Chapter 6

Software User Manual

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6. Software User Manual

This chapter explains how the snapscan software can be used to configure the snapscan system, acquire hyperspectral data cubes and finally view and export the data.

First, an overview is given of the workflow and user interface layout, after which each view is explained in more detail.

6.1 General

snapscan software provides the following two key functionalities:

1. Cube acquisition (see Section 6.2)
2. Cube display (see Section 6.3)

Figure 63 shows the different elements in the user interface of the software:

- **Mode selection panel** – Provides separate tabs to select cube acquisition or cube display mode.
- **Control & configuration panel** – This panel is specific to the selected mode. It provides control and configuration options to the user.
- **Display panel** – This panel is also specific to the selected mode. In acquisition mode, the panel displays live view from the sensor, whereas in cube display mode it shows a previously acquired cube as selected by the user.
- **Status panel** – Provides camera related information. For example, sensor temperature.

Cube acquisition tab is selected by default when the software starts.

Figure 64 shows the typical workflow that a user must follow while using the software. Details of each step in the workflow are provided in the upcoming sections.

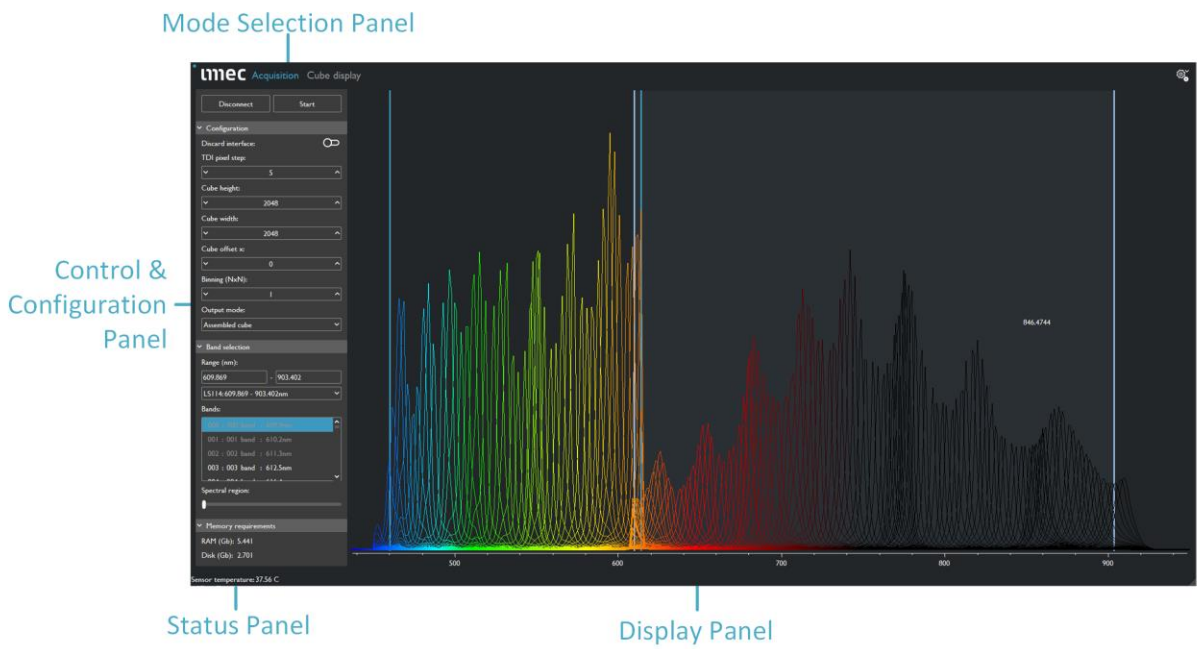


Figure 63: Annotation of the main elements in the snapscan software's user interface

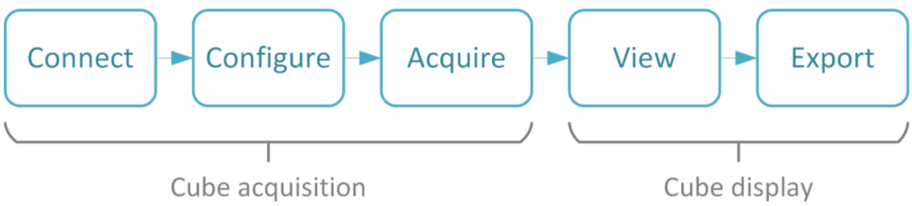


Figure 64: Illustration of the workflow of the snapscan software. This workflow guides the user from connecting to the snapscan system to exporting hyperspectral data.

6.2 Cube acquisition mode

Cube is acquired from the snapscan camera by following the first three steps in the workflow shown in Figure 64.

Connect step – select your snapscan system and establish connection

Configure step – configure the acquisition properties

Acquire step – control the system and acquire data

Each of these steps are discussed in detail in the upcoming sections.

6.2.1 Connect step

Follow the steps below to connect to the snapscan camera system:

Step 1 - Click the *"Select SnapScan file"* button to load the system configuration file specific to your snapscan camera unit.

This file contains information on how to connect to the hardware as well as which sensor calibration file to use to interpret the data. When the file is loaded, the name of the file is shown and the connect button becomes available.

The software keeps track of the last used snapscan system file. When restarting the software, reconnecting is possible without having to select the system file again.

Step 2 - Click the *"Connect"* button

This will establish a connection to the snapscan system, initialize the hardware and switch the user interface to the configuration step. If needed, refer to Section 5.4 for troubleshooting instructions.

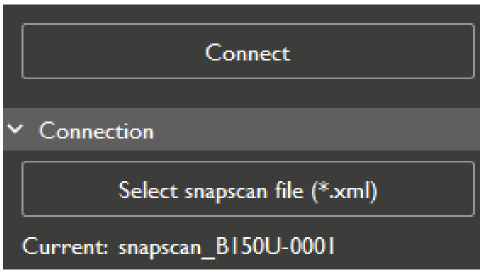


Figure 65: Controls available to connect to the snapscan system.

6.2.2 Configure step

Follow the steps below to configure the snapscan camera system for the cube acquisition:

Step 1 - Set the camera parameters by following the instructions in Section 6.2.2.1

Step 2 - Select the spectral bands by following the instructions in Section 6.2.2.2

Step 3 - Click the Start button to switch to acquisition interface (discussed in details in Section 6.2.3)

6.2.2.1 Configuration parameters

The configuration parameters available are shown in Figure 66 and their description is provided in Table 9. These parameters determine the memory requirements, output data size, quality, and maximum acquisition speed.

An estimation of the memory requirements and data size is displayed below the settings and are updated when the user changes a configuration parameter.

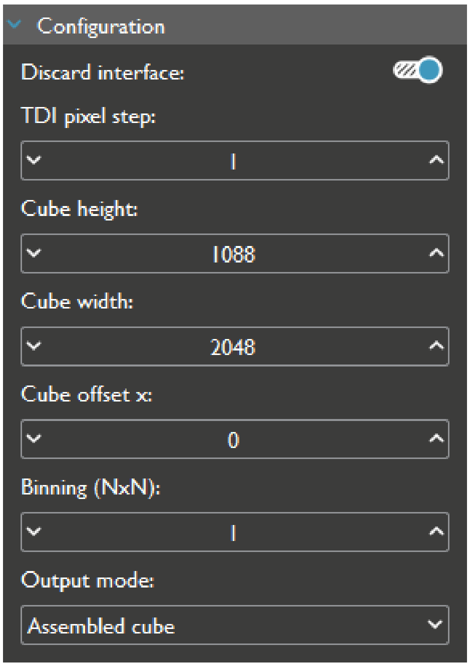


Figure 66: Controls available to configure the snapscan output data. The output data properties define the memory requirements, output data size, quality, and maximum acquisition speed.

Table 9: Overview of the parameters available to configure the snapscan system.

Parameters	Values	Description
Discard interface pixels	ON / OFF Default: OFF	ON: Pixel rows at the edges of spectral bands are ignored. This will reduce the crosstalk between the spectral bands. OFF: All the pixels rows of a spectral bands are used.
TDI pixel step	1 to 5 (number of pixel rows per spectral band) Default: 5	Sets the travel range between two consecutive images. *Tip:* Smaller values avoid band to band crosstalk, enable software TDI, reduce noise, increase number of frames needed, increase acquisition duration.
Cube height	1 to 3600 (number of pixel rows in the sensor) Default: 1088	Sets the number of rows in the output data. *Tip:* Higher values will increase the vertical spatial resolution but it will also increase the required memory and the size of output file.
Cube width	1 to 2048 (number of pixel columns in the sensor) Default: 2048	Sets the number of columns in the output data. *Tip:* Higher values will increase the horizontal spatial resolution but it will also increase the required memory and the size of output file.
Cube offset x	0 to 2048 (number of pixel columns in the sensor) Default: 0	Sets the offset from top edge in live view in case the selected cube width is lower than 2048. *Tip:* Use cube height, width and offset to acquire selected region in the field of view.
Binning (NxN)	1 to N (2, 3, ... ,20) Default: 1	Pixels within a NxN neighborhood are merged by averaging. *Tip:* Binning increases the SNR but decreases the spatial resolution and the size of output file.
Output mode	Assembled cube / Frame stack	Assembled cube: The acquired frames are assembled in a cube and stored in a single file. Frame stack: The acquired frames are stored in separate files. The number of files generated is equal to number of bands.

6.2.2.2 Spectral bands selection

In Section 2.2.4.4, we have introduced the principle and benefits of band selections. In this section, we will guide you on how to select bands using graphical visualization and configuration panel.

The default band selection is configured during the in-factory system calibration, which selects all the bands in the full spectral range of the camera. In case of VNIR version, the default number of SROI is 2 which corresponds to the separate VIS and NIR filter zones on the sensor (see Section 1.1.3 for details about the VNIR filter layout). In case of NIR version, the default number of SROI is 1 which corresponds to the single NIR filter zone on the sensor (see Section 1.1.4 for details about the NIR filter layout).

Band selection can be carried out using the graphical visualization in the Display panel where the spectral response of all the bands are shown. The selected bands can be edited either using the graphical visualization or using the Control & Configuration panel.

- *When using band selection, the software will automatically compute a correction matrix to compute the true spectral signal from the selected bands.*
- *The actual index of the band on the sensor is stored in the band's name when exporting the data without correction.*

Using graphical visualization

Follow the steps below to add, remove and modify SROIs:

Add	Left click on the plot to add a SROI. A faint blue overlay, bordered by two blue lines (handles), indicates the added SROI. The response of all selected bands is shown in the color corresponding to the wavelength.
Remove	Right click on a SROI to remove it
Modify	Hold and drag the left or right handles on the overlay to include or exclude additional bands.
Reset	Left click and drag over the full spectral range displayed

Figure 67 shows an example of band selection with two SROIs.

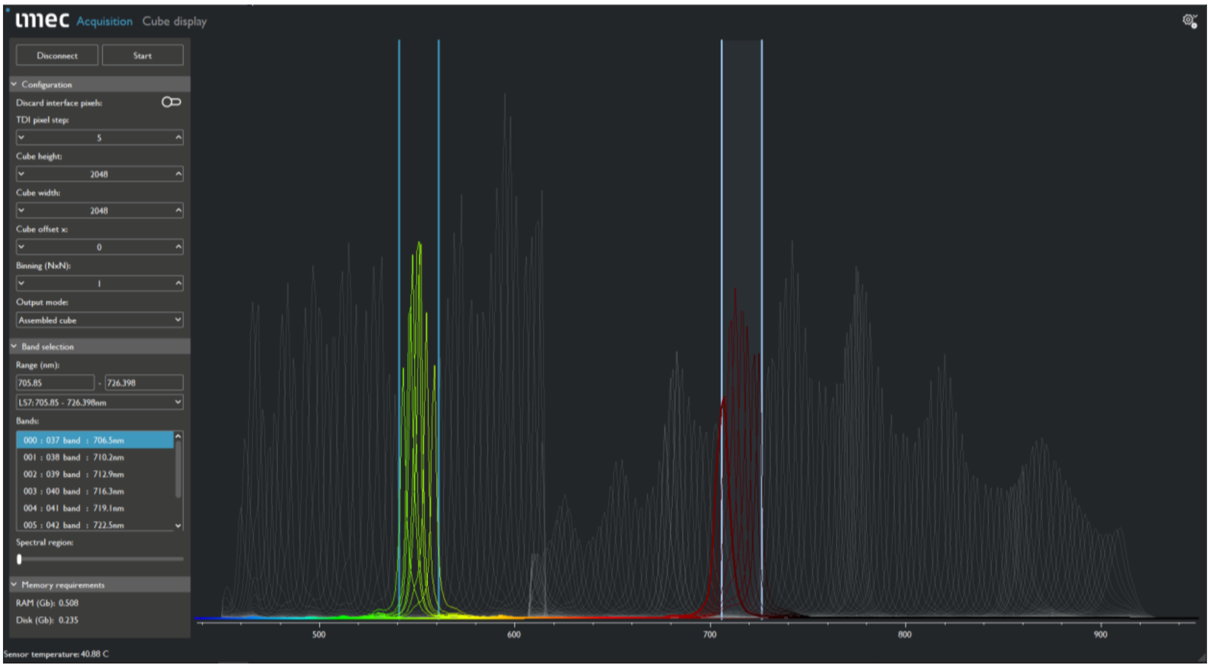


Figure 67: Example of a band selection with two spectral regions of interest. The user can interact with the visualization to modify the band selection. By default, after connection, the full sensor is read out.

Using configuration panel

The band selection can also be modified using the configuration panel, as shown in Figure 66. The lower part of the panel provides controls for band selection, as shown in Figure 68. These controls are described in Table 10.

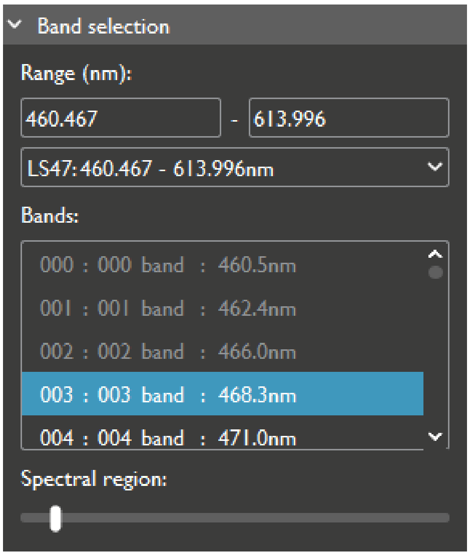


Figure 68. Band selection tool is complementary to the right side and can be used to fine-tune the range or highlight a given band by clicking on it or moving the slider.

Table 10 Description of controls for band selection in the configuration panel

Range (nm)	The central wavelength of the first and last spectral band in the selected SROI is displayed here. The spectral range of the selected SROI can be edited by changing the beginning and the end wavelengths. All the SROIs selected using the graphical visualization are listed in the pulldown menu and it can be used to select a specific SROI.
Bands	Displays the list of bands in the selected SROI. Specific band can be highlighted by clicking it in the band list or using the slider below. *Tip:* Some bands on the sensor have been disabled during the in-factory system calibration to optimize the system's spectral response. When these bands fall in a spectral region they are greyed out in the region's band list. The band data will be recorded in the data, but will not be used for spectral correction.
Spectral region	The slider can be used to scroll through the bands displayed for the selected SROI.

6.2.3 Acquire step

The user interface for the acquisition mode is shown in Figure 69, where

1. The Control & Configuration panel can be used to set the image acquisition parameters, such as integration time, gain and scanning mode.
2. The Display panel shows the live view from the snapscan camera.
   - The live view provides a sight on the scene as seen by the snapscan camera. The outer border is displaying the maximum possible size while the inner one indicates the region that will be scanned as specified in the configure step.
   - When a preview image has been captured it is displayed as a background of the view.
   - An overlay is masking the unselected bands of the sensor.
   - In the top-right corner, controls are provided to rotate/flip the view. Saturated pixels are shown in red.

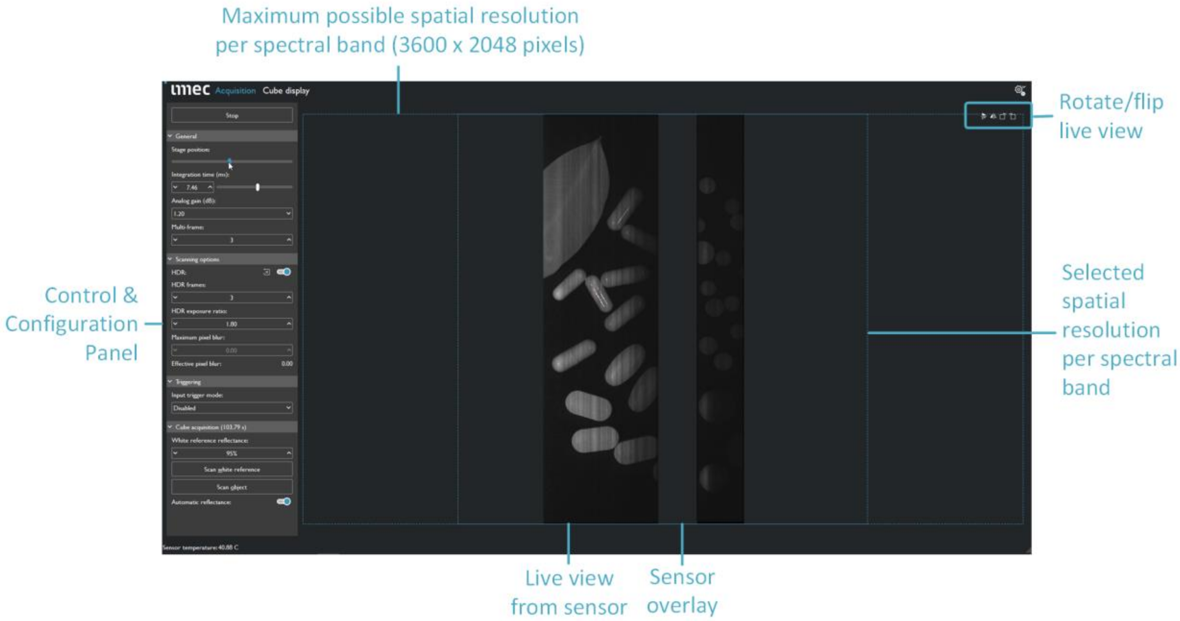


Figure 69: User interface and live view display for the acquisition mode after the camera has been connected and configured with default SROI settings, i.e. all spectral bands are selected.

