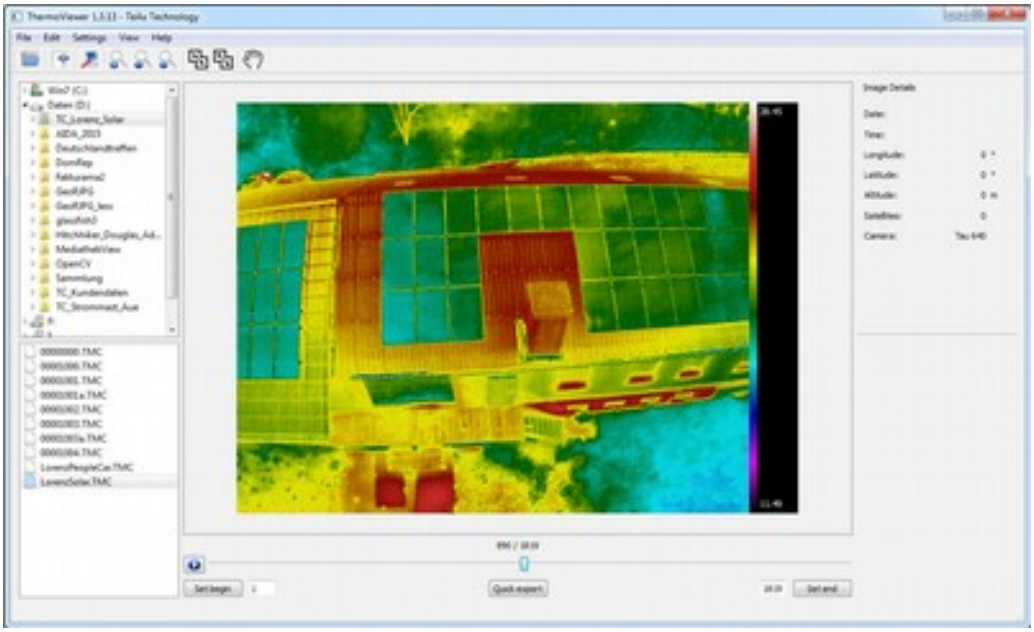


Figure 3: ThermoViewer after loading RAW data file

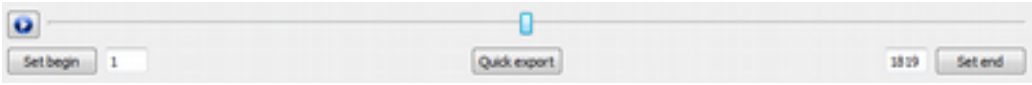


Figure 4: Video controls

A data set contains from 1 to 1000 frames, when recorded with ThermalCapture 2.0. To quickly browse through the frames, a simple slider drag, shown in Figure 4 is enough. Left to the slider there is a playback button which starts an automatic replay.

4.2.3 Zooming and dragging

To zoom in and out simply place the mouse cursor over the image and turn the mouse wheel up, or down.

Alternatively three buttons from the toolbar can be used:

Zoom in

Zoom out

Original size

If the zoom level is high, the image may not fit into the canvas anymore. To move the currently visible part of the image, either the two scrollbars can be moved, or the mouse behavior can be changed.

Switch to drag mode

Switch to measurement mode

When in drag mode the image can be dragged around by holding down the left mouse button and moving the mouse.

4.2.4 Temperature reading

ThermalCapture 2.0 stores radiometric data. That means, that for every pixel in every frame, temperature information is available. To determine the temperature of a given pixel, simply move

the mouse cursor over the pixel. It is recommended to switch the mouse mode to “measurement” to be able to select pixels more accurately. The temperature value is shown together with the pixel position in the lower left corner of the ThermoViewer window.

Figure 5: Temperature reading

If instead of the temperature a RAW value is displayed you need to change the “Radiometry” setting. See 4.3.4 how to do this.

