HYPERSPECTRAL ANALYZER

Software Instructions Manual

Read the manual carefully before operating this software

Photon Systems Instruments

Professional Instruments for Plant Science, Biotechnology and Agriculture

www.psi.cz

Photon Systems Instruments

PSI, spol. s r. o., Drásov 470, 664 24 Drásov, Czech Republic
FAX: +420 511 440 901, TEL: +420 511 440 011, www.psi.cz

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The contents of this manual have been verified to correspond to the specifications of the device. However, deviations cannot be ruled out. Therefore, a complete correspondence between the manual and the real device cannot be guaranteed. The information in this manual is regularly checked, and corrections may be made in subsequent versions.

The visualizations shown in this manual are only illustrative.

This manual is an integral part of the purchase and delivery of equipment and its accessories and both Parties must abide by it.

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1 Hyperspectral Analyzer

This section of the manual contains description of the Hyperspectral Analyzer application.
The manual describes Hyperspectral Analyzer version 1.0.0.2.

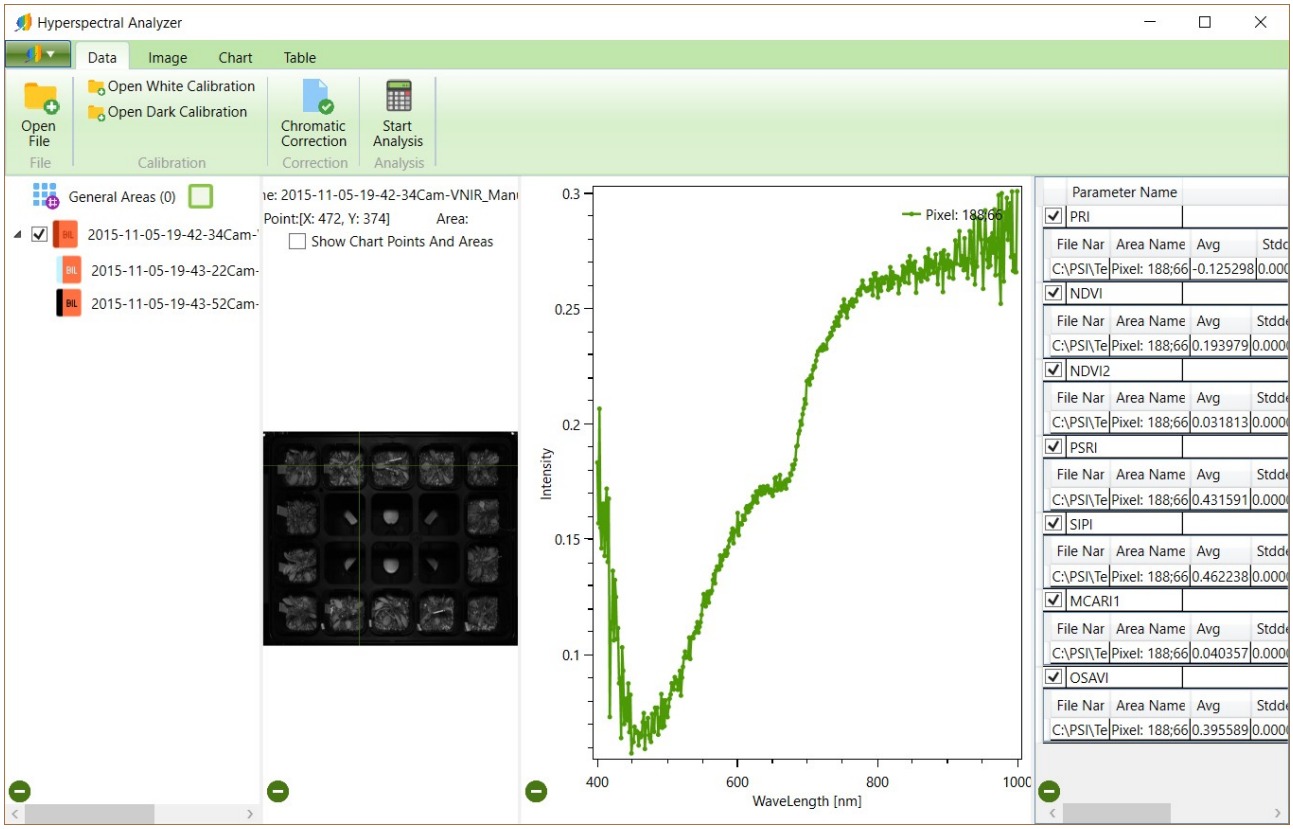

Fig 1: Hyperspectral Analyzer

1.1 Introduction

Hyperspectral Analyzer is an application for advanced processing of hyperspectral data. It provides tools for visualization, analysis and chromatic correction of data in .bil format. The same processing chain can be run over batch of data cubes.
Data visualization allows to show image by wavelength, formula or RGB settings. User can define points or regions of interest; their spectral profiles are then displayed in a wavelength normalized graph and analysis parameters are calculated on-the-fly, without the need to run full analysis process.
Hyperspectral analyzer computes complete hyperspectral analysis with possibility to customize the analysis with settings like area of interest, new analysis parameters or new plant mask formula.
Each analysis parameter can be displayed and edited by scale management control.

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1.2 Main Window

Main menu is located in the top part of the main window (Fig 2-1). The rest of the window contains loaded data and is composed of four parts: *Data* (Fig 2-2), *Image* (Fig 2-3), *Chart* (Fig 2-4) and *Table* (Fig 2-5), individual parts are described later in this manual.

Each part of the main window (except the *Main menu*) can be minimized or maximized by its hide/show button (Fig 2-6). Parts are divided by spliters, which allow to resize parts.