Figure 70: User interface and live view for the acquisition mode after the camera has been connected and configured with specific bands selected. The semi-transparent colored overlay indicates bands that fall outside of the band selection.

Follow the steps below to configure the acquisition parameters and acquire images from the snapscan camera

Step 1 - Set the image acquisition parameters by following instructions in Section 6.2.3.1.

Step 2 - Acquire reference data for white balancing and image data for the object under scanning by following instructions in Section 0.

Step 3 - Go to *"Cube Display"* tab for viewing the acquired data and for further processing or click *"Disconnect"* button to go back to configuration mode.

Figure 71 shows the different elements available in the Control & Configuration panel.

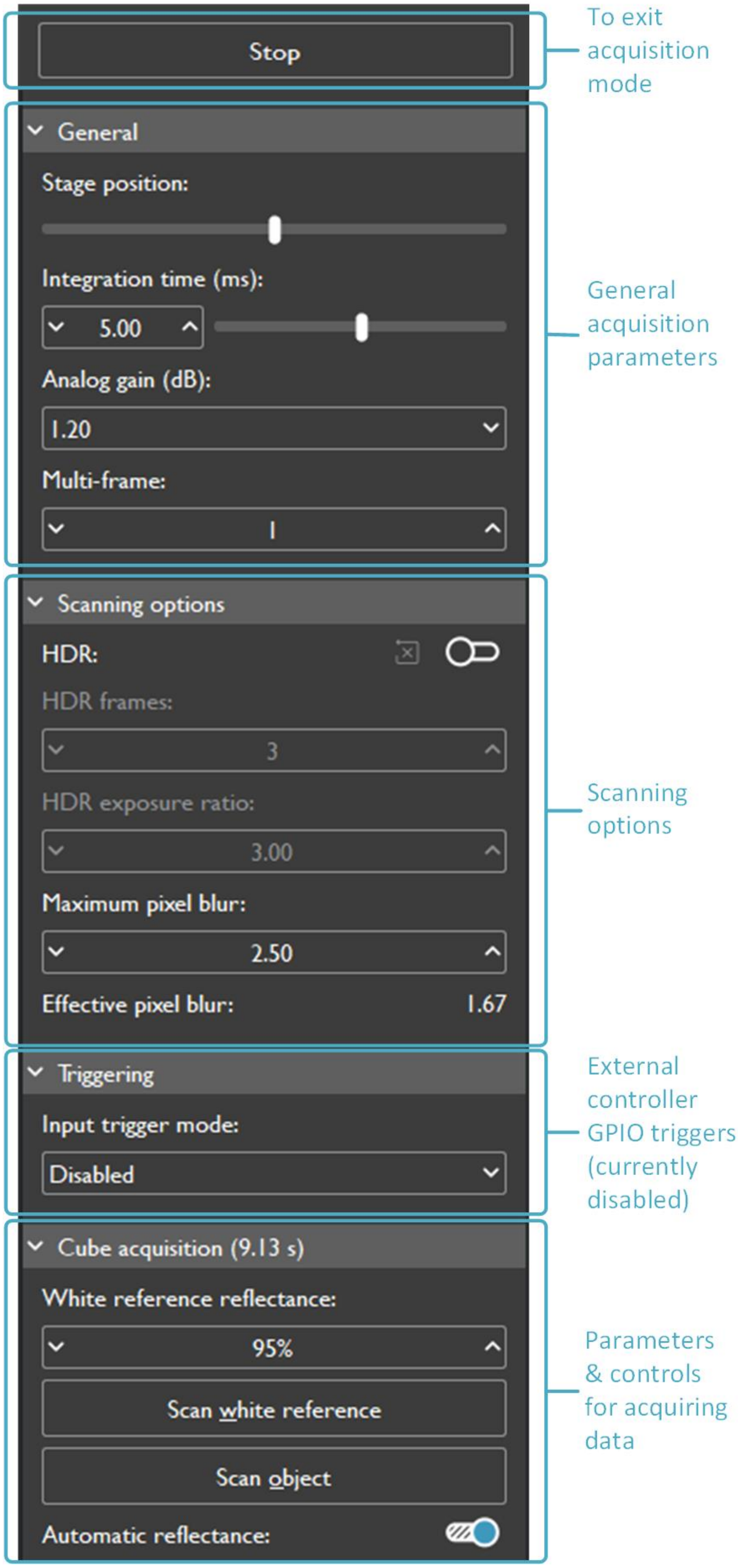


Figure 71 Control and configuration panel in the acquisition mode

6.2.3.1 Image acquisition parameters

There are the following categories of image acquisition parameters:

- General
- High Dynamic Range (HDR) control
- Pixel blur control
- External triggering control

Modifying the cube size and TDI settings requires returning to the configuration mode by stopping the acquisition. This is done by clicking the stop button.

General acquisition parameters

The general acquisition parameters, as shown in Figure 72, let the user set the integration time and analog gain for the acquisition as well as the number of times a single frame should be acquired and averaged. An overview of these parameters is given in Table 11.

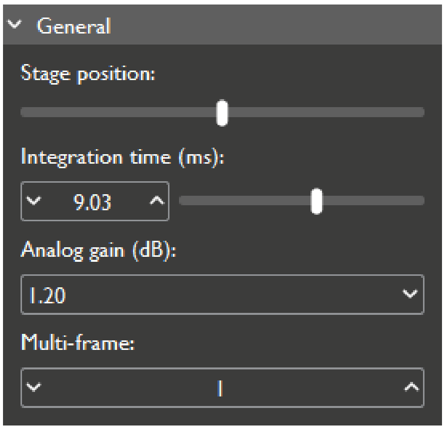


Figure 72: The general acquisition parameters allow setting integration time, gain, scanning mode.

Table 11: Overview of the general parameters available to configure the acquisition with the snapscan system.

Parameter	Values	Description
Stage position	N.A	Drag the slider left or right to move the sensor live view across the field-of-view of the camera.
Integration time	0.5 – 50ms	Set the time period during which photons are collected by the sensor to capture a single frame. *Tip:* Lower values enable faster acquisition but may decrease the SNR.
Analog gain	1 – 3.2dB Default: 1.2	Set the sensor analog gain. *Tip:* Higher gain allows shorter integration times, but increases photon shot noise.
Multi-frame	1 – 100 Default: 1	Sets how many times the measurement must be repeated. The final scan is an average of the repeated measurements. Higher values increase SNR at the cost of scanning time.

Tips for obtaining sensor's maximal dynamic range

- The integration time and gain settings are the primary tools to maximize the use of the sensor's dynamic range.
- The dynamic range is maximized by choosing the parameters such that a slight increase of either the integration time or analog gain results in saturated pixels.
  - *The impact of selected parameters can be verified by looking at the live view from sensor. The entire field of view can be verified by translating the sensor in the camera body by using the Stage position slider.*
  - *Double clicking the Stage position slider will center the sensor.*
- A higher gain allows using shorter integration times and hence increases the scanning speed. The drawback of a higher gain setting is that this amplifies the photon shot noise.
- A reasonable tradeoff is found with a gain between 1 and 3.2db and integration time below 15ms.

High Dynamic Range (HDR) control parameters

HDR scanning increases the dynamic range of the captured data by selecting optimal integration time for frame acquisition of each spectral band.

Why HDR is needed?

There is variation in sensitivity of different spectral bands due to the variation of sensitivity of the underlying CMOS image sensor and variation in the intensity of illumination across different wavelengths (as shown in Figure 8 and Figure 73). Thus, selecting a single integration time for all spectral bands will under-expose spectral bands with lower sensitivity as the integration time should be set such that the most sensitive spectral band does not saturate. It can be seen in the left-hand side sensor live view in Figure 73 that spectral bands on the right-half of the sensor are under-exposed as compared to the spectral bands on the left half of the sensor.

The exposure can be balanced across all spectral bands by enabling HDR, as seen in the right-hand side live view in Figure 73.

Figure 74 shows an example of image acquired using different integration times for different spectral bands when HDR is enabled. It can be seen that higher integration times were used for spectral bands between 470-680nm (physically located on the right half of the sensor live view in Figure 73) as compared to spectral bands between 680-900nm (physically located on the left half of the sensor live view in Figure 73).

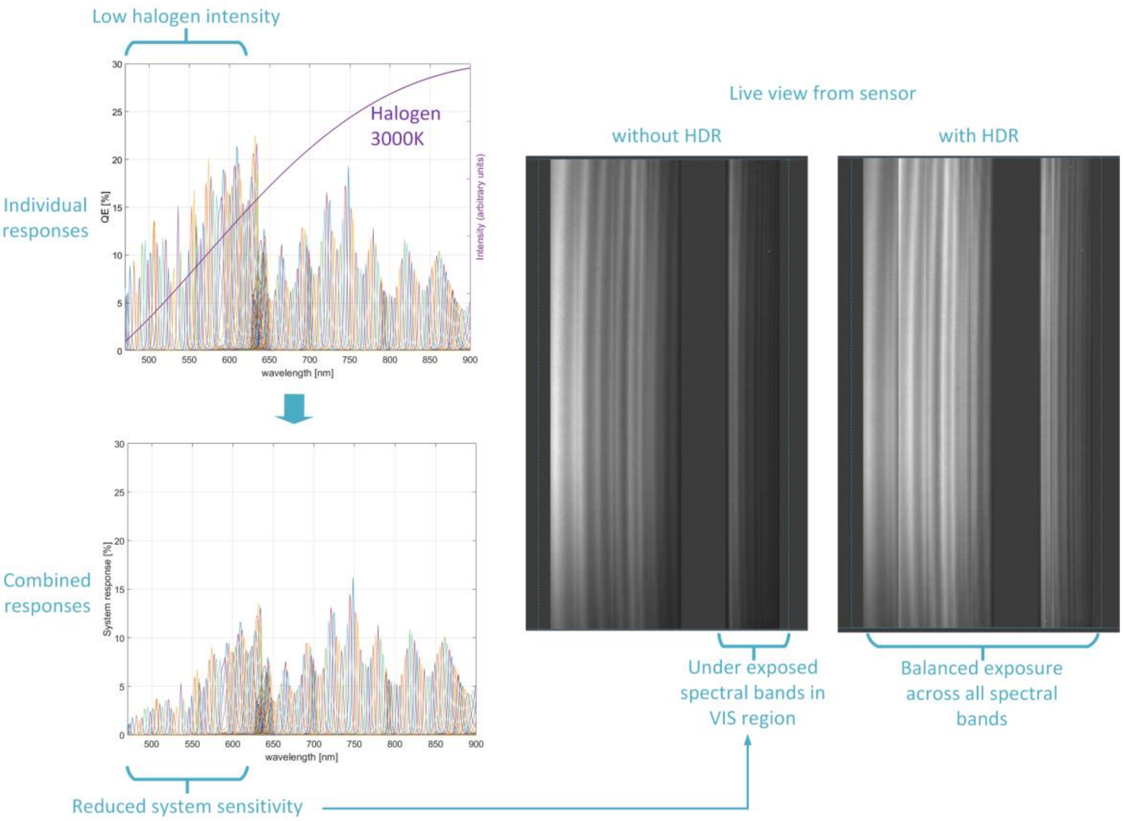


Figure 73 Illustration for the need of HDR to have balanced exposure across all spectral bands. The system response is a product of sensor QE and the spectral response of the illumination. Due to lower intensity of halogen in the VIS spectral range, the overall system sensitivity is reduced, resulting in underexposed spectral bands in VIS spectral range.

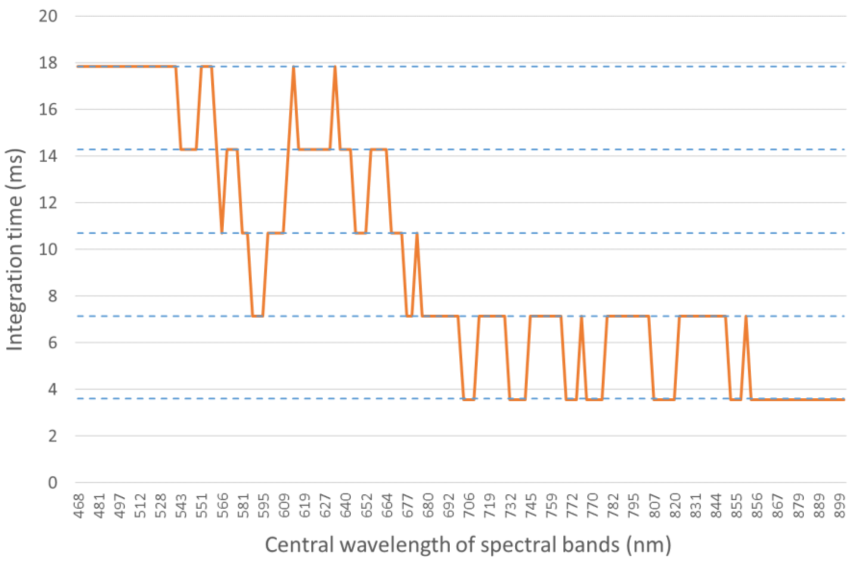


Figure 74 Integration times selected for different spectral bands when HDR is enabled. In this case, the system acquired images for different spectral bands using 5 different integration times. Setting used: HDR frames = 5, HDR exposure ratio = 5, integration time = 3.7ms (see Section 0 for explanation of these terms)

What is the effect of HDR?

Enabling HDR results in improved SNR of the acquired images, as shown in Figure 75. The figure illustrates the same scene acquired with and without HDR. In case of image acquired without HDR, the spread in spectral responses across the pixels in the selected region (shown as red block on the left-hand side of the image) is higher than in the case with HDR. This shows that the SNR of the image can be improved by using HDR. However, enabling HDR will increase the overall time required to acquire the image. Thus, there is a trade-off in quality versus time and the user should taking this into consideration will configuring the acquisition parameters.

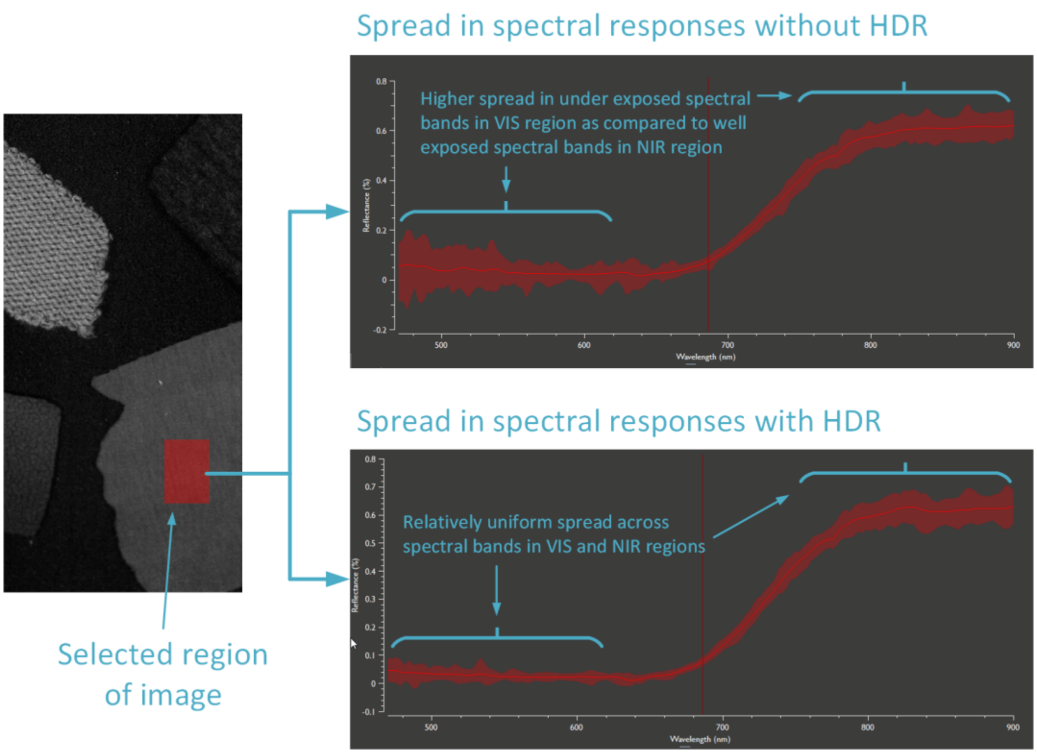


Figure 75 Illustration of reduction in spread in spectral responses with HDR, i.e. improving the SNR of the acquired image.

How to configure HDR in snapscan?

The HDR scanning parameters provided in snapscan software are shown in Figure 76 and Table 12.

Follow the steps below to configure HDR:

Step 1 - Place the white tile below the camera such that it covers the entire field of view of the camera.

⚠ *Always use the white tile as it has a uniform surface.*

Step 2 - Enable HDR by clicking on the slider button.

Step 3 - Set integration time and analog gain under general acquisition parameters.

Step 4 - Set the number of *"HDR frames"*. This parameter sets the number of different integration times that will be used for acquiring HDR frames. The software will automatically compute these different integration times (see next step).

For example, if *"HDR frames"* is set to 3, then the software will calculate 3 different integration times and will acquire all the HDR frames using one of these integration times.

Tip: Larger values yield flatter SNR over the spectral range at the cost of acquisition speed.

Step 5 - Set the *"HDR exposure ratio"*. This parameter sets the maximum integration time that will be used.