4.2.5 Split and merge

Sometimes it is useful to combine multiple recorded .TMC files into one, or split a single file into smaller parts. There are two buttons within the toolbar for this tasks:

Merge

Split

Merge: Opens a dialog where multiple files can be chosen and merged into one single output file.

Split: Splits the currently loaded .TMC file starting with the frame defined using the “Set begin” button up to the one defined by “Set end”. After clicking, a file browse dialog appears, where location and name for the new file can be defined.

4.3 Adjust RAW conversion parameters

In general ThermoViewer uses a built-in algorithm to convert every recorded dataset into a good looking image. But in some cases the user wants to adjust parameters to specific needs in order to highlight details, or to fade out meaningless areas. This section describes the available tools to optimize the results.

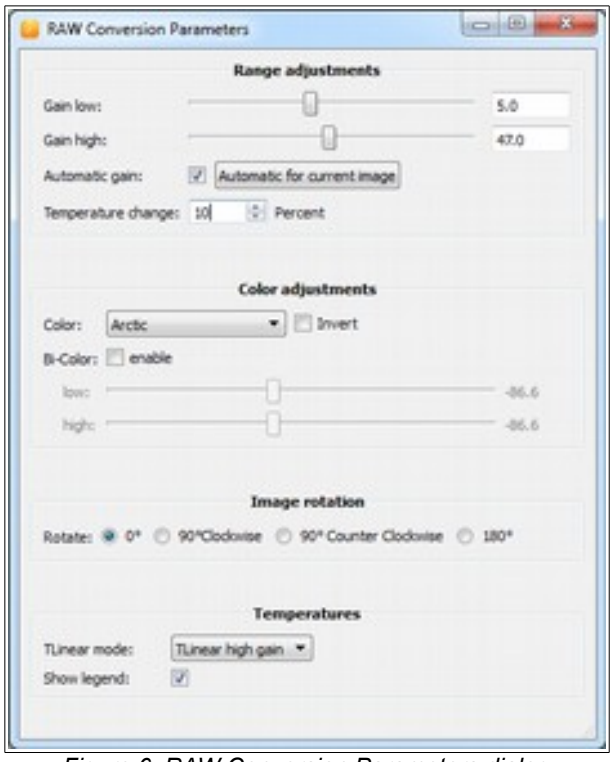


Figure 6: RAW Conversion Parameters dialog

4.3.1 Range adjustments

“Gain low” and “Gain high” represent the minimum and maximum temperatures, or RAW values that are used to produce the false color representation of measured data. In standard settings this values are determined automatically for each frame. If this is not wanted, deselect the “Automatic gain” option.

Manual settings are recommended, if recorded data contains a wide range of temperatures, but only a smaller range is of interest. By adjusting the boundaries, objects of interest can be segmented without the need for further post-processing. An example for this is given in Figure 7.

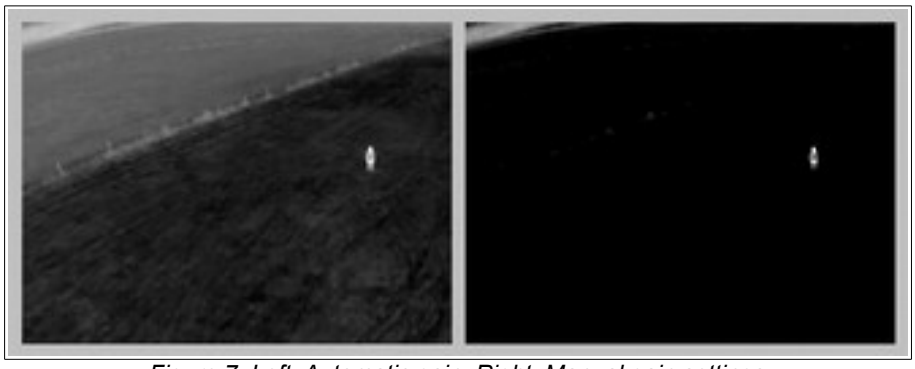


Figure 7: Left: Automatic gain, Right: Manual gain settings

If the data results in flickering representation during automatic playback or after video export, the maximum changes for “Gain low” and “Gain high” from one frame to the next can be delimited. This acts like a low-pass filter for video and playback.