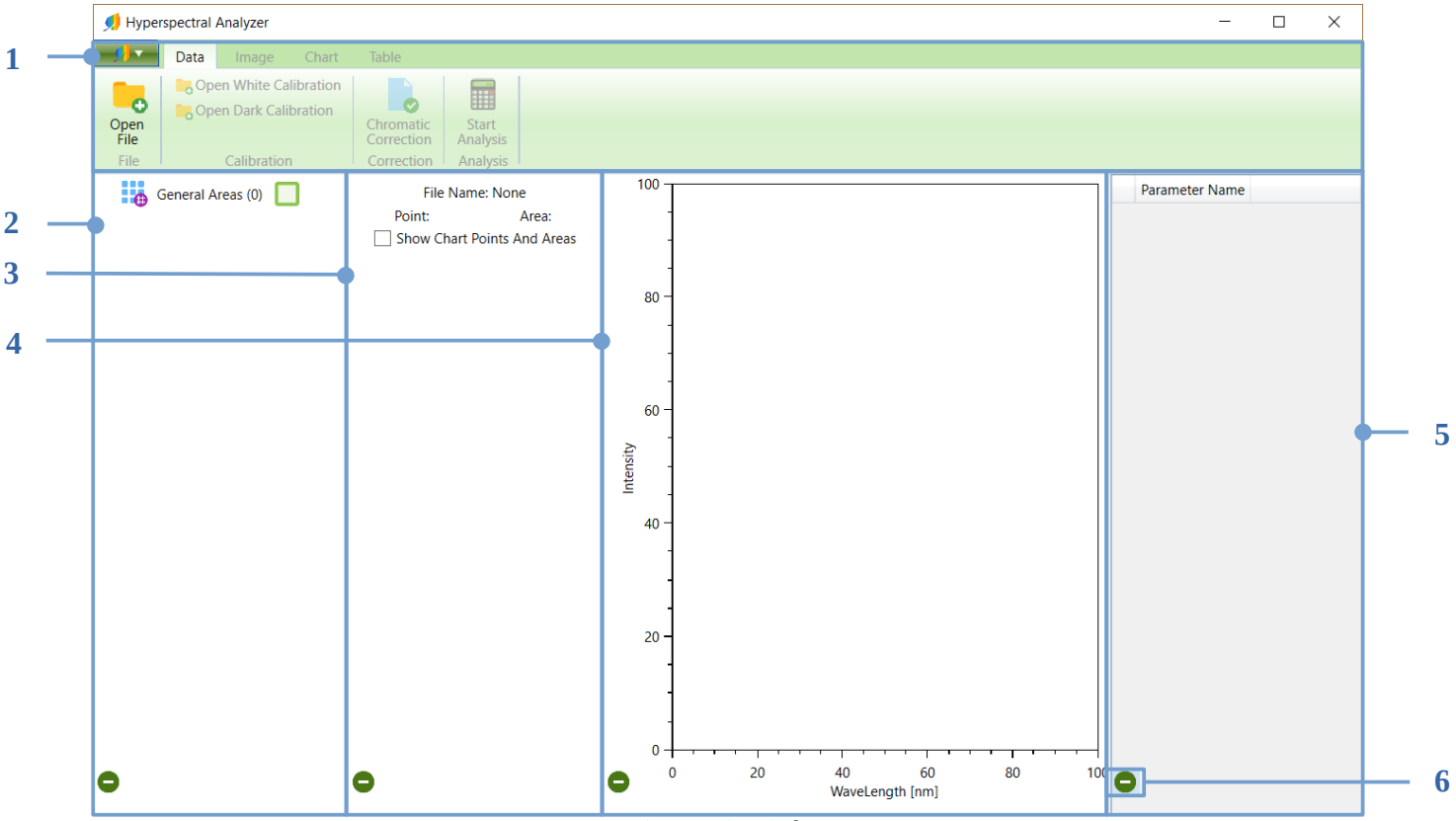

Fig 2: Main Window

1.2.1 Main Menu

Main menu contains four tabs - *Data*, *Image*, *Chart* and *Table*. Each tab corresponds to one part of the main window and allows to control it using various tools and settings.

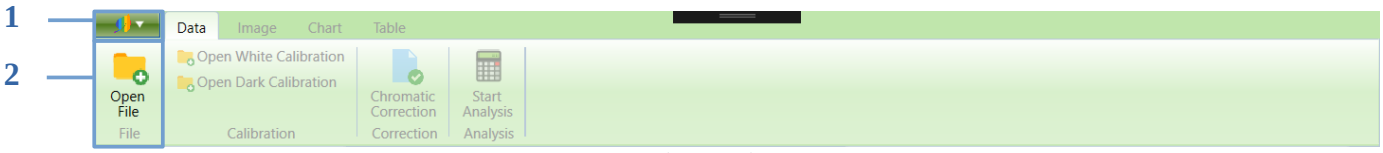

Fig 3: Main menu

On application startup, most of the menu items are disabled and become available once after the hyperspectral data are loaded. *Application Menu* button (Fig 2-1) opens Application Menu, which contains information about the application (Fig 4-2) and buttons (Fig 4-1)

- *Open File* – opens hyperspectral data selection dialog
- *Update* – opens application update dialog
- *Open Manual* – opens user manual
- *Settings* – opens application settings dialog
- *Close* – closes the application

Open File button (Fig 2-2) has the same functionality as the corresponding menu item.

Fig 4: Application Menu

1.3 Data

Fig 5: Data tab

Data tab contains buttons for opening hyperspectral data files (Fig 5-1), for opening white and black calibration corresponding to the selected hyperspectral data (Fig 5-2) and for opening chromatic correction window (Fig 5-3) and analysis window (Fig 5-4). Start Analysis button is disabled until the white calibration data is loaded for selected data. Selected data are data with the first checkbox checked in the tree structure (Fig 6).