For example, if *"Integration time"* (under general acquisition parameters) is set to 10ms, *"HDR frames"* is set to 3 and *"HDR exposure ratio"* is set to 5 then the software will compute three different integration time as shown below.

Minimum integration time	10ms (=integration time set under general acquisition parameters)
Maximum integration time	50ms (=Minimum integration time x HDR exposure ratio)
Intermediate integration time	30ms (= average of minimum and maximum integration times) In case, of more than 3 HDR frames, the intermediate integration times are selected at equal intervals between minimum and maximum integration times.

Tip: Larger values increase the final dynamic range at the cost of acquisition speed.

Step 6 - Verify the effect of HDR by dragging the stage across the field of view of the camera to ensure that

- there is no saturation in any spectral band(s) for the spatial region to be acquired
- the spectral band(s) are optimally exposed as expected

Step 7 - Click ⊠ to recompute the HDR, i.e. the software will compute the integration time for the HDR frames based on the current scene and the above settings.

Tip: Always recompute HDR after changing any parameters under HDR and/or general acquisition when HDR is enabled.

Step 8 - If needed, repeat above steps and verify again.

The live view shows the effect of the HDR computation without normalization by integration time. The data is automatically normalized when processed into a hyperspectral data cube.

The internal HDR settings must be computed either with the white reference in view or with a diffuser in front of the lens.

Using different internal HDR settings for the object and white reference acquisition may further increase the SNR of your recording.

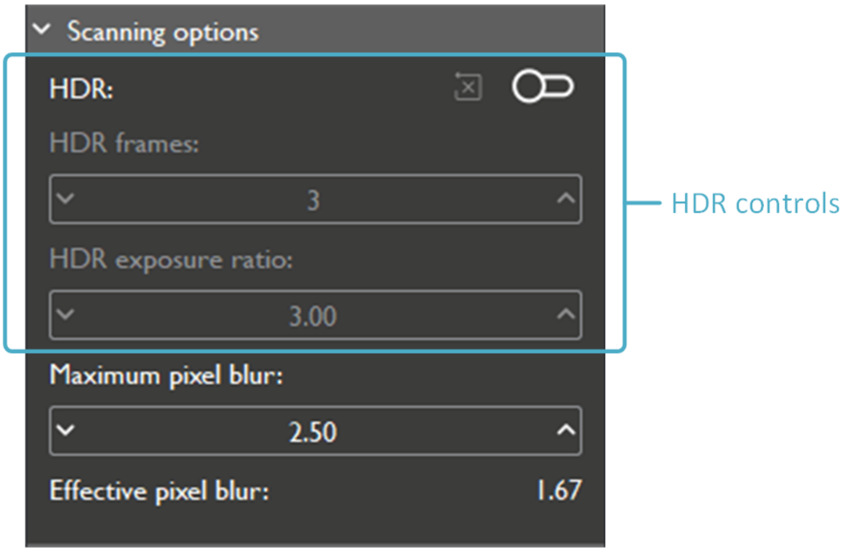


Figure 76: Scanning options available in the stop motion scanning mode. HDR can be enabled and configured by setting the number of frames and the multiplier limiting the maximum integration time used as compared to the integration time set in the general settings.

Table 12: Overview of the parameters available for HDR controls

Parameter	Range	Description
HDR	On / Off Default: Off	Enables / disables the HDR mode. HDR increases the SNR of bands with low signal at the cost of acquisition speed.
	N.A.	Triggers computation of the integration time for the HDR frames based on the current scene.
HDR frames	2 – 100 Default: 3	The number of different integration times used to compute one HDR frame. Larger values yield flatter SNR over the spectral range at the cost of acquisition speed.
HDR exposure Ratio	1 – 100 Default: 3	Factor multiplied to the general integration time defining the maximum integration time used for HDR. Larger values increase the final dynamic range at the cost of acquisition speed.

Pixel blur control parameters

Pixel blur refers to the distance travelled by the sensor while sensor exposure is in progress. The traveled distance is measured in terms of pixels. The snapscan camera can operate in one of the following two modes:

1. Continuous: Data is acquired in-motion. The frame acquisition is synchronized to the motion by a hardware signal. The motion during the acquisition causes motion-blur in the data which can be controlled using the pixel blur control parameter.
2. Stop motion: Data is acquired in standstill. The sensor is moved by the pixel step (defined in the configuration view) and brought to standstill before acquiring the next frame. Hence, the pixel blur control parameter is not applicable in this mode.

The snapcan will always operate in stop motion when HDR is enabled. Hence, skip this setting if you have enabled HDR. Otherwise, follow the steps below to configure pixel blur control parameter (see Figure 77 and Table 13):

Step 1 - Check the *"Effective pixel blur"* value. This value is automatically calculated by the software based on the achievable frame rate, TDI steps and selected integration time. The achievable frame rate is displayed in the Configuration panel and is dependent on the bit-depth and number of spectral regions-of-interest (SROI).

Step 2 - Estimate the required resolution in terms of minimum number of pixels required to cover the targeted feature size. Count the number of pixels covering the feature size in the live view of the sensor.

Step 3 - Verify if the *"Effective pixel blur"* value is acceptable or not based on the table below.

Feature size (in pixels) [as seen in sensor live view]	Recommended maximum pixel blur
≥ 7	≤ 5
6	≤ 4
5	≤ 3
4	≤ 2
3	≤ 1
2	0

Step 4 - If the *"Effective pixel blur"* value is higher than the recommended maximum allowable pixel blur, set *"Maximum pixel blur"* parameter to a value lower or equal to the recommended value.

Step 5 - If the system does not accept the specified value then change the configuration and acquisition parameters mentioned in Step 1. If the *"Effective pixel blur"* is still higher than the recommended value and it is not acceptable then you may have to change the optics and/or working distance such that the targeted feature size (in terms of pixels) and as seen in sensor live view increases.

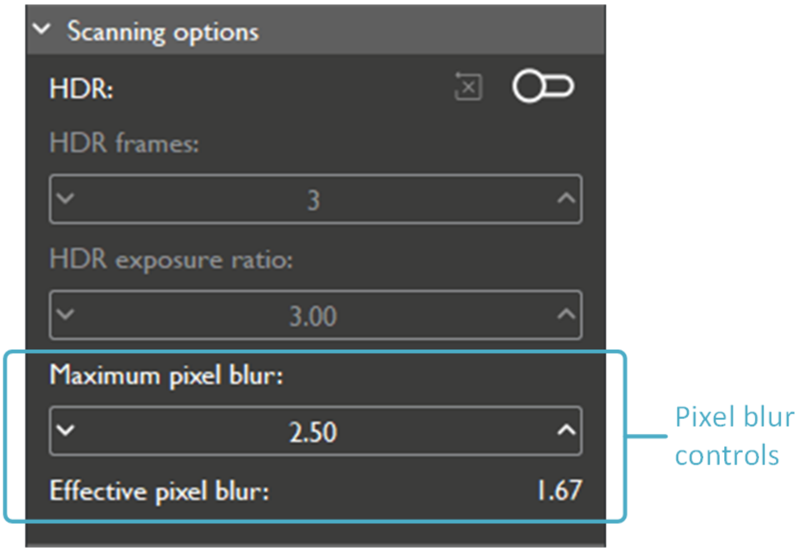


Figure 77: Scanning options available in the continuous scanning mode. Motion blur is controlled by limiting the distance traveled during the exposure time.

Table 13: Overview of the parameters available to configure the pixel blur controls

Parameter	Range	Description
Effective pixel blur	0 - 5	Distance traveled by sensor (in terms of pixels) during the exposure time. Tip: Smaller values indicate lower blurring and hence sharper images.
Maximum pixel blur	0 - 5	Threshold specified by user on the pixel blur.

External triggering control parameters

The snapscan hardware is equipped with two triggering ports: in and out. Output can be used to control additional hardware synchronously to frame acquisition (e.g. a punctual illumination). By default, the sensor's read out is handled by the software. If need be, the user can use an external triggering system: the camera will then acquire frames when told to.

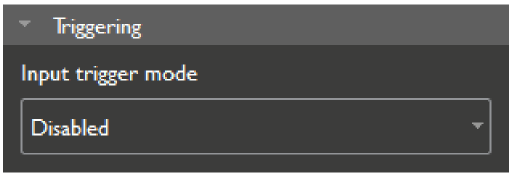


Figure 78. Triggering system selection. When disabled, the software is let in charge of the control.

6.2.3.2 Acquiring data

The actual data acquisition typically consists of two acquisitions:

1. A scan of the object
2. A scan of a white reference (used in the software to normalize or white balance the object data into raw reflectance or raw transmittance)

These acquisitions can be done in any order.

Multiple object scans can be acquired with the same white reference. The software temporarily stores internally the white reference after it is acquired. This temporary copy is maintained until the user exits acquisition mode by clicking "Stop" (see Figure 71) or a new white reference is acquired.

Figure 79 shows the controls for acquiring the data. The estimated time required for an acquisition is displayed above the controls.

Scans are always stored in memory until exported. Creating a new object or white reference scan replaces in memory the previously acquired object or reference scan respectively.

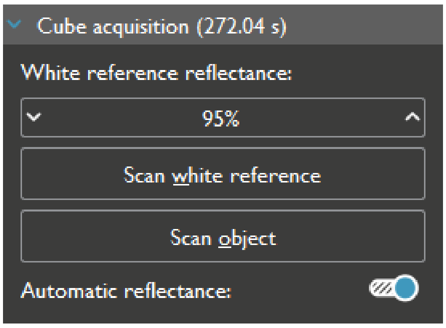


Figure 79: Cube acquisition controls. An estimate of the acquisition time given the current parameters is displayed on top of the section.

Acquiring white reference image

Follow the steps below to acquire white reference scan:

Step 1 - Place a white reference under the camera.

Step 2 - Set *"White reference reflectance"* parameter. The default value is 95%. If you are using the white reference target provided with the snapscan system, then leave this value at 95%. In case you are using a different white reference target then set this value accordingly.

Step 3 - Ensure that the spatial resolution of the white reference image is same as that of the object image.

Step 4 - Set the acquisition parameters (general, default and HDR) as needed. Ensure that there is no over or under exposure for any of the spectral band(s) and parts of the scene.

Step 5 - Click *"Scan white reference"*.

i. The system will start acquiring the image and wait until it is over.

ii. The snapscan camera has an integrated software-controlled mechanical shutter (see Section 1.2.3). The software will automatically acquire the dark reference image by closing the shutter.

Acquiring object image

Follow the steps below to acquire object scan:

Step 1 - Place the object under the camera.

Step 2 - Ensure that the spatial resolution of the object image is same as that of the white reference image.

Step 3 - Set the acquisition parameters (general, default and HDR) as needed. Ensure that there is no over or under exposure for any of the spectral band(s) and parts of the scene.

Step 4 - Click *"Scan object"*.

i. The system will start acquiring the image and wait until it is over.

ii. snapscan has an integrated software-controlled mechanical shutter (see Section 1.2.3). The software will automatically acquire the dark reference image by closing the shutter.

Step 5 - If *"Automatic reflectance"* is enabled (default setting) and both object and white reference images are available, then the software will automatically carry out the reflectance correction (see Section 2.2.5) and prompt the user to go to *"Cube display"* mode.

6.3 Cube display mode

The acquired cube is visualized, analyzed and saved by following the last two steps in the workflow shown in Figure 80 (see Section 6.2 for the first three steps).

View step – process, visualize and analyze the acquired data

Export step – export to save the acquired data and reference data

Each of these steps are discussed in detail in the upcoming sections.

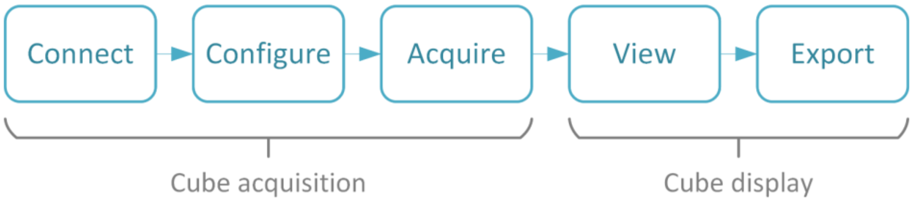


Figure 80: Illustration of the workflow of the snapscan software. This workflow guides the user from connecting to the snapscan system to exporting hyperspectral data.

The user interface for the cube display mode is shown in Figure 81, where

- Control & Analysis panel can be used select, export and render the acquired images. This panel also provides controls to display spectral information of selected regions on the image as well as carry out classification.
- Image Display panel shows the rendered image. This panel can also display the classified image.
- Data Visualization panel can be used to view the metadata of the acquired cube, spectral and pixel responses of regions selected in the control & analysis panel, as well as ground truth and class image for classification.

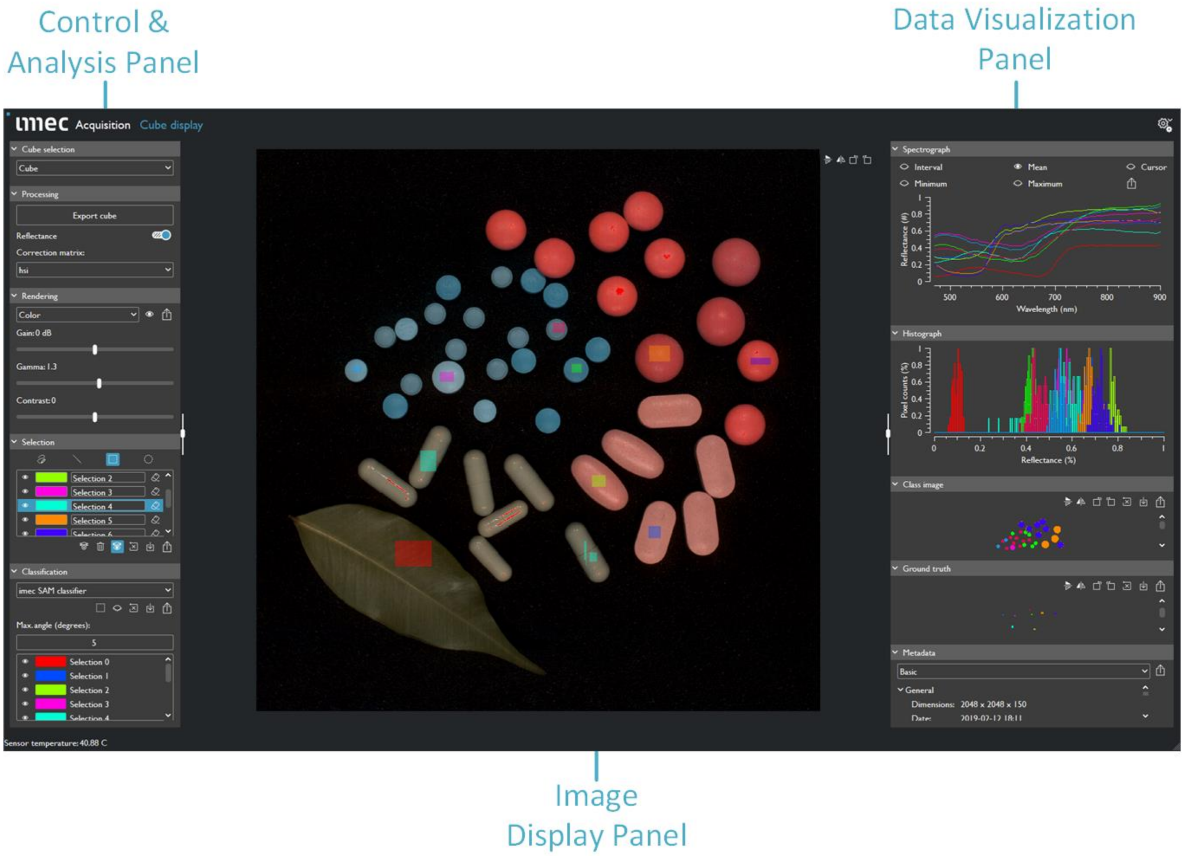


Figure 81: GUI of the Cube display mode

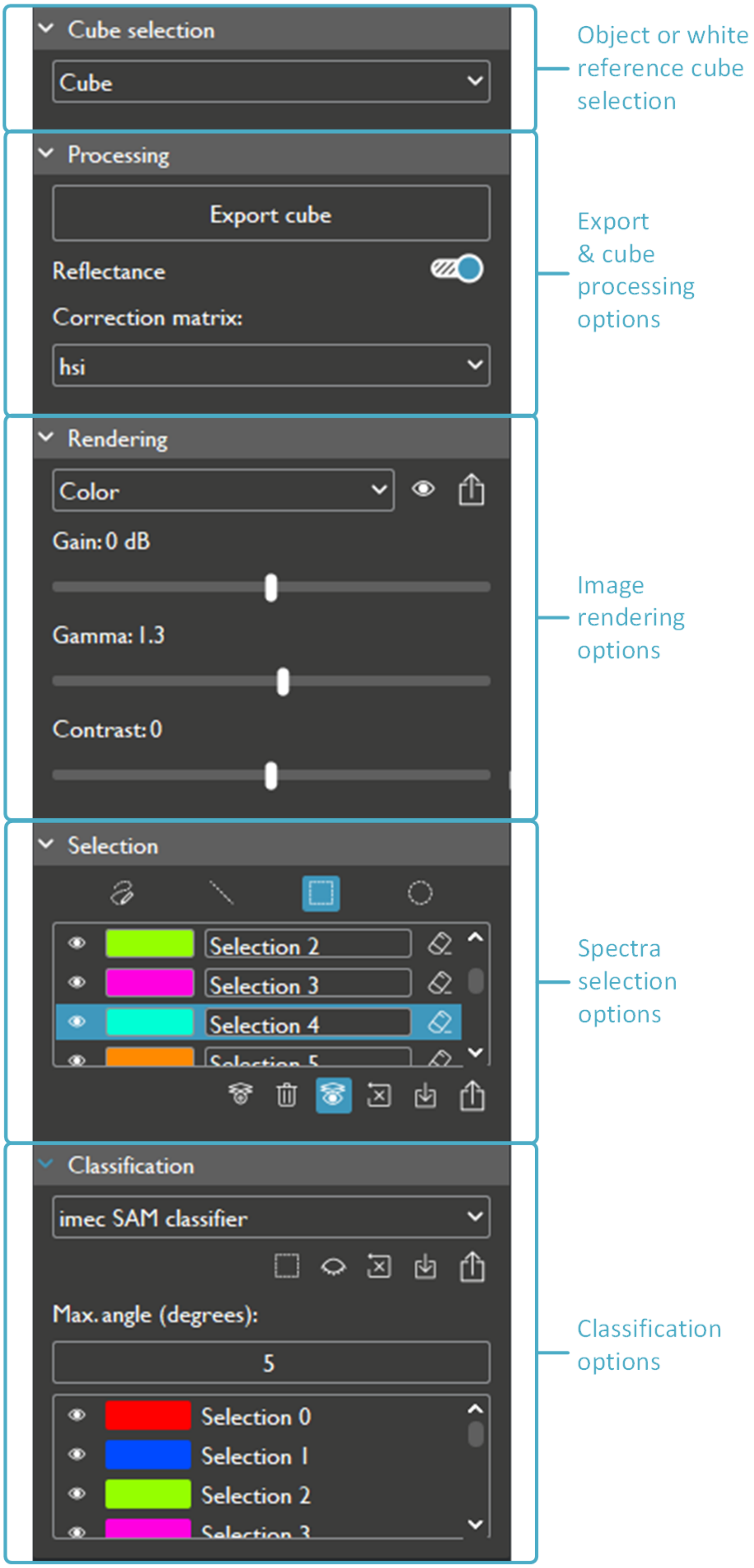


Figure 82 View of the “Control & Analysis Panel” (see Figure 81)