4.3.2 Color adjustments

There are four different color palettes available, which all can be inverted for even better adoption to needed results. Figure 8 shows resulting false color images for the same dataset.

Each of the four palettes can be inverted, so that in total eight false color representations are available. Depending on the required result, different settings should be tested and verified.

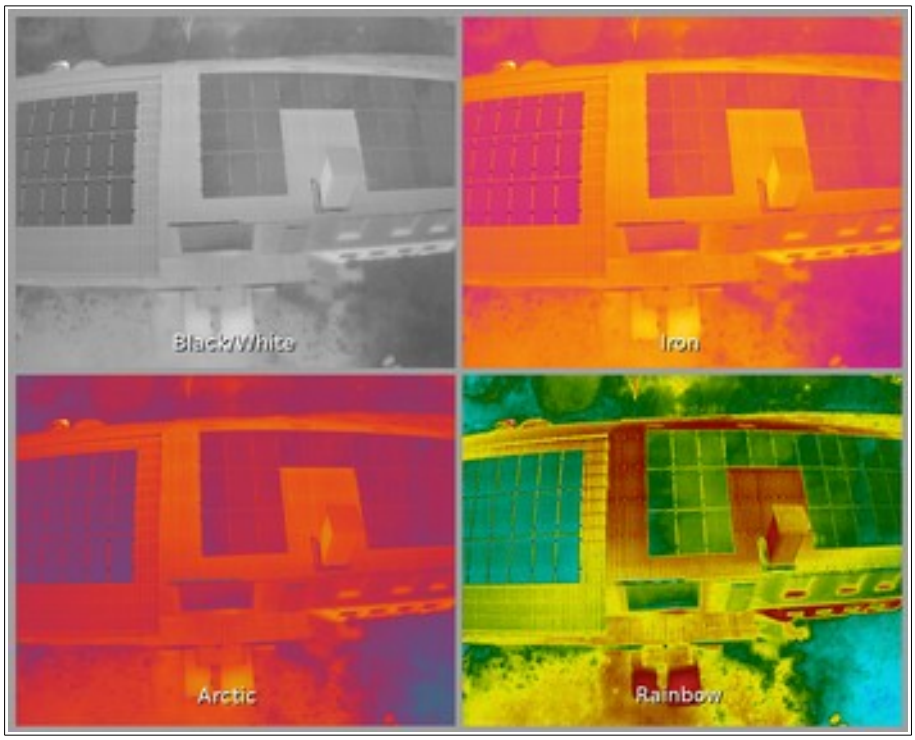


Figure 8: Color palettes

4.3.3 Image rotation

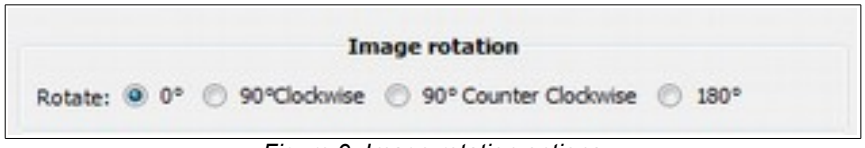


Figure 9: Image rotation options

Depending on how ThermalCapture 2.0 is mounted, it may be necessary to rotate recorded data. 90° steps are available.