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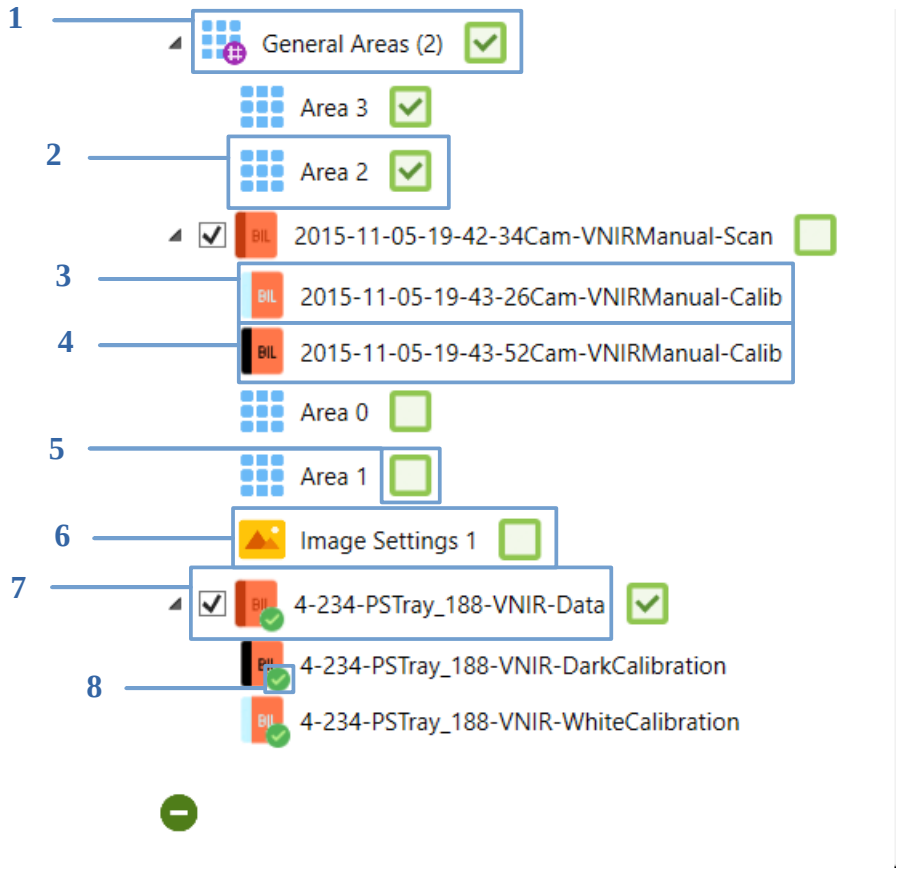

Fig 6: Tree Structure

Tree structure (Fig 6) displays loaded data. *General Areas* (Fig 6-1) node and data file nodes (Fig 6-7) are root nodes of the structure. Child nodes can be of the following types:

- region of interest (Fig 6-2)
- White Calibration File (Fig 6-3)
- Dark Calibration File (Fig 6-4)
- Image Settings (Fig 6-6)

If the data can be visualized as an image, green checkbox (Fig 6-5) is shown next to it. If checked, data are displayed.
All nodes in the tree view (except the *General Areas* root node) can be renamed or deleted from right click context menu (Fig 7).

Description of the tree structure nodes (Fig 6):

1) **General Areas** – root node, only region of interest node types can be inserted
2) **Data File** – node corresponding to an open file. The checkbox in front of the node name selects the data for further processing. The green checkbox at the end of the text controls visualization of the data. The green tick mark (Fig 6-8) is displayed if the node data was chromatically corrected. Node information is displayed in the tooltip on mouse over.
3) **White Calibration File, Dark Calibration File** – calibration data files, always child nodes of Data File node. The green tick mark (Fig 6-8) is displayed if the node data was chromatically corrected. Node information is displayed in the tooltip on mouse over.
4) **Region of Interest** – user defined area. Default naming convention is Area N.
5) **Image Settings** – user defined settings for data visualization, always child node of Data File node

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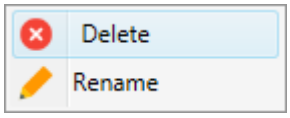

Fig 7: Tree Node Right Click Menu

1.3.1 Chromatic Correction

Chromatic correction window contains tools to customize and apply chromatic correction algorithm to selected data files. Files with already applied correction are marked with green tick mark. Algorithm settings profile can be selected from the combo box (Fig 8-1) and chromatic correction is applied to the data by *Apply Correction* button (Fig 8-5). Information about the currently selected algorithm settings profile is displayed in the information area (Fig 8-3).