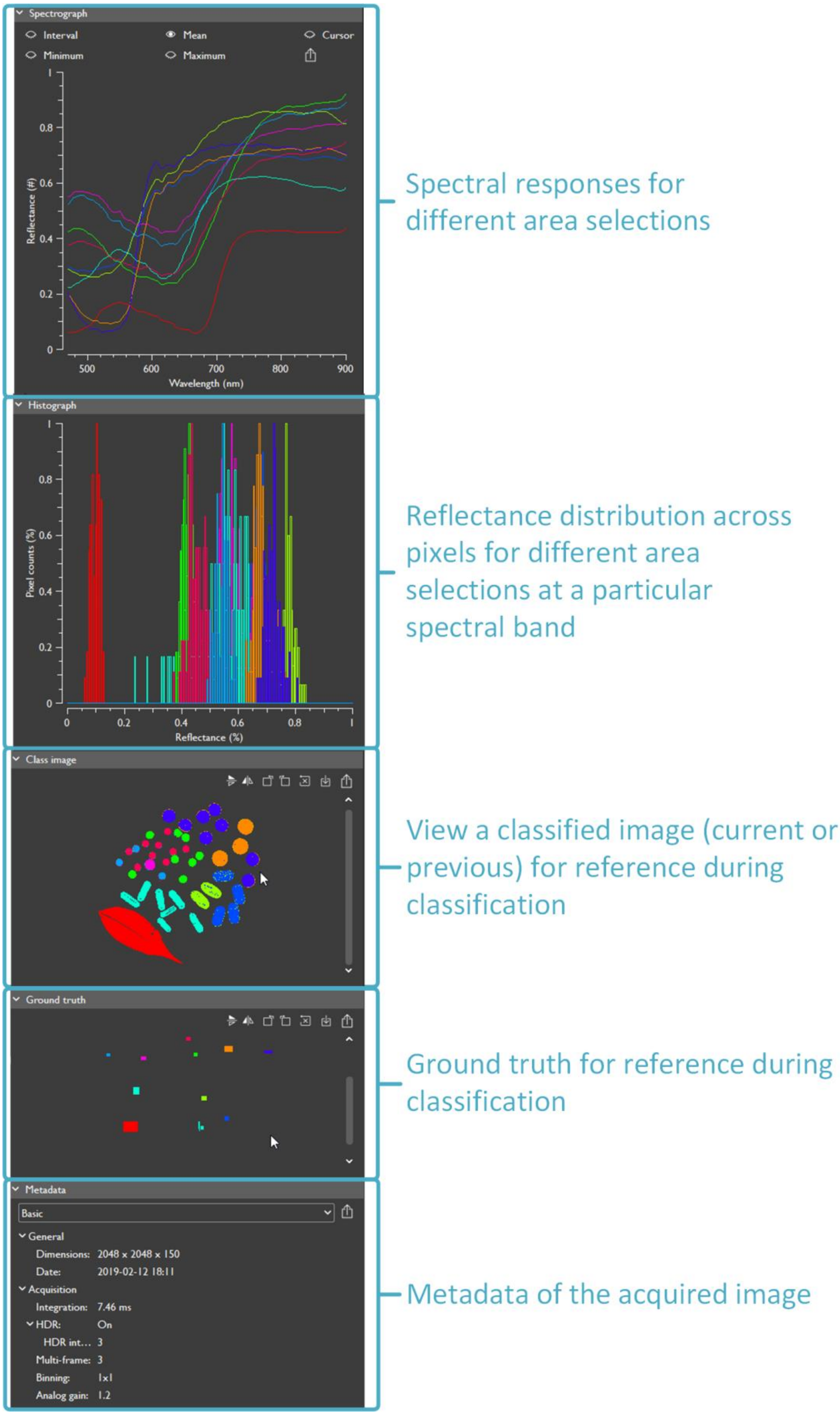


Figure 83 View of the "Data visualization" panel (see Figure 81)

6.3.1 View step

Follow the steps below the view the acquired cube –

Step 1 - Select the object or the white reference cube using the *"Cube selection"* control. The object cube will be selected and displayed by default after switching to cube display mode.

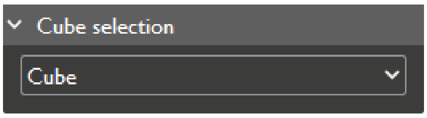


Figure 84. Cube selection. Switches between cube and white reference.

Step 2 - Select/ de-select the post-processing to be applied on the cube. By default, the software applies reflectance correction (when both object and white reference cubes are available) and spectral correction to the acquired cube. User can select/ de-select one or both post-processing to visualize the cube. (see Section 6.3.1.1 for details)

This step is applicable only to the object cube.

Step 3 - Select the rendering type for visualization. The snapscan software offers three rendering types – color matching, false color and single band. (see Section 6.3.1.2 for details)

Step 4 - Analyze the spectral quality of the acquired image by selecting different areas on the image and plotting the spectral response for these different areas. (see Section 6.3.1.3 for details)

Step 5 - Carry out classification (if needed). (see Section 6.3.1.4 for details)

6.3.1.1 Processing

The snapscan software offers following post-processing options prior to visualization –

- Export cube – see Section 6.3.2.
- Reflectance – software will automatically carry out reflectance correction when both object and white reference images are available. It is possible to disable reflectance to view the irradiance cube.
- Correction matrix – software will automatically carry out spectral correction if reflectance is enabled. It is possible to disable spectral correction by selecting "None" in the pull-down menu.

Figure 85 shows the configuration parameters for the processing section.

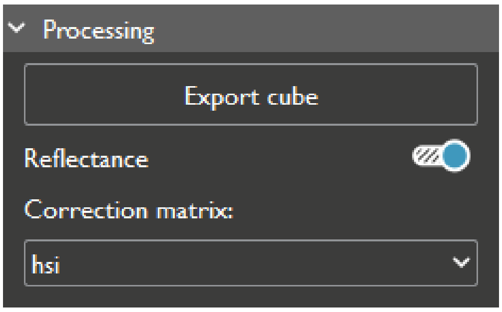


Figure 85. The processing section lets the user switch between irradiance and reflectance data and choose which correction matrix to apply to the reflectance data. The Export cube button gives access to the data export dialog.

6.3.1.2 Rendering

The snapscan software provides the following three rendering options to view the selected cube:

- Color
- Single band
- False color

The rendering type can be selected using the pull-down menu (see Figure 86) and each rendering type is discussed further in this section.

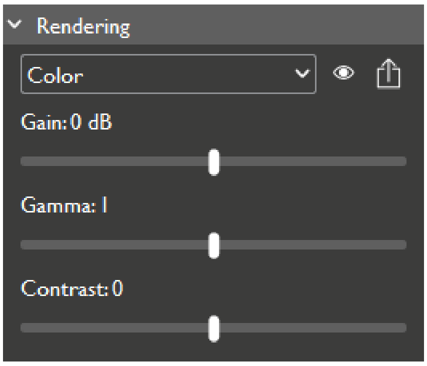


Figure 86 Rendering type selection

Color rendering

The color rendering generates an RGB image using three groups of spectral bands in blue, green and red regions. The software automatically selects these spectral bands to generate as good as possible, a true color rendering of the image.

Following controls are available to adjust the rendering (see Figure 87):

Parameter	Range	Description
Gain (in dB)	-40 to 40 Default: 0	Adjust brightness of the image by increasing or decreasing the gain.
Gamma	0.17 – 6 Default: 1	Adjusts both brightness and contrast of the image. Different pixels in the images are impacted differently depending on their original intensity levels.
Contrast	-128 to 128 Default: 0	Adjust the distinction between the lighter and darker areas in the image by increasing or decreasing the contrast value.

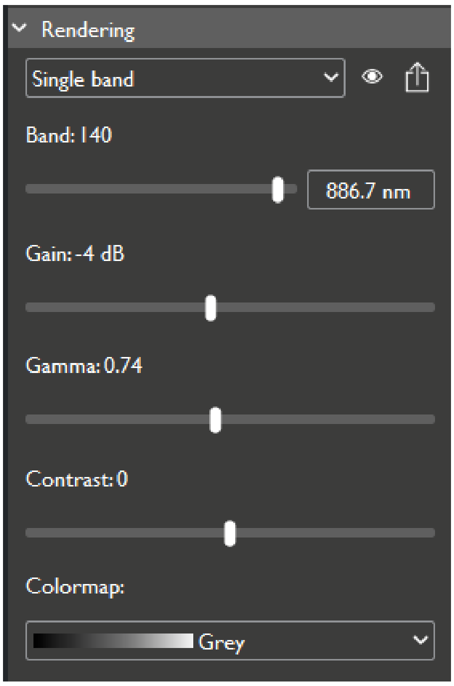
(a) (b)

Figure 87 (a) Color rendering controls, (b) Rendered image

Single band rendering

The single band rendering generates an image from a single spectral band in the data cube. Following controls are available to adjust the rendering (see Figure 88):

Parameter	Range	Description
Band	0 to 150 Default: NA	Move the slider left or right to scroll through the images corresponding to different spectral bands. The bands are ordered from left to right in increasing order of their central wavelengths, i.e. moving slider to the left will select bands with decreasing central wavelengths and vice versa when slider is moved to the right.
Gain (in dB)	-40 to 40 Default: 0	Adjust brightness of the image by increasing or decreasing the gain.
Gamma	0.17 – 6 Default: 1	Adjusts both brightness and contrast of the image. Different pixels in the images are impacted differently depending on their original intensity levels.
Contrast	-128 to 128 Default: 0	Adjust the distinction between the lighter and darker areas in the image by increasing or decreasing the contrast value.
Colormap	Grey Grey inverted Inferno Viridis Default: Grey	snapscan software provides 4 different color maps. Switching between color maps helps enhancing the visualization contrast. The colormaps have been selected to maximize the contrast sensitivity to the human eye.



(a)

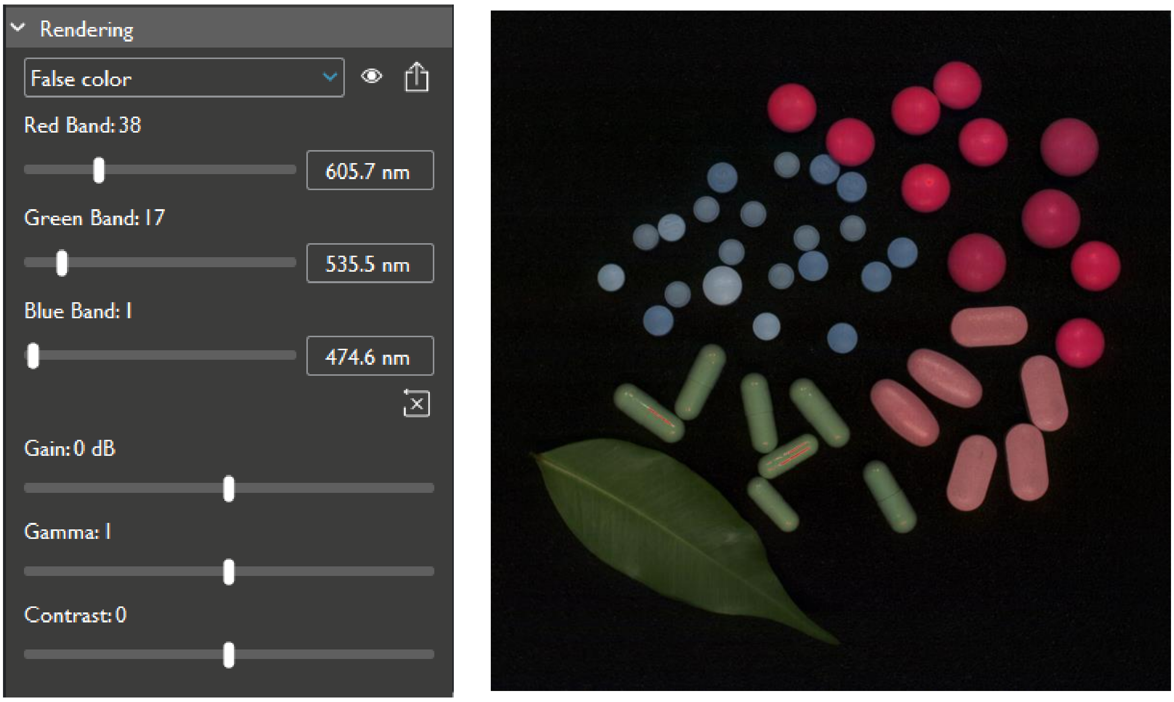
(b)

Figure 88. (a) Single band rendering controls, (b) Rendered image of spectral band with central wavelength at 747nm

False color rendering

The false color rendering generates an RGB image using three spectral bands in the data cube. The difference as compared to color rendering is that in case of false color rendering single bands are selected for each of the RGB channels whereas in case of color rendering multiple bands are selected for each of the RGB channels. Following controls are available to adjust the rendering (see Figure 89):

Parameter	Range	Description
Red/ Green/ Blue Band	0 to 150 Default: Computed by software	The snapscan software automatically selects the red, green and blue bands such that the color rendering is close as possible to the true color rendering. User can change the band selection for red, green or blue channels by moving the respective sliders.
Gain (in dB)	-40 to 40 Default: 0	Adjust brightness of the image by increasing or decreasing the gain.
Gamma	0.17 – 6 Default: 1	Adjusts both brightness and contrast of the image. Different pixels in the images are impacted differently depending on their original intensity levels.
Contrast	-128 to 128 Default: 0	Adjust the distinction between the lighter and darker areas in the image by increasing or decreasing the contrast value.



(a) (b)

Figure 89 (a) False color rendering controls, (b) Image rendered in false color

6.3.1.3 Spectral analysis

The selection panel allows user to select specific areas on the rendered image and display the spectral response of the pixels in the selected area in the spectrograph. This helps the user to quickly analyze the spectral quality of the acquired data.

Figure 90 shows an example where a single area is selected on the image (marked in red) and the corresponding mean and interval spectra are displayed in the spectrograph.

Figure 91 shows an example where multiple areas are selected on the image (marked in different colors) and the corresponding mean and interval spectra for each area is displayed in the spectrograph.