4.3.4 Temperatures

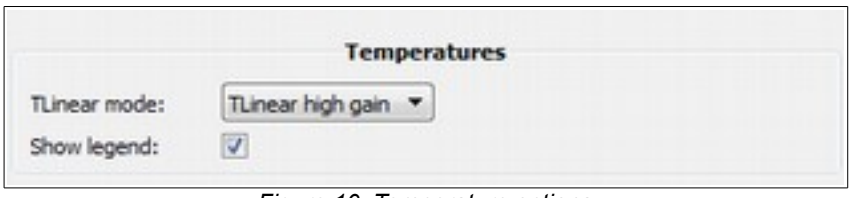


Figure 10: Temperature options

ThermalCapture 2.0, respectively the Tau Cores can operate in two different temperature ranges, which are called “High gain” and “Low gain”. In “High gain” mode temperatures between -25°C and +135°C can be measured. “Low gain” mode allows temperatures between -40°C and +550°C to be obtained. Settings within ThermoViewer must match settings within the Tau Core to provide valid temperature output.

The “Show legend” checkbox determines, if a temperature scale together, with the minimum and maximum temperature of the scene is placed to the right side of an image, or not.

4.4 Export functions

Data can be exported into several output formats, in order to use them for reports or further post-processing with other software tools. Most requested feature is the compatibility to FLIR software packages like, FLIR Tools(+), or ResearchIR and the export into CSV (comma-separated-values) files.

Figure 11: Toolbar

To open the export dialog press the 2nd item from the left within the toolbar, or select the item “Export frames” from the file menu.

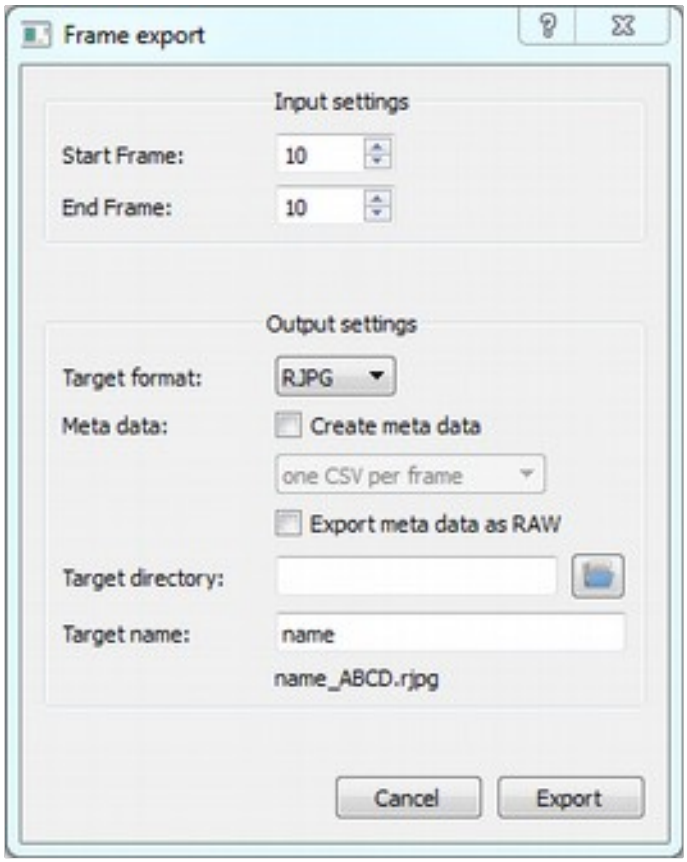


Figure 12: Frame export dialog

In the “Frame export” dialog the user can set all necessary options for the export of single or multiple frames. The first step is to select frames, which should be exported. The values in the input fields are taken from the main window input fields, but can be adjusted here if needed.

4.4.1 Target format

Target format can be selected by the drop down menu. Available formats are radiometric JPG (RJPG), PNG, JPG, TIF, CSV and AVI.

RJPG: 24-bit RGB image with compression; Includes complete radiometric information to be compatible with FLIR software.

PNG: 24-bit RGB image with lossless compression

JPG: 24-bit RGB image with compression

TIF: Single channel 16-bit image without compression. Contains the 14-bit data shifted to 16-bit.