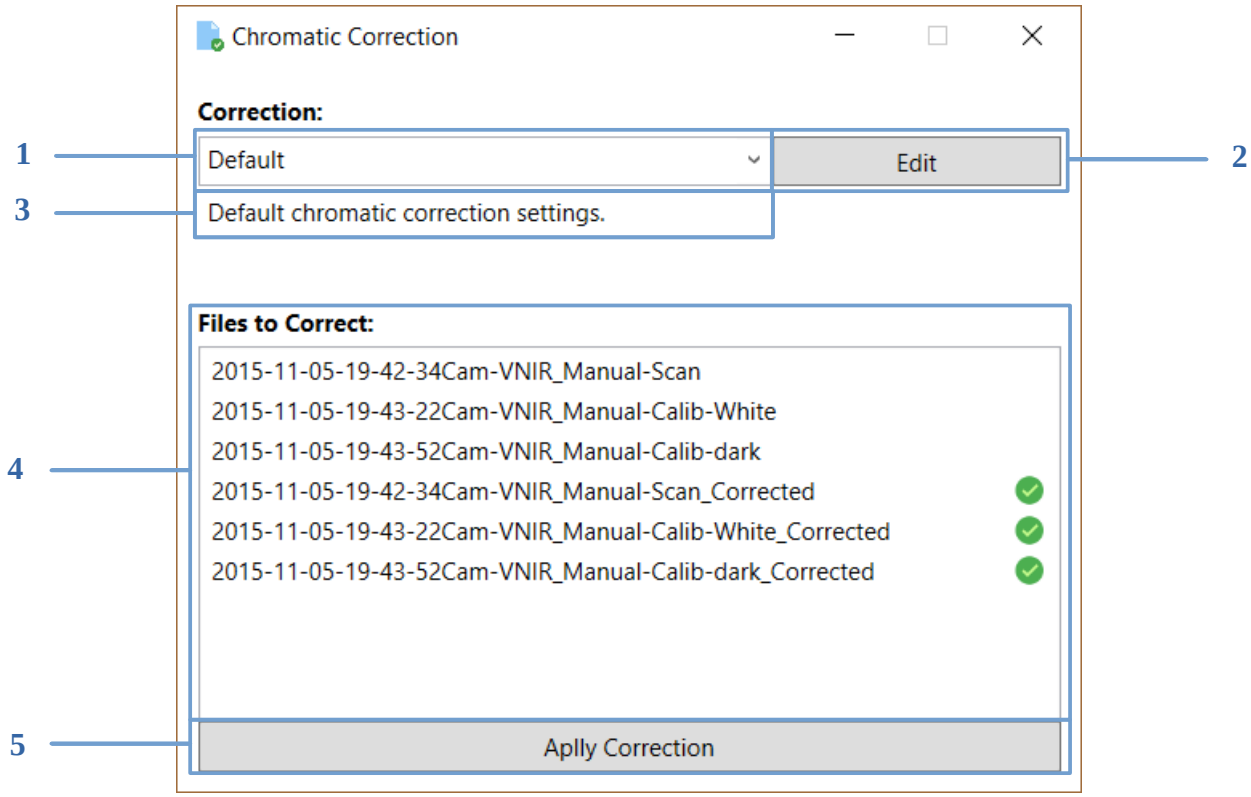

Fig 8: Chromatic Correction Window

Algorithm settings profile can be created/edited/deleted in the *Edit Chromatic Correction* window (Fig 9), which is opened by the *Edit* button (Fig 8-2). If the settings *Name* (Fig 9-2) is changed, it is possible to add (Fig 9-5) new settings item to the list. If the *Description* (Fig 9-3) or numeric values are changed, it is possible to Edit/Add/Remove

Description of chromatic correction settings value is in chapter 4 Procedure of obtaining Chromatic Correction values.

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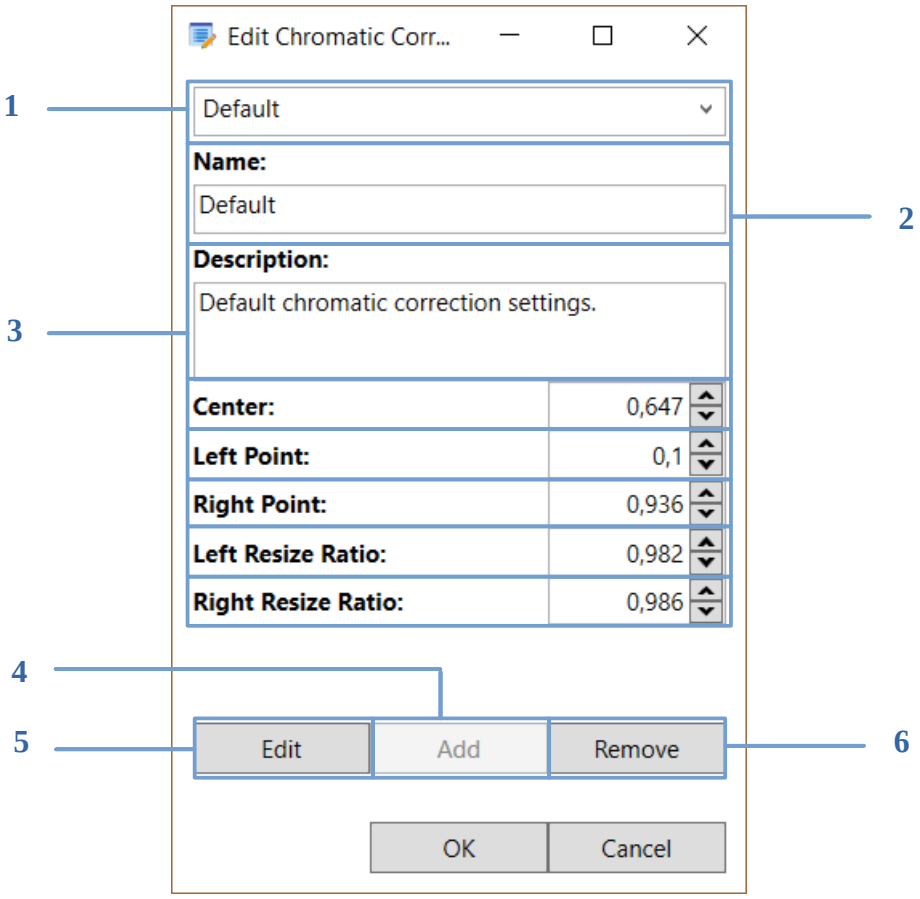