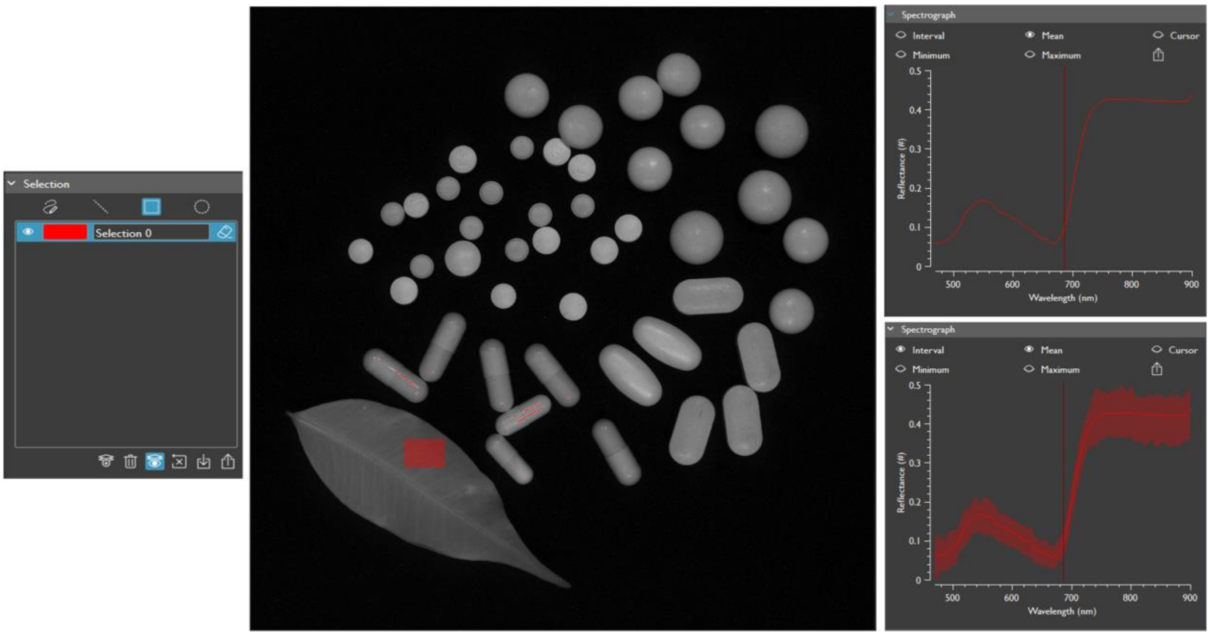


Figure 90 Illustration of the selection of single area on the rendered image and displaying in the spectrograph, the mean & interval spectra across all the pixels

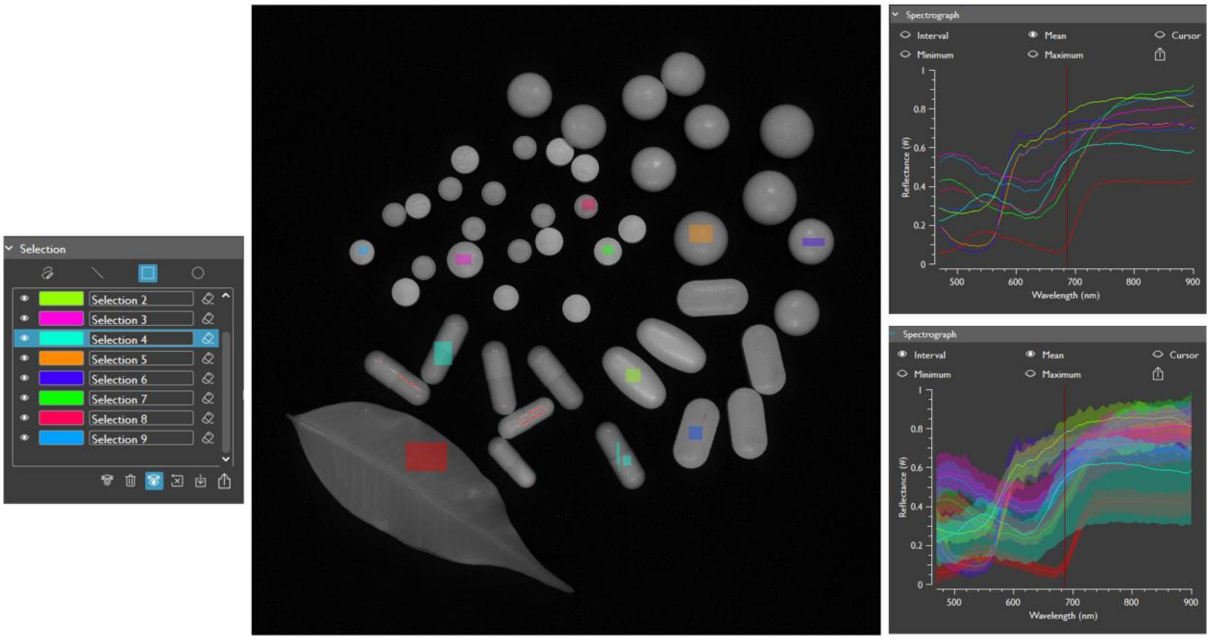


Figure 91 Illustration of the selection of multiple areas on the rendered image and displaying in the spectrograph, the mean and interval spectra across all the pixels for each of the selected area

Follow the steps below for carrying out spectral analysis:

Step 1 - Add a new selection by clicking on the  icon. Provide a suitable name and select a suitable color for the selection (if needed).

Step 2 - Select a suitable drawing tool  and mark the area(s) on the image to be included in this selection.

Step 3 - Repeat steps 1 and 2 until all desired selections are created and areas for each selection are marked on the image, as shown in Figure 91.

Step 4 - Analyze the spectral responses using the spectrograph.

Step 5 - Edit the selections (if needed) by using the icons provided on the panel and as described in Table 14 and Table 15.

Step 6 - If needed, export and save the selections as well as the spectrograph.

A description of different controls in the selection panel is given in Table 14 and those for spectrograph is given in Table 15.

Table 14 Description of controls in the selection panel

Icon	Description
	Free hand drawing tool to select regions on the image. Pixels under the drawn curve are selected.
	Straight line drawing tool to select regions on the image. Pixels under the drawn line are selected.
	Rectangle drawing tool to select regions on the image. All the pixels within the drawn rectangle are selected.
	Circle drawing tool to select regions on the image. All the pixels within the drawn circle are selected.
	Add new selection
	Delete an existing selection. First select the selection to be deleted.
	Toggle ON/OFF visibility of all selections
	Delete all selections
	Import a file with pre-saved selection(s)
	Export and save the current selection(s)
	Toggle visibility of a selection
	Software will automatically assign a color when a new selection is added. This color will be used to mark the selected area on the image as well as for plotting the spectra in the spectrograph. User can change the color by clicking on this icon and selecting a new color.
Selection 0	Software will automatically assign name to each selection. User can edit the assigned name by clicking on the text box.
	Erase the areas marked on the image for a selection

Table 15 Description of controls in the spectrograph

Icon	Description
Interval	By default, the software plots the mean spectra for a selection. Click on this icon to toggle on/off the display of spectral responses for all the pixels included in the selection(s). This will affect plots for all the selections.
Mean	Click on this icon to toggle on/off the display of mean spectra. This will affect the plots for all the selections.
Cursor	Click on this icon to toggle on/off the display of spectra under the cursor.
Minimum	By default, the software plots the mean spectra for a selection. Click on this icon to toggle on/off the display of lower limit in the spread of spectra across all the pixels included in the selection(s). This will affect plots for all the selections.
Maximum	By default, the software plots the mean spectra for a selection. Click on this icon to toggle on/off the display of upper limit in the spread of spectra across all the pixels included in the selection(s). This will affect plots for all the selections.
	Export and save the spectrograph.

Histograph

The histograph visualizes the data variability and distribution of a selection in a specific spectral band. To enable comparison of different selections the distributions are normalized to the number of pixels in a selection. A screenshot of the histograph is given in Figure 92.

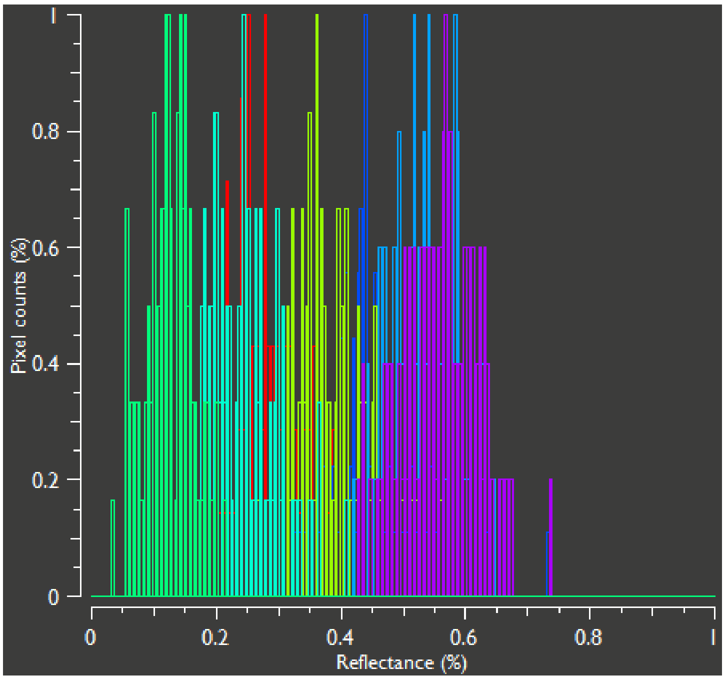


Figure 92. Distribution of three different selections in a specific spectral band.

6.3.1.4 Classification

snapscan software provides the following two options for classification:

- In-built imec Spectral Angle Mapper (SAM) classifier
- Integration with 3rd party industry leading HSI analysis software perClass Mira

Imec Spectral Angle Mapper (SAM) classifier

Follow the steps below to use SAM classifier:

Step 1 - Create the training set by creating one or more selections and marking areas per selection on the image (see Section 6.3.1.3 for instructions on how to create the selections).

Each selection will be treated as a separate class by the classifier and the spectral response of all the pixels in all the areas belonging to a selection will be treated as the set of training data for that class.

Step 2 - Select *"imec SAM classifier"* using the pull-down menu (see Figure 93).

Step 3 - If needed, adjust the classifier parameter *"Max. angle degrees"* (see Figure 93). The default value for this parameter is 5.

Step 4 - Train the classifier by clicking on  icon. This will also automatically apply the trained model on the selected cube and display the classified image (see Figure 94).

Clicking on  icon will also toggle on/off the display of classified image. When toggled off, the classified image can still be seen in the class image panel on the right hand side (see Figure 83).

All the selections used for training the classifier will also be listed in the classification panel (see Figure 93).

Step 5 - Repeat steps 1 to 4 if needed to get the desired classification results.

Step 6 - The classifier model can be exported and saved by clicking on  icon.

Step 7 - A pre-saved classifier model can be loaded and applied by clicking on  icon. Use this option to apply the same classification model on more than one images. Repeat steps 1 to 4 if needed. Export and save the edited classification model if needed.

A description of different controls in the classification panel is given in Table 16.

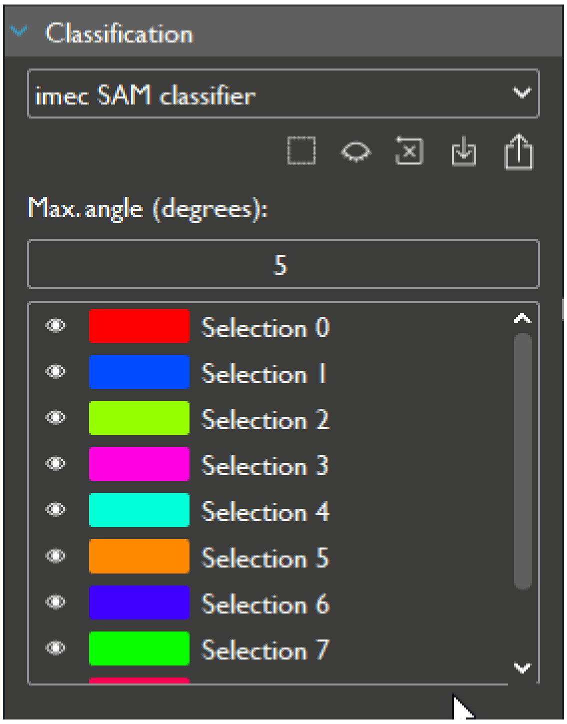


Figure 93. View of the classification panel when "imec SAM classifier" is selected

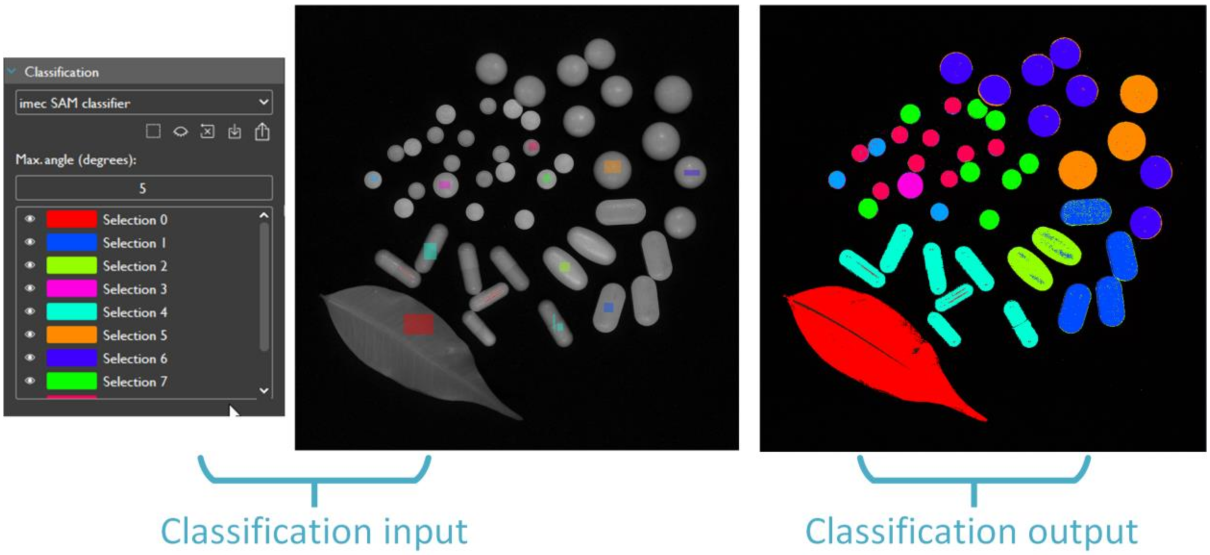
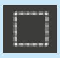
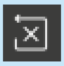
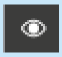
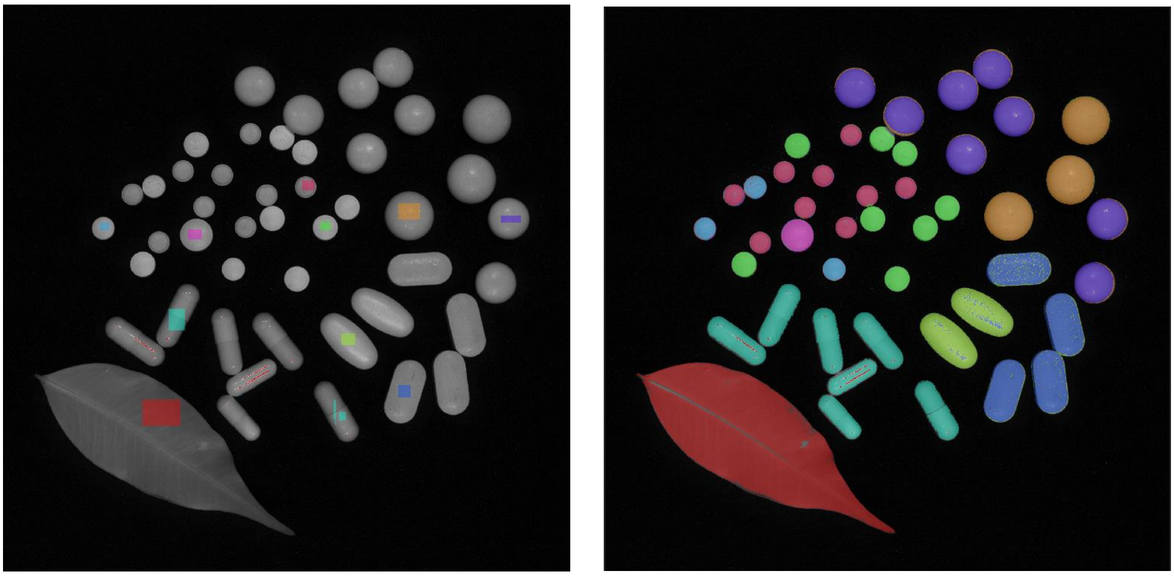


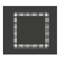
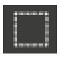
Figure 94 Illustration of the input and output of classification using imec SAM classifier

Table 16 Description of controls in the classification panel when imec SAM classifier is selected

Icon	Description
	The SAM mapper will assign different pixels to different selections while carrying out the classification. By clicking this icon, the original selection is replaced with the output of the classification, i.e. the areas classified by SAM as belonging to a particular class will be assigned to the corresponding selection. (see Figure 95)
	This icon has two functionalities ▪ Train the classifier, apply the trained model on the selected cube and display the classified image ▪ Once the above is done, toggle on/off the overlay of classified image over the actual image.
	Reset the classifier model. These will delete the existing classes and the trained model.
	Import a file with pre-saved classification model. Use this option to apply the same classification model on more than one images.
	Export and save the current classification model.
Max angle	Sets the tolerance on the spectral angle from a spectrum to a centroid. Value range: 0 to 180 Default value: 5
	Toggle on/off the display of classification of a class. By default, the classification for all the classes are displayed.



(a) (b)

Figure 95 Example of impact of  "Convert to Selection" icon. (a) Original selection, (b) Updated selection after clicking on  icon.

perClass Mira classifier

perClass Mira is a spectral imaging software from perClass BV which can be used for viewing and analyzing the acquired hyperspectral image data. A 14-day limited functionality demo license is included with snapscan software.

See Section 5.2.1 for instructions on how to install and activate perClass Mira.

Follow the steps below to use perClass Mira classifier:

Step 1 - Select *"perClass classifier"* using the pull-down menu (see Figure 96).

Step 2 - Click on *"perClass Mira"* button to open the perClass Mira software (see Figure 96).

Step 3 - A new project dialog box will open. Select *"IMEC"* as the project type and select an appropriate path to store the data (see Figure 97).

Step 4 - The cube will open in the perClass Mira software (see Figure 98). Please refer to http://doc.perclass.com/perClass_Mira/Introduction.html for full documentation and user manual on how to use perClass MIRA software to analyze the cube.

You may also refer to the video on the following link to see the workflow for using perClass Mira with the snapscan software - http://perclass.com/applications/separating-dark-textiles.

Step 5 - A pre-saved classifier model created in perClass Mira can be loaded and applied by clicking on icon. Use this option to apply the same classification model on more than one images.

A description of different controls in the classification panel is given in Table 17.