CSV: Comma-separated value file, which contains the RAW measurements, respectively the measured temperature per pixel. Output depends on the temperature settings (page 19) within the RAW conversion parameters dialog (page 16).

AVI: Video in motion JPG format. Settings from the RAW conversion parameters dialog (page 16) are applied.

4.4.2 Meta data

There is also the option to export meta information together with each frame to have position information. There are three target formats:

CSV: This selection creates either one file per frame, or one file for all frames containing rows for each frame in the following format:

Column	Content
1	Date: DD.MM.YYYY
2	Time: HH.MM.SS
3	Latitude: -180 to +180 decimal degrees
4	Longitude: -180 to +180 decimal degrees
5	Pitch: decimal degrees
6	Roll: decimal degrees
7	Yaw: decimal degrees
8	Altitude above N.N. in meters
9	Number of visible satellites

KML: This selection creates a Google Earth compatible output, which places a marker at each position, where a frame is recorded.

RAW: This exports the raw data recorded with each frame into a .DAT file, which can be parsed in post processing.

4.4.3 Filename

Target directory into which the output files will be written can be entered manually into the text field, or can comfortable be selected by opening a file browsing window using the button.

The target name consists of three parts. The first part can be entered by the user. ThermoViewer will automatically add a continuous number to this name and also the extension determined by the selected target format.

4.4.4 Quick export

Once the settings for export are made and further frames with the same settings shall be exported, the Quick export button below the image slider can be used. Every time the button is pressed, the currently visible frame is exported using the settings made before.

4.5 NMEA Parser

If a GPS receiver is connected to the serial interface of ThermalCapture 2.0 and the device is set up to send NMEA data, then the “Parse NMEA Data” option in Settings menu can be activated. Extracted data from the GPRMC messages is then shown on the right side of ThermalViewer main window.

4.6 Command line arguments

In order to automate conversion from .TMC data format into different output formats ThermoViewer can be started using command line arguments. The available parameters are listed in Appendix A.

Appendix A

Man page of ThermoViewer command line arguments:

```
NAME
      ThermoViewer - Application to process ThermalCapture files

SYNOPSIS
      ThermoViewer [OPTIONS]

OPTIONS
      -c
          Automatically closes the application after processing all given tasks

      -cp palette
          Sets the color palette
          Available are: gray, iron, arctic, rainbow

      -folder path
          Processes all files in given path

      -help
          Displays this help screen

      -i file
          Loads the given file after opening the application

      -ic
          Enables color inversion

      -exef number
          Sets export ending frame to number

      -exfn name
          Sets the name prefix for exported files to name

      -exfo <format>
          Sets the export format
          Available are: png, jpg, tif, avi, csv, rjpg

      -expa path
          Sets the directory to which exports are written to path

      -exsf number
          Sets export starting frame to number

      -exmeta <type>
          Set the ouput format for meta data. If ommited, no meta data will be written
          Available options are:
              CSVpf - One CSV per frame
              CSVfa - One CSV for all frames
              KML   - One .kml for all frames
              RAW   - Binary raw data

      -tl format
          T Linear settings
          Available are: none, high, low
```

```
              high = Tau core is in high gain mode
              low  = Tau core is in low gain mode

      -l
          Adds a legend to the exported image

      -r degree
          Rotates the input frames. Supported degrees are 0, 90, 180, 270.

EXAMPLE
       ThermoViewer -i 00000001.TMC -r 180 -l -cp iron -expa /home/thamke/Desktop/ -exfn
image -exfo jpg -exsf 42 -exef 42 -c

          * Opens the file '/home/thamke/Desktop/00000001.TMC'
          * Rotates the output by 180 degrees
          * Adds a legend to the image
          * Sets the color palette to iron
          * Set the export directory to '/home/thamke/Desktop/'
          * Sets the file prefix to 'image'
          * Sets the export format to 'jpg'
          * Sets the start frame to 42
          * Sets the end frame to 42
          * Closes the application after export
```