Fig 9: Chromatic Correction Edit Window

1.4 Image

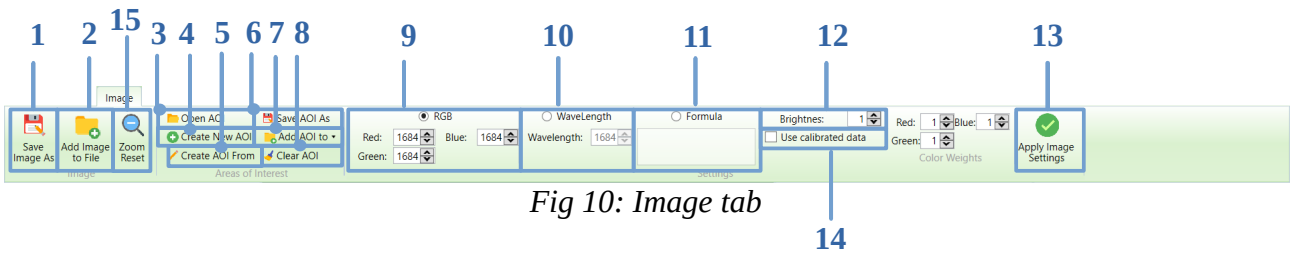

Fig 10: Image tab

Image tab contains image and area of interest controls. Displayed image can be saved to file by *Save Image As* (Fig 10-1) or added to tree structure by *Add Image to File (*Fig 10-2) button. Image in tree structure is possible show again with same settings. Mouse wheel zooms image and button in Fig 10-15 resets it.

Open Areas (Fig 10-3) opens areas of interest from file and *Save Areas As* (Fig 10-6) save it to file as .xsel file. *Create New Areas/Create Areas From* (Fig 10-4) allows to open Mask Builder (1.4.2) window, *Create Areas From* (Fig 10-5) uses displayed area of interest in image as pattern. *Add Areas to* (Fig 10-7) show menu with buttons to add AOI (area of interest) to tree structure under *Displayed File*, *General Areas* or *All Files* node. (Fig 11). *Clear Areas* button (Fig 10-8)clears displayed area of interest in the image.

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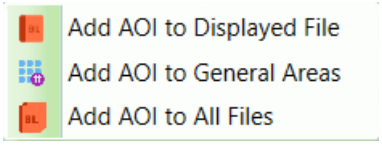

Fig 11: Add Areas to button Menu

Radio buttons *RGB*, *Wavelength* and *Formula* switch between image display settings. *RGB* (Fig 10-9) colors image by number value of *Red*, *Blue* and *Green*, for these paints is possible to set weights (Fig 12). *Wavelength* setting shows image in setted wavelength value (Fig 10-10) and Formula by set formula, to set min and max values in displayed formula image is *Formulas Scale* control(Fig 13). Color Weights and Formula Scale controls are showed next to *Apply Image Settings* button (Fig 10-14).

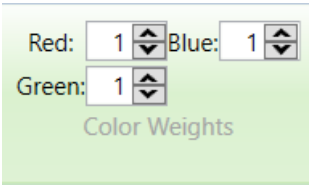

Fig 12: Color Weights

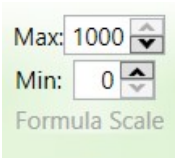

Fig 13: Formula Scale

Some images are dark, it is possible to add brightness using numeric control in Fig 10-12. In default application do not use calibration data to display image, for use it is checkbox *Calibrated Data* in Fig 10-14, marking off this control affects data in chart and table.

After change some setting is necessary to confirm changes by *Apply Image Settings* button (Fig 14), button indicates change by changing background color.

Fig 14: Apply Image Settings button

In Fig 16 is displayed image, name of the image is in top (Fig 16-2), under that are x,y mouse cursor coordinates (Fig 16-1) of image and aoi name(Fig 16-3), the name is displayed only if mouse cursor is above some aoi. Aoi (Fig 16-6) or mouse point (Fig 16-7) is possible to hide or show by *Show Chart Points and Areas* (Fig 16-4) checkbox. After aoi or point click is drawed cursor(Fig 16-7), and data are computed and added to chart and table. Chart allows to lock series, in that case cursors displayed by *Show Chart Points and Areas* checkbox has same color as chart series.

In right click menu for picture is possible to show frame image which is created by cross section 3d hyper cube, more in capture 1.4.1 Frame Image.

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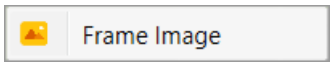