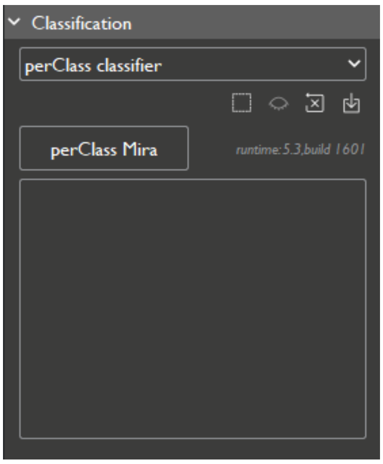


Figure 96 View of the classification panel when *"perClass classifier"* is selected

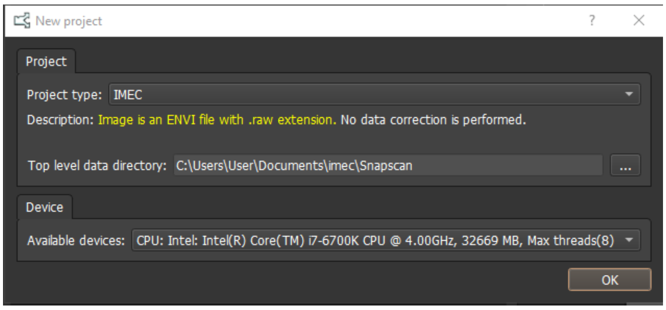


Figure 97 New project dialog box when the cube is opened in perClass Mira software. Select *"IMEC"* as the project type and select an appropriate path to store the data.

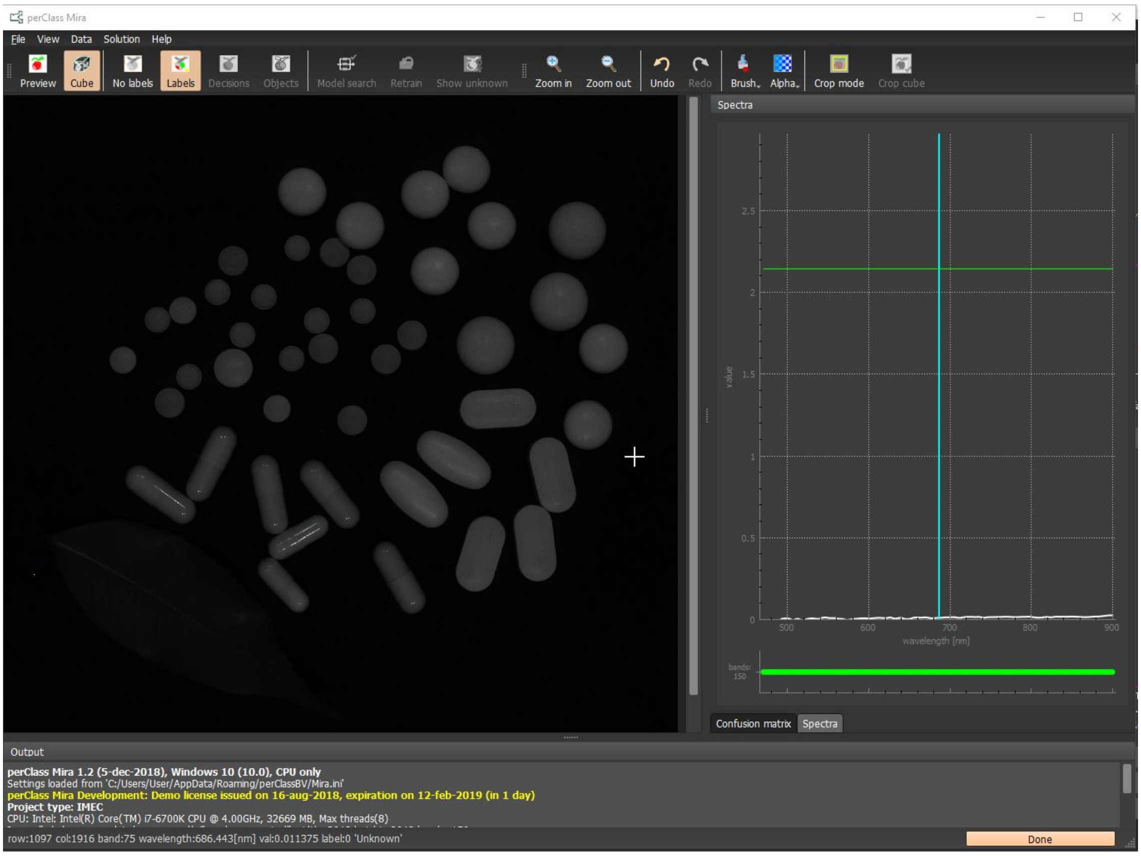


Figure 98 GUI of perClass Mira software

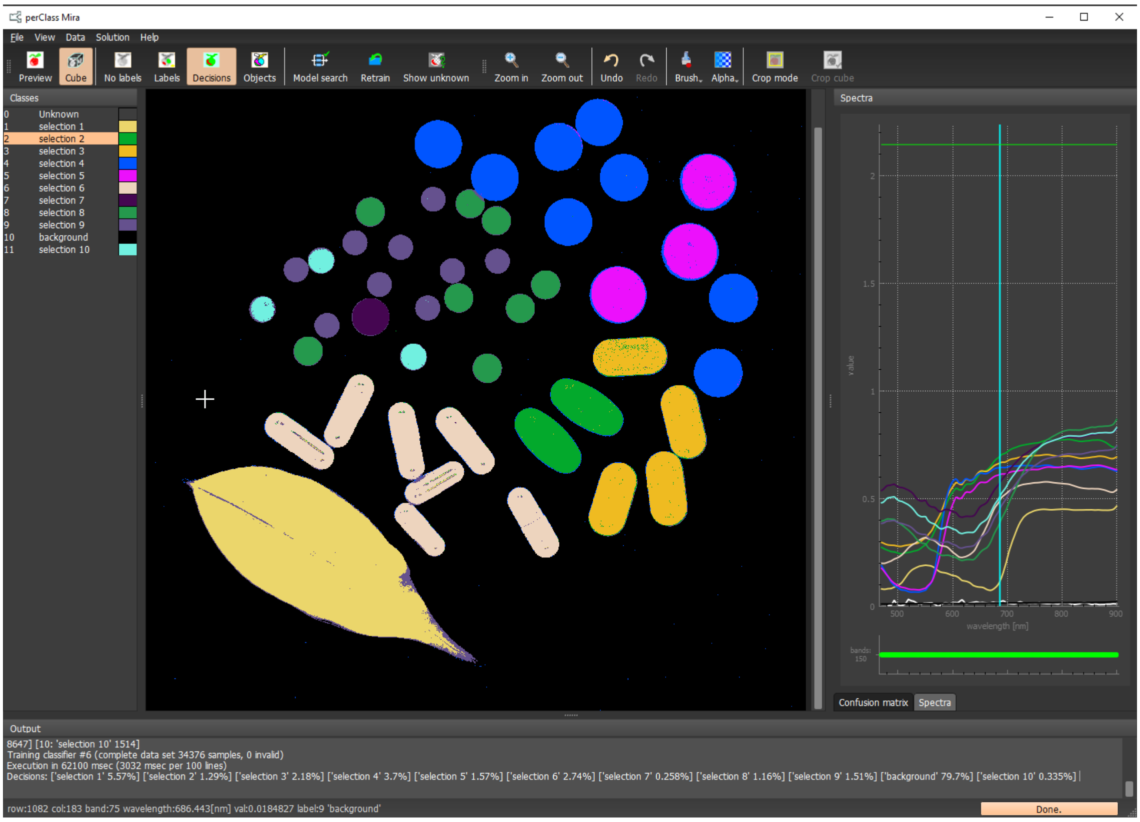
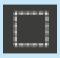
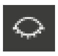
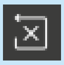


Figure 99 An example of classification carried out in perClass Mira software

Table 17 Description of controls in the classification panel when "perClass classifier" is selected

Icon	Description
	The perClass classifier will assign different pixels to different selections while carrying out the classification. By clicking this icon, the original selection is replaced with the output of the classification, i.e. the areas classified as belonging to a particular class will be assigned to the corresponding selection. (see Figure 95)
	Click on this icon to toggle on/off the overlay of classified image over the actual image. (Active only when a pre-saved classification model is imported)
	Reset the classifier model. These will delete the existing classes and the trained model.
	Import a file with pre-saved classification model. Use this option to apply the same classification model on more than one images.

6.3.2 Export step

The snapscan software enables user to export the acquired hyperspectral data in the following file formats – ENVI, PNG, PGM and TIFF.

Follow the steps below to export the acquired hyperspectral data:

Step 1 - Click *"Export cube"* button on the left-hand side panel (see Figure 100).

Step 2 - An *"Export Setting"* dialog box will open (see Figure 101). Follow the sub-steps below:

a. Select the destination folder and provide the filename

b. Select the file format. The snapscan software can export file in ENVI, PNG, PGM and TIFF formats.

   ENVI is the default file format[3] in which the hyperspectral data is exported. In cases of PNG, PGM and TIFF file formats, each spectral band is saved as a separate image file and the metadata is stored in an accompanying XML file.

   An overview of the non-standard metadata stored in the ENVI file header or in the XML file is given in Table 18.

c. Select the references to be exported along with the object cube. The snapscan software does not exports the references by default.

   - *It is important to export the references if you plan to re-process the data cubes later using a different software pipeline. In this case, the irradiance data cube should also be exported (see the next step).*
   - *Dark references are always exported as RAW and white references are always exported in ENVI file format.*
   - *White Reference and White Dark Reference are only available if a white reference was acquired.*
   - *Cube Dark Reference is only available if an object was acquired.*

d. Select the data cubes to be exported.

   - *Irradiance* – raw data cube without white balancing applied (see Section 2.2.5.1)
   - *Reflectance* – data cube with white balancing applied (see Section 2.2.5.1)
   - *Corrected* – data cube with white balancing and spectral correction applied. The available correction matrices are listed in the dropdown menu, which is enabled if the *"Corrected"* option is checked.
   - *Reflectance and Corrected are only available if a white reference was acquired.*

[3] See the following link for the ENVI file format specification: http://www.harrisgeospatial.com/docs/ENVIHeaderFiles.html

The snapscan software exports only the corrected cube by default (if white reference was acquired).

Step 3 - Click *"OK"* to start exporting the data and close the dialog box.

Applying reflectance and spectral correction to the object cube requires processing of the acquired data. This operation may take up to a couple of minutes depending on the resolution of the cube and the computing power of the system.

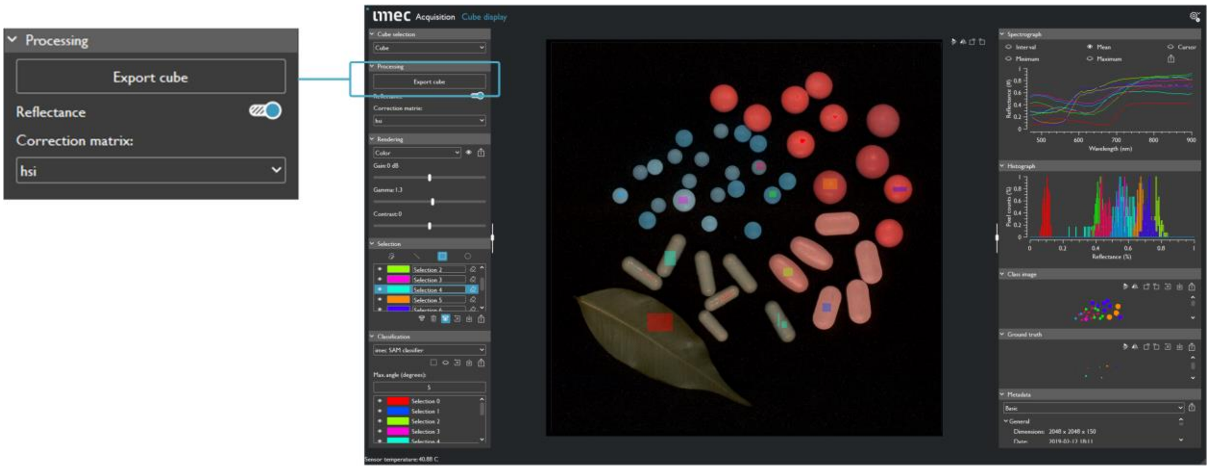


Figure 100 *"Export Cube"* selection button in the *"Cube display"* GUI.

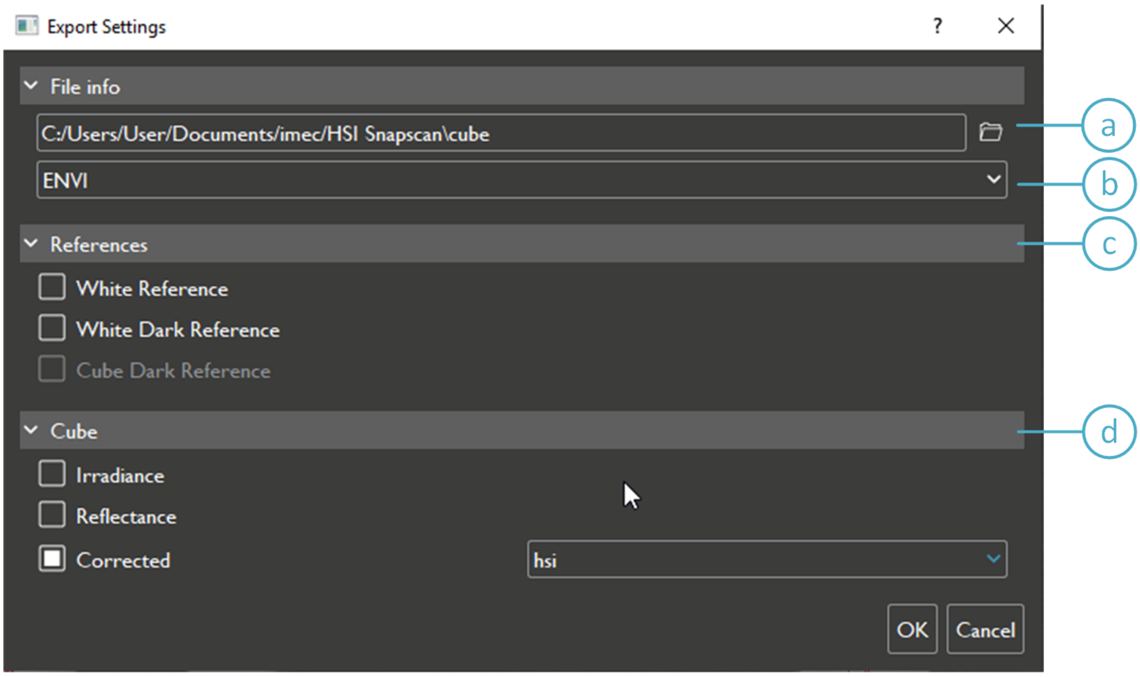


Figure 101 Screenshot of the export settings dialog box which allows the user to choose the location, name and format of the file. It also allows user to select the references and cubes to be exported.

Table 18: Overview of all metadata fields stored in the ENVI file header or XML metadata file.

Parameter	Description
Binning columns	The binning applied on the columns during the acquisition.
Binning rows	The binning applied on the rows during the acquisition.
Integration time	The integration time (in milliseconds) used to create the scan.
Analog gain	The sensor analog gain used to create the scan.
Scanning mode	The scanning mode used to create the scan.
Scanning direction	Direction of motion of the sensor during the scan. Either right to left or vice-versa.
Scanning velocity	The velocity of the sensor during the scan, in millimeters per second.
Pixel step	The step size between any two positions in number of pixels.
Pixel blur	The effective pixel blur incurred due to motion during integration.
HDR flag enabled	Flags if HDR was enabled (1) to acquire the data for the scan or not (0).
HDR flag scaling	Flags if the HDR frames are rescaled by their exposure time factor (1) or not (0). This flag is meaningless if HDR is not enabled.
Number of averaged frames	The number of frames that are averaged to acquire one frame. This value is equal to the multi-pass setting.
Number of frames	The total number of frames acquired to create the scan.
Frame positions	Vector with the position of each frame that was acquired during the scan, in millimeters.
Frame temperatures	Vector with the sensor temperature for each frame that was acquired during the scan, in degrees Celsius.
Frame timestamps	Vector with the time of acquisition of each frame that was acquired during the scan, relative to the first acquired frame, in seconds.
Output mode	Depicts if the data contains a stitched cube (Datacube) or a stack of unstitched frames (Framestack).
Max value	The maximum data value.
Saturation value	The data value marking saturation. All values in the data equal or larger than this value are considered saturated. This value is always less or equal to the maximum data value.
No data value	The value marking data points with “no value”, e.g., due to defect pixels.
Corrected data	Flags if a correction matrix was applied to the data (1) or not (0).
Reflectance data	Flags if the data has been white balanced and hence can be interpreted as reflectance percentage (1) or not (0).
Data source	The software name and version that generated the data.
Sensor bit depth	The bit-depth of the ADC on the sensor converting electrons to digital number.
Sensor id	The four-number unique sensor identifier.
Sensor pixel pitch	The size of one pixel, in millimeters.
Sensor type	The sensor’s hyperspectral filter layout type.

6.4 Tutorial

This chapter provides step by step tutorials to easily learn making good acquisitions with the snapscan system.

6.4.1 Basic configuration

This tutorial will guide the user to easily acquire, analyze and export hyperspectral data cubes.

1. Connect your snapscan system to the PC.
2. Open the snapscan software.
3. Select your snapscan system file.
4. Click *"Connect"*.
5. Keep the default configuration settings.
6. Click *"Start"*
7. Put your object in the field of view.
8. Set the lens parameters.
    - Set the aperture to F/2.8.
    - The optimal focus is found such that all spatial features appear sharp in the image.
9. Set the gain to 2.0 and tune the integration time.
    - The optimal integration time is found as the large possible value at which only very few or no pixels are saturated.
    - In case of strong light conditions lower gain values may be required to avoid saturation.
    - In case of low light conditions, first increase the integration time and gain.
10. Verify your integration time setting.
    - Moving the sensor left and right will show if the integration time is valid to capture spectral data for all spatial points. Reduce the integration time if pixels saturate when moving the sensor left and right.
11. Click *"Scan object"* in the *"Cube acquisition"* section.
12. Remove the object and put the reflectance target in the field of view.
13. Tune the integration time. Verification is not needed in case of uniform illumination.
14. Click *"Scan white reference"* in the *"Cube acquisition"* section.
15. Go to the *"Cube display"* tab to show the data.
16. Inspect the spatial data in the image view.
    - Scroll through the bands using the slider in the rendering group.
    - Adjust the digital gain using the slider in the rendering group.
    - Zoom and pan using the mouse.