Fig 15: Image Right click menu

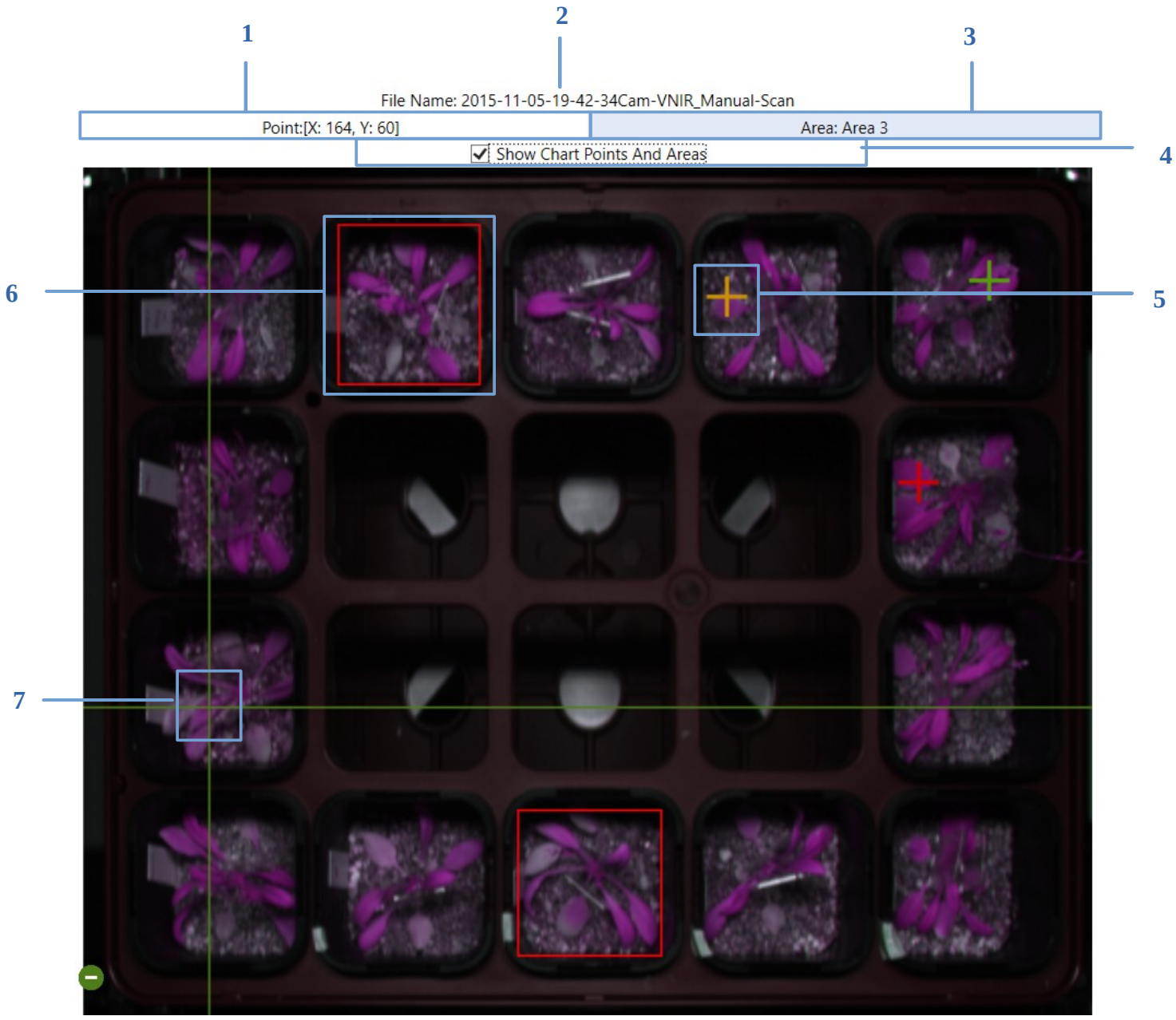

Fig 16: Image

Image settings are used locally in Image tab page, they are not applied to analysis window.

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1.4.1 Frame Image

Frame Image window displays cross section of 3d hyper cube. Result picture of horizontal cut shows wavelength in Y axis and spatial axis of hyper cube in X axis. Coordinates of clicked pixel are in Fig 17-1, to draw coordinate in frame image use *Show Line* (Fig 17-3) checkbox. *Show Axis* (Fig 17-4) checkbox control draws wavelenght axis in right side of image. Window allows to add brightness (Fig 17-2) or save image to file (Fig 17-5).