17. Select pixels within the view.

    - Press and hold the left mouse button. Move the mouse keeping the left mouse button pressed to drag. Then release the left mouse button to complete the selection.

18. Optional: click icon in the *"Selection"* panel or by using the right click context menu and select other pixels. Click icon the *"Classification"* panel to show a classified image on top of the rendering.

19. Open the data export dialog by clicking *"Export cube"* button.

20. Select a destination folder and filename prefix.

21. Disable all options except *"Corrected"*. This will export the hyperspectral data reflectance data, corrected for the system model.

22. Click *"Ok"* to export the data.

23. The last step concluded the acquisition. The software can now be closed or go back to the *"Acquisition"* tab to acquire more data.

6.4.2 Tuning focus, aperture and acquisition parameters

There is an interplay between the acquisition parameters (i.e., integration time and analog gain), the lens' aperture and the focus. Opening the lens' aperture allows more light in the system, allowing shorter integration time and lower gain settings, but reducing the depth of field. It is also recommended to limit the aperture to a maximum opening of F/2.8 as the Fabry-Perot filters have an angular dependency. This tutorial provides guidelines to find the optimal configuration of these parameters.

1. The aperture should be set to the largest value possible yielding the required depth of field. For a given focal length and distance to the subject, the f-stop can be computed with the following tool: http://www.dofmaster.com/dofjs.html

    - Limit the maximum aperture opening to F/2.8.

2. Set the analog gain to 1.0 and choose an integration time such that the image is optimally exposed, while keeping the scan duration within acceptable limits.

    - The optimal integration time is found as the large possible value at which no pixels are saturated.
    - Increase the analog gain setting in case the maximum integration time is reached far below the saturation point.
    - Limit the maximum integration time to 25 ms for low gain values.

3. Focus the lens on the subject such that all features are clearly in focus.

    - On surfaces with disparity, the sharpest focus must be achieved halfway the total depth of the subject.
    - Different wavelengths have a different focal error, hence focusing for one wavelength may bring the image out of focus in different wavelengths. Optimize the focus for the wavelengths of interest for your application.

As the available parameters are all connected, there might not be an optimal solution within the constraints of the application. In this case a tradeoff must be made, or the illumination intensity must be increased.

6.4.3 Typical acquisition scenarios and recommended parameter settings

The snapscan camera system provides flexibility to optimize the acquisition parameters depending on the application requirements. In this section, we use three typical scenarios as example to show the trade-off between these scenarios and recommended parameter settings.

The three typical scenarios are:

- High speed acquisition – scenarios where acquisition time is critical. E.g. in-line sorting applications or applications where target objects can be stationery only for limited duration.
- High quality acquisition – scenarios where image quality is critical. E.g. microscopy and art restoration.
- Speed-quality balanced acquisition – scenarios where both acquisition time and image quality are equally critical and needs to be balanced. E.g. skin oximetry.

The performance trade-offs across these scenarios are shown in Figure 102 and the recommended settings for configuration and acquisition parameters are shown in Table 19. It is assumed that the spatial dimensions of the acquired cube are same in all the scenarios.

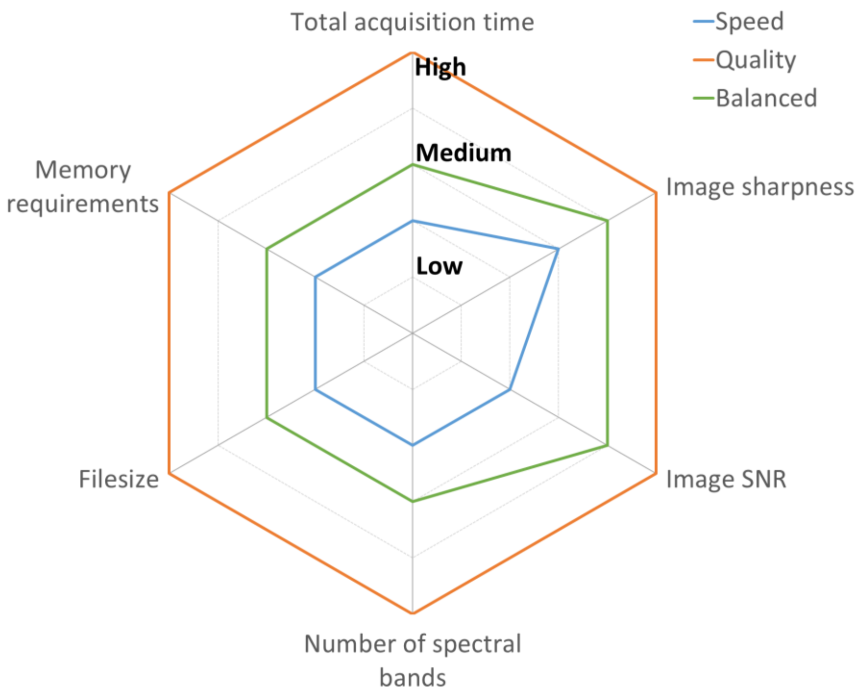
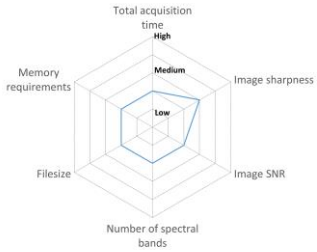
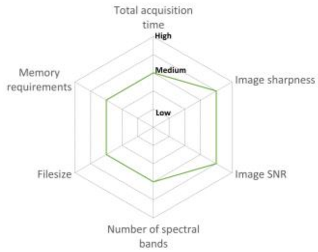
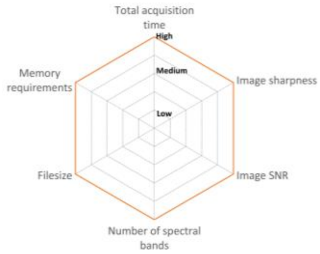


Figure 102 Performance trade-offs across the three acquisition scenarios – high speed, high quality and speed-quality balanced. It is assumed that the spatial dimensions of the acquired cube are same in all the scenarios.

Table 19 Recommended configuration and acquisition parameter settings for the three acquisition scenarios







	High speed acquisition	Speed-quality balanced acquisition	High quality acquisition
Discard interface	NO	YES	YES
TDI pixel steps	5	3	1
Cube height	Minimum required to cover the field-of-view		
Cube width	Minimum required to cover the field-of-view		
Binning	2x2 to 4x4 (to improve SNR while trading-off some spatial resolution)	Up to 2x2 (improve SNR while minimizing loss in spatial resolution)	NO
Spectral band selection	Select minimum required spectral bands	Select almost all key spectral ranges of interest	Use all spectral bands
Integration time	Minimum possible without underexposing	Set it between minimum & maximum values based on overall acquisition time targeted	Maximum possible without saturating
Analog gain	> 1.6	1.6	Minimum possible (1.2)
Multi-frame	1	2-3	> 3
HDR	NO	YES Smaller HDR steps (2-3)	YES Larger HDR steps (4-6)

6.5 Support for 3rd party software

6.5.1 perClass Mira

perClass Mira is a spectral imaging software from perClass BV which can be used for viewing and analyzing the acquired hyperspectral image data. A 14-day limited functionality demo license is included with snapscan software.

Full documentation and user manual can be found online at http://doc.perclass.com/perClass_Mira/Introduction.html. Please refer to Section 5.2.1 for instructions on installing and activating perClass Mira.

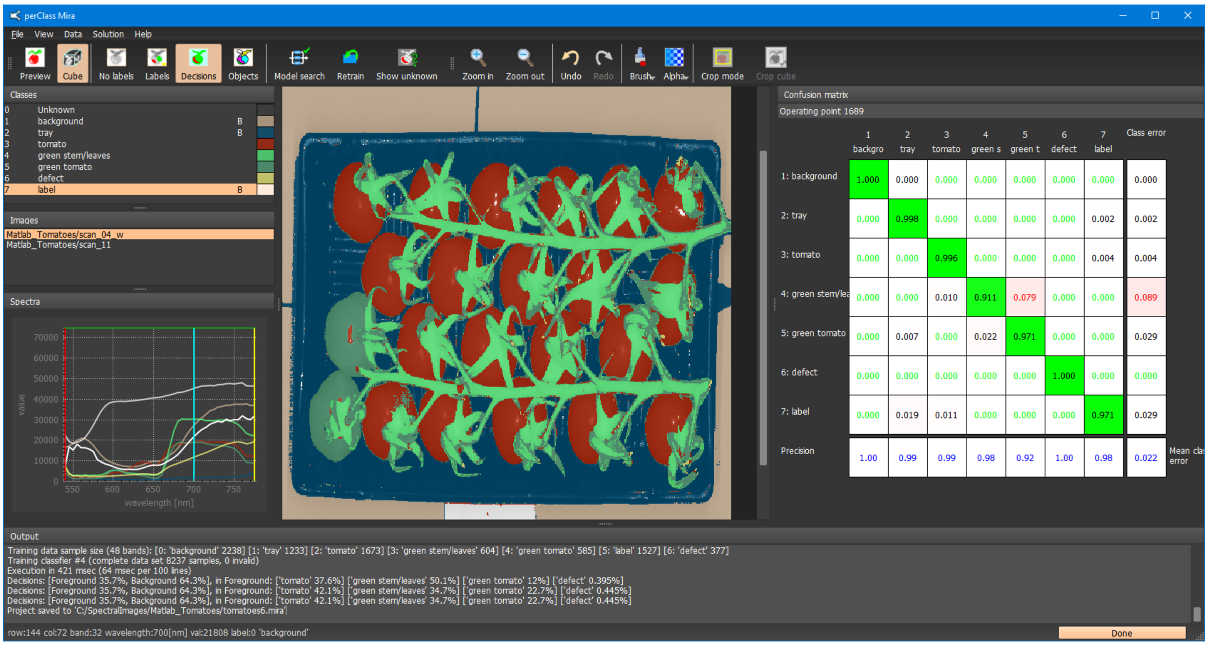


Figure 103 Screenshot of perClass Mira GUI (source: http://doc.perclass.com/perClass_Mira/Introduction.html)

6.6 Troubleshooting

There is no live image after starting the snapscan system
Check if there is enough memory available to allocate all data. If not, then stop the snapscan system and free up memory by closing other software. *All required memory is allocated when starting the snapscan system. To not compromise the performance of the system, the camera driver will not work when the system is swapping memory to disk.*

Data acquisition is very slow and the software is unable to acquire cube
Check 1: Camera is plugged in a USB3.0 port. **Check 2:** No other devices are connected to the same USB hub. **Check 3:** When working on a mobile system, ensure it is on mains power and the system is set to high performance mode. **Check 4:** The CPU not to be fully used; close other software to reduce load.

Scanning finishes with an error message of dropped frames
Switch to the stop motion scanning mode. *When scanning large cubes at high speed it is possible that the system cannot process the data in time. Switching to the stop motion scanning mode will pace the acquisition to the system's processing speed.* *When scanning at long exposure times and/or small pixel blur settings the stage speed is too low to guarantee a smooth and stable movement. Switching to stop motion scanning mode will yield better results.*

The camera makes a clicking sound after it is connected and during scanning
This is normal. The camera shutter will cycle after connection and before starting a scan. During a scan the translation stage is moved internally, which can also lead to audible clicking.

The software does not respond when exporting a cube
Check 1: There is sufficient disk space. • *Exporting data can appear slow as filesize of a cube can reach up to 5.4Gb. When disks run full, the export speed may further slow down due to fragmentation of free disk space.* **Check 2:** System has enough RAM available. ▪ *The system will swap RAM to disk in case more memory is needed than available. This is very slow and seriously affects system performance.* **Check 3:** Please wait. ▪ *Computing spectral correction on the exported data may appear slow as it involves up to 2.6 trillion operations. Depending on the computer's processor speed and the size of the data cube, this operation may take up to one full hour.*

Contact imec HSI support if the problem persists or for any other problems:

Email: hsisupport@imec.be

Website: http://hsisupport.imec.be


HSI Studio
imec
pharma_pil...
Files
Load
erfeiting/pharma_pills-green_leaves.hdr
Rendering
Selection
fresh leaf
blue pill #1
blue pill #2
blue pill #3
blue pill #4
red pill #1
red pill #2
pink pill #1
pink pill #2
Classification
Spectrograph
Interval
Mean
Cursor
Minimum
Maximum
Reflectance (#)
Wavelength (nm)
Histograph
Class image
Ground truth
Metadata

Chapter 7

Applications

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7. Applications

We provide here a few examples of applications for which our customers and partners are using the snapscan camera system. Besides these applications, snapscan can be used in a wide range of other applications such as forensics, agriculture, quality control in industrial processes, waste sorting, food & feed analysis, etc.

7.1 Microscopy

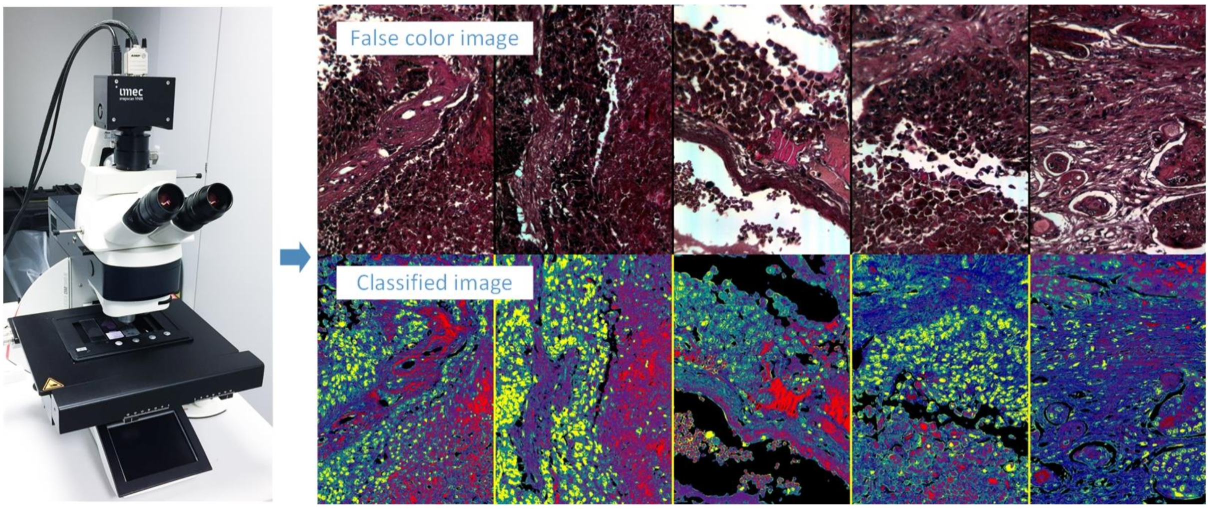

Figure 104 snapscan camera mounted on a Leica microscope and example of histopathology samples for H&E stained lung cancer (image courtesy: Hyperspectral Intelligence Inc[4])

The snapscan camera can be mounted on microscope, as shown in Figure 104. This enables high spectral and spatial resolution hyperspectral imaging of samples examined under microscopes. Figure 104 shows an example of histopathology samples for H&E stained lung cancer for which hyperspectral images were obtained at more than 150 spectral bands and the spatial resolution for each band is 7Mpx.

snapscan makes it easy to setup hyperspectral imaging for microscopy and acquire high quality at a fast acquisition speed. Care must be taken to select the right components (illumination and optical lenses) and also to carry out system calibration and white balancing correctly. Please contact imec HSI support for further details.

7.2 Fundus imaging

The snapscan camera can also be integrated with fundus cameras. In a manner similar to microscopy, snapscan enables high spectral and spatial resolution hyperspectral imaging of retina. Please contact imec HSI support for further details.

[4] https://www.hyperspectral-intelligence.com/

7.3 Skin/ wound imaging

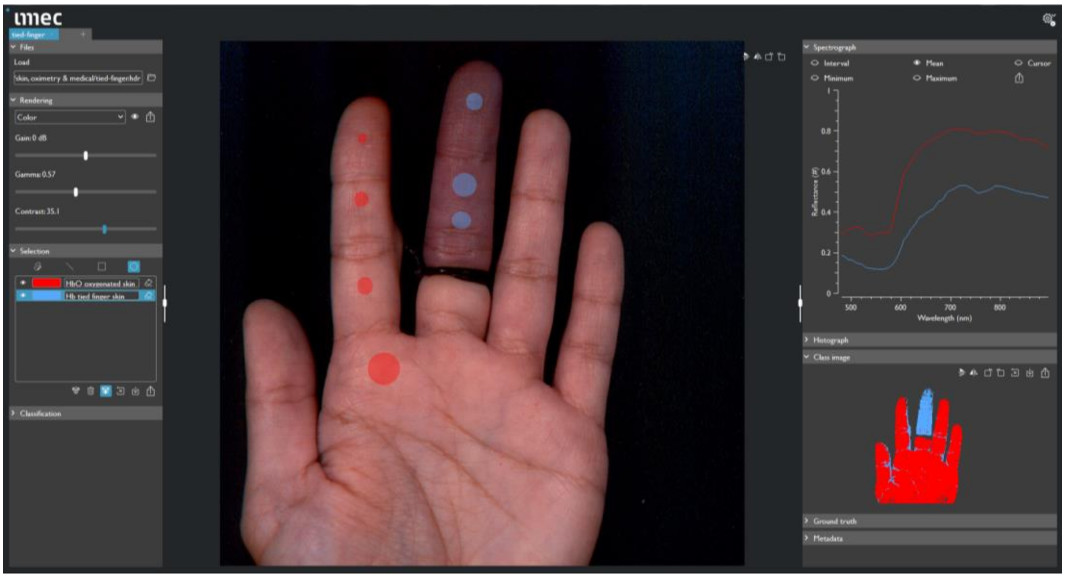

Figure 105 Example of skin oximetry. The blood flow to the upper part of the middle finger is restricted by tying the finger. The difference in oxygenation levels in the index finger and the tied finger results in differences in their respective spectral responses. This can be used to generate oxygenation maps, as shown in the classified image on the right-hand side.