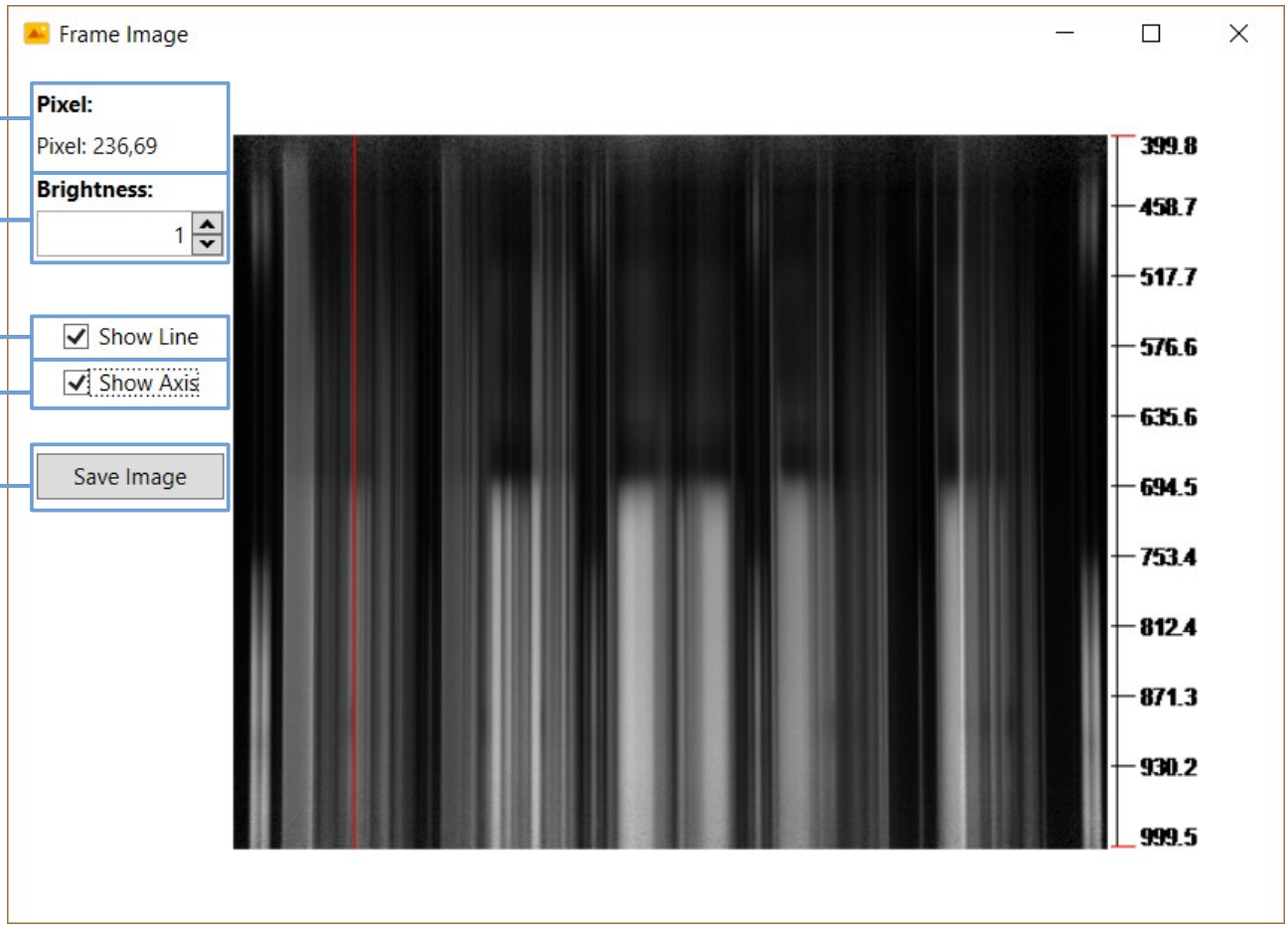

Fig 17: Frame Image

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1.4.2 Mask Builder

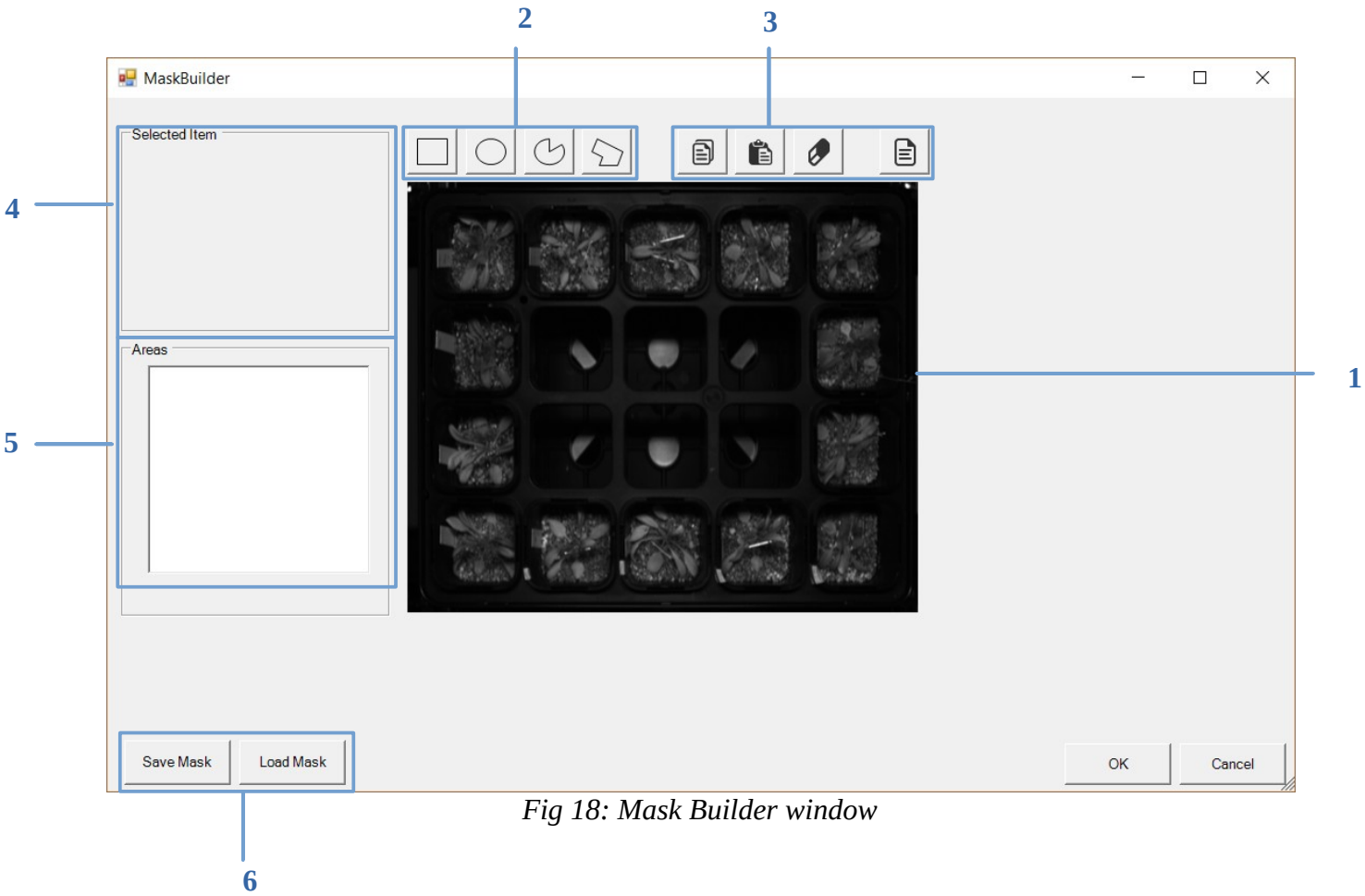

Fig 18: Mask Builder window

There are four basic area types available (Fig 18-2):

- rectangle
- ellipse
- pie
- polygon

Drawing mode is activated by selecting one of the area types. New area is created by clicking and holding the left mouse button and moving the mouse over the drawing window (Fig 18-1). It is possible to create more areas of the same type until the drawing mode is deactivated; this is done by clicking the right mouse button.

Custom shape is drawn in a little different way. Selection of the custom area type activates the drawing mode, and clicking of the left mouse button adds single point on the position of the mouse pointer. When right mouse button is clicked, area is closed if it contains at least three points – the last point is connected with the first one. If the three point's condition is not met, area is discarded. Custom shape drawing mode is then deactivated.

If drawing mode is not active, existing areas can be selected by clicking the left mouse button. More areas can be selected by holding the SHIFT key while clicking. When mouse cursor is placed over the selected area(s), it is changed to action icon corresponding to the cursor position in the area, allowing it to be moved or resized.
If more areas are selected, the operation is applied to each item from the selection.
If CTRL key is pressed while changing the area dimensions, area width and height are equalized, so perfect square or circle is created instead of rectangle or ellipsis.