The snapscan camera system can be used for health and medical applications, such as skin imaging, wound imaging, etc. The spectral range of snapscan covers several important skin/tissue biomarkers such as oxygenated/ de-oxygenated hemoglobin, hemoglobin, fat, hydration, etc. Please contact imec HSI support for further details.

7.4 Outdoor imaging

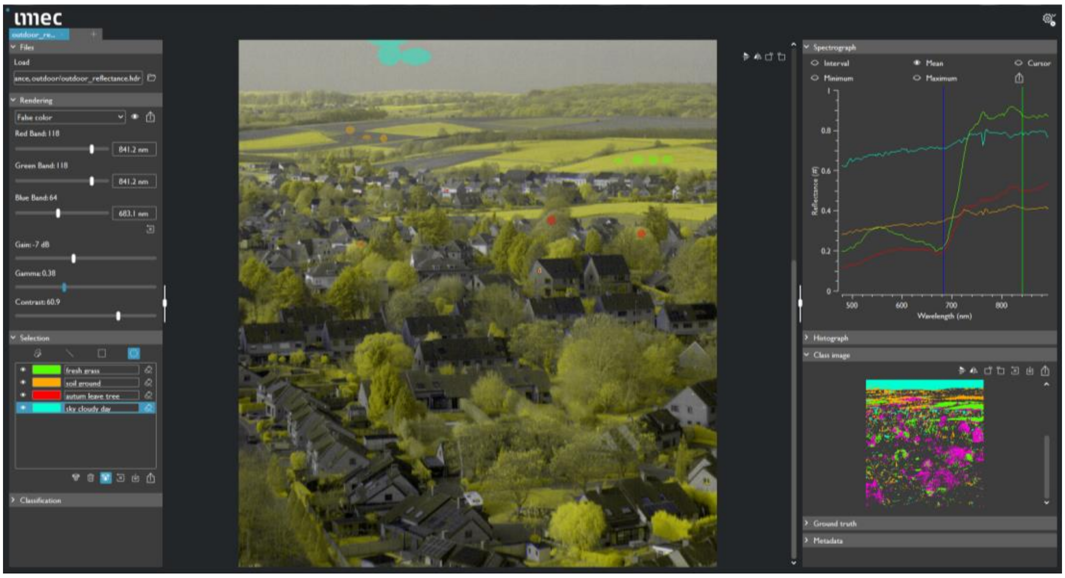

Figure 106 Example of pseudo NDVI image of an outdoor scene

The snapscan camera system can be used for outdoor imaging where natural light is used as the illumination. Care must be taken to correctly carry out system calibration and white balancing. Please contact imec HSI support for further details.

7.5 Art & antiquities conservation

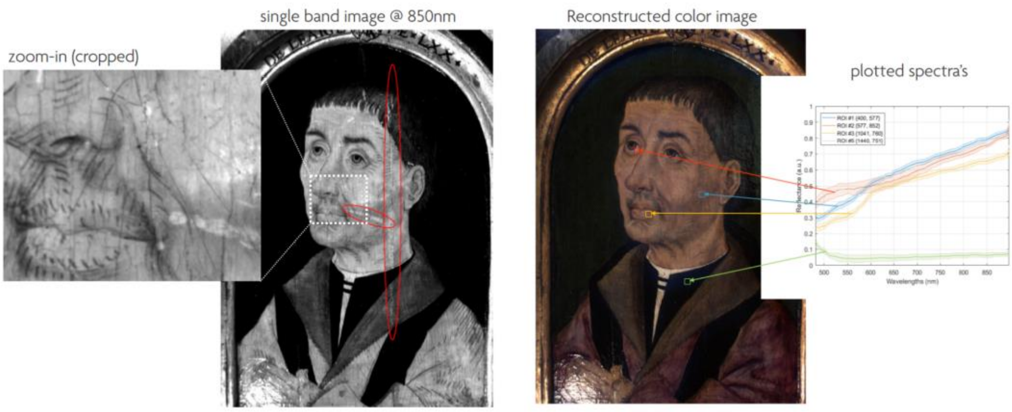

Figure 107 Digitize artwork to generate preliminary study information on exact color and pigment information's used by the original painter. Courtesy Prof. dr. Maximiliaan Martens, Dept. Art History, Musicology and Theatre Studies, Ghent University. Painting – portrait of Jean Wouters, collection of Jan Muller.

Combined VIS-NIR spectral range, high spatial and spectral resolution of the snapscan camera system allows art and antiquities conservators to extract exact color and pigment information. Please contact imec HSI support for further details.

7.6 Mineralogy

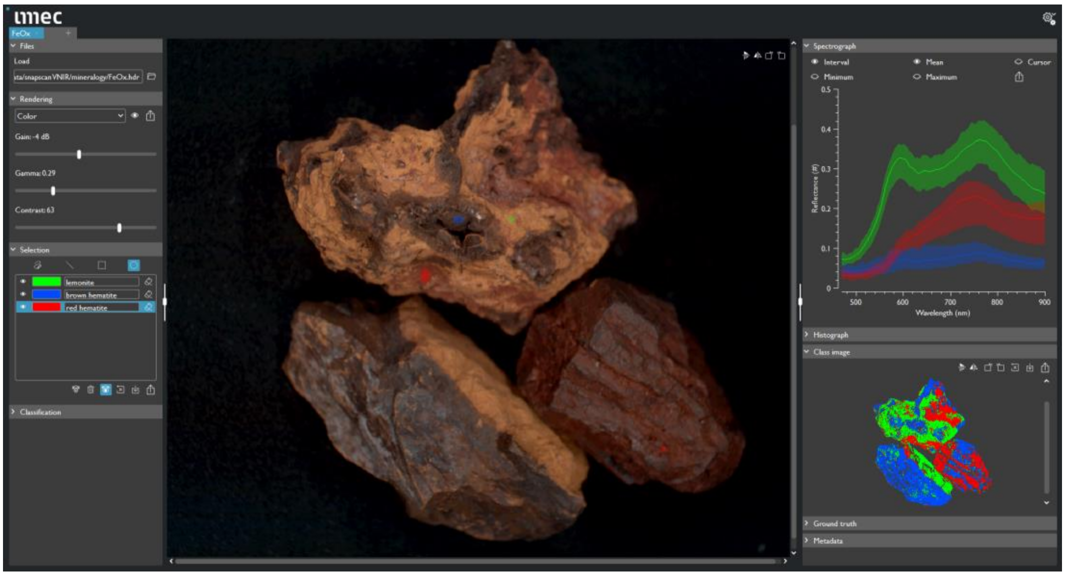

Figure 108 Spectral analysis of iron ore to determine the iron content as well as distribution for grading the ore.

Combined VIS-NIR spectral range, high spatial and spectral resolution, dust-proof and robust construction and on-board cooling of the snapscan camera system also makes it suitable for use in outdoor and dusty environments, such as ore extraction mines or ore analysis labs. Please contact imec HSI support for further details.

7.7 Pharmaceuticals

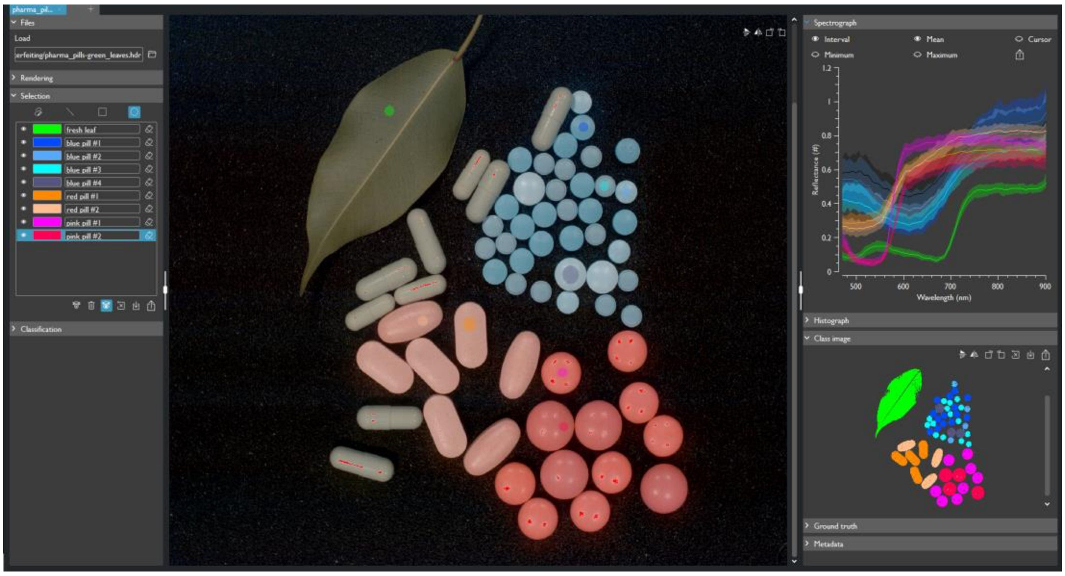

Figure 109 Example of differentiating similar looking pharmaceutical pills.

Combined VIS-NIR spectral range and ability to optimize spatial and spectral resolution along with scanning speed of the snapscan camera system enables non-destructive inspection of the pharmaceutical products for quality control, composition analysis as well as differentiating similar looking products. Snapscan camera system can also be used to identify counterfeit drugs. Please contact imec HSI support for further details.

7.8 Food quality grading and sorting

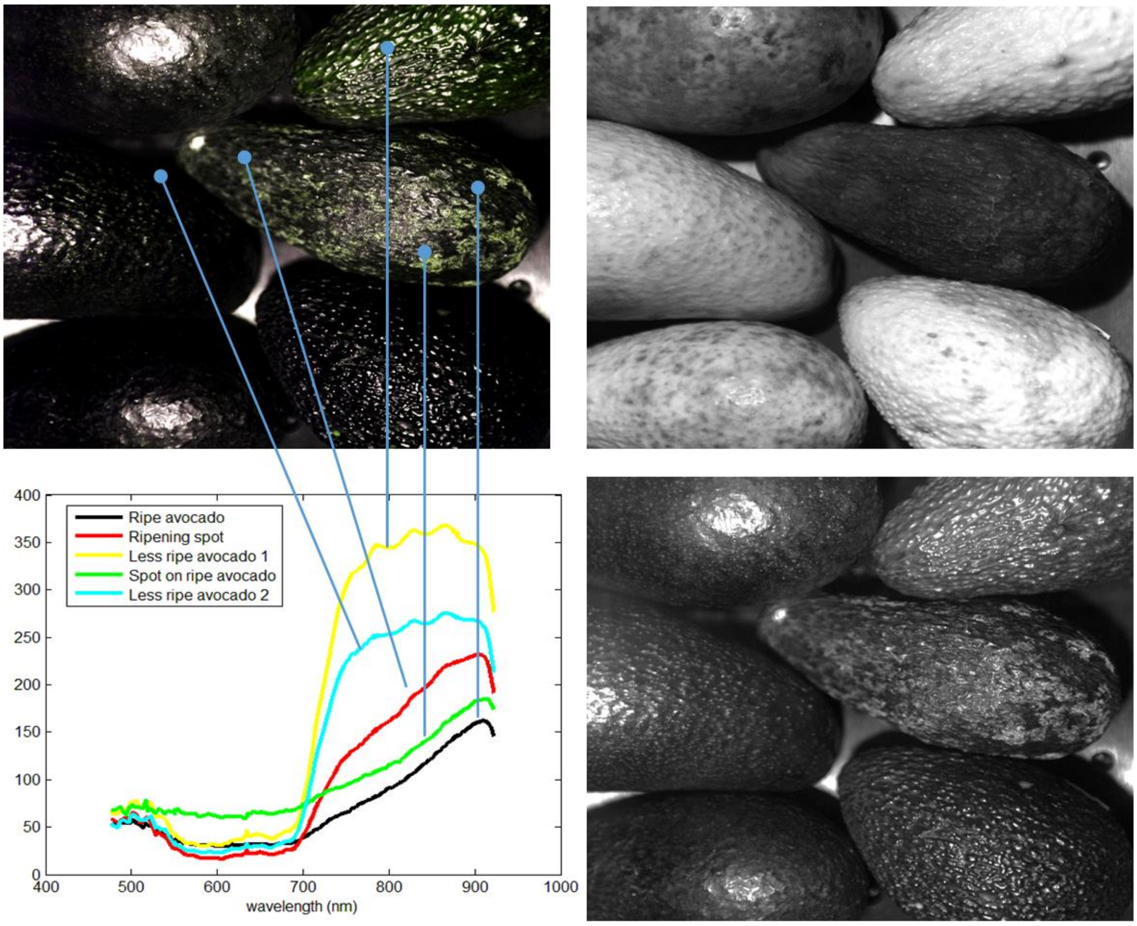

Figure 110 Detection of ripeness of avocados

The snapscan camera system enables high spatial and spectral hyperspectral imaging for food quality grading and sorting. For example, fruit growers can use it for detection of ripeness, bruises and diseases for fruits like apples, lemons, cherries, kiwis, peaches, avocados, etc. Please contact imec HSI support for further details.

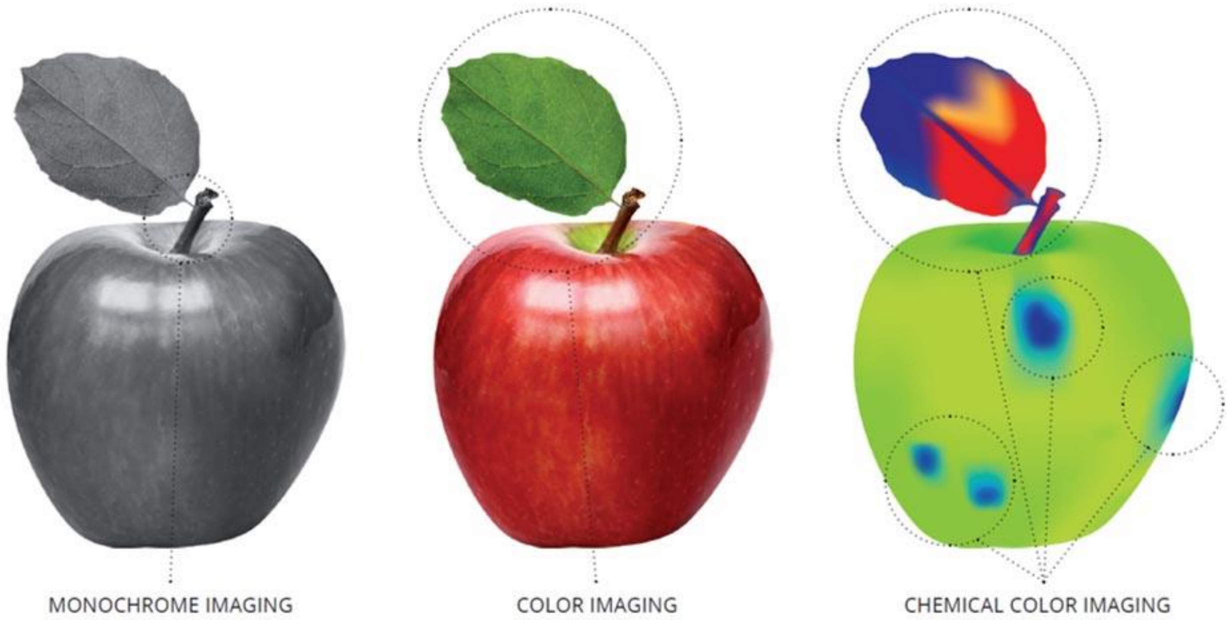

Image source: Perception Park GmbH

Chapter 8

Appendices

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8. Appendix – Glossary and Shortcuts

8.1 Glossary

Parameter	Description
Analog gain	Gain applied when converting photons to electrons.
Cross talk	Signal in a pixel generated by electrons leaking in from neighboring pixels.
Digital gain	Gain applied when converting electrons to digital number.
Exposure / Integration time	Time during which the sensor is exposed to photons.
HDR	High Dynamic Range
SAM classifier	Spectral Angle Mapper classifier
SNR	Signal to Noise Ratio
TDI	Time Delayed Integration

9. Appendix - Software changelog

9.1 snapscan v1.2.0

- Following enhancements have been made to the user interface
  - Tooltips have been added to icons and buttons
  - New icons have been added
  - Toolbar has been extended by adding support, about and languages in the tool button
  - Support for following languages have been added – Japanese and Chinese
  - Abort and progress bar have been added in spinner dialog
- Configuration parameter "Cube Offset X" have been added which sets the offset from top edge in live view in case the selected cube width is lower than 2048.
- Stop Motion and Continuous camera modes are automatically selected by the software and is no longer a user setting
- Support for snapscan SWIR range hyperspectral camera added to the software
- Following widgets added to cube display - class image, ground truth and metadata
- Import/ export options added to different widgets in cube display mode (for example, rendering, spectrograph, selection, classification, etc.)
- Default location for file I/O is moved to Documents\imec\<AppName>
- Internal file management is moved to AppData\Roaming\imec\<AppName> for admin restricted systems

9.2 snapscan v1.1.2

- Added support for perClass Mira
- Selection model is no longer reset on loading classifier
- Class model is now separated from selection model
- Class label layer is now split into multiple layers that can be hidden/shown individually
- Background image can be hidden to focus on classes
- Gaussian smoothing on spectrums added
- Default export reworked: unchecked by default but the most processed available cube
- There is now a visual feedback when modification of a parameter is not yet taken into account. Enter or focusOut to validate entry.
- Storing to cache is now only applied when required to fasten up the visualization of irradiance.
- Color match rendering is now default


imec
snapscan VNIR
imec
snapscan SWIR
snapscan SWIR arriving Q2 2019
100+ bands, 1.1-1.7um, 1200x640 px/ band

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