Set of function buttons is available (Fig 18-3):

-  actual selection is copied to the clipboard
-  clipboard content is pasted to the drawing area
-  actual selection is deleted
-  toggles the area names display

Content of the actual selection is displayed in the *Area field* (Fig 18-5) and details of the selected areas in the *Selected Item* group box (Fig 18-4). Name and parameters can be changed by typing the value to the corresponding field and pressing the ENTER key.

If more areas are selected, the parameters in the *Selected Item* group box are displayed only if the selected areas are of the same type. Values of the parameters are displayed only if they are identical across the all selected areas. If parameter is changed, it is changed for all selected areas.

Area name has to be unique in the mask scope. A check is done before the mask is saved, if the condition is not met, areas with the same name are put to a selection and warning dialog is displayed.

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1.5 Chart

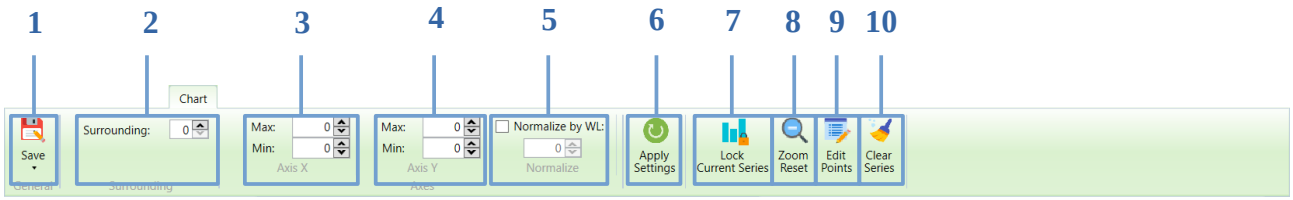

Fig 19: Chart tab

Chart series are generated by mouse click on Image, always after new click on image are series refreshed. Button *Lock Current Series* (Fig 19-7) allows to save last added series and button *Clear Series* (Fig 19-10) clear all series in chart. Series in chart can be smoothed by *Surrounding* (Fig 19-2) control or normalized by wavelength value (Fig 19-5) control. Chart in default has few colors for series, default colores are repeated, to set custom colors use *Edit Points (Fig 19-9)* more in chapter 1.5.1 Edit Points. Axes range controls (Fig 19-3, Fig 19-4) display and allow to set axes range. Mouse wheel zooms the chart and *Zoom Reset* button (Fig 19-8) reset it. Editing series using surrounding and normalize or changing axis range requires confirmation Fig 19-6. Data from chart can be saved to file as excel, csv or image by *Save* (Fig 19-1) button.

1.5.1 Edit Points

Edit points window edits series graphics like color(Fig 20-3), marker color(Fig 20-4) and marker size(Fig 20-5). Combobox Fig 20-1 switching between chart series. After editing is necesary to click on Ok button.

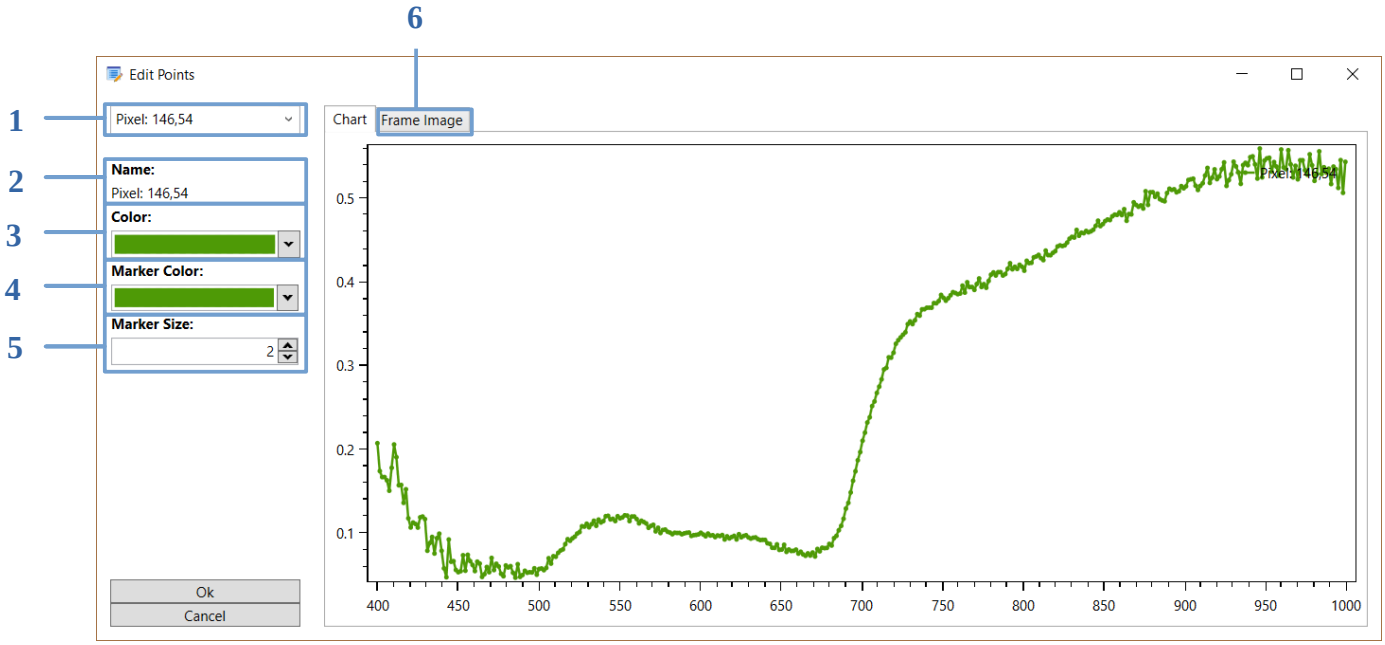

Fig 20: Edit Points

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After mouse left click on series point is displayed info rectangle with basic info (Fig 21-1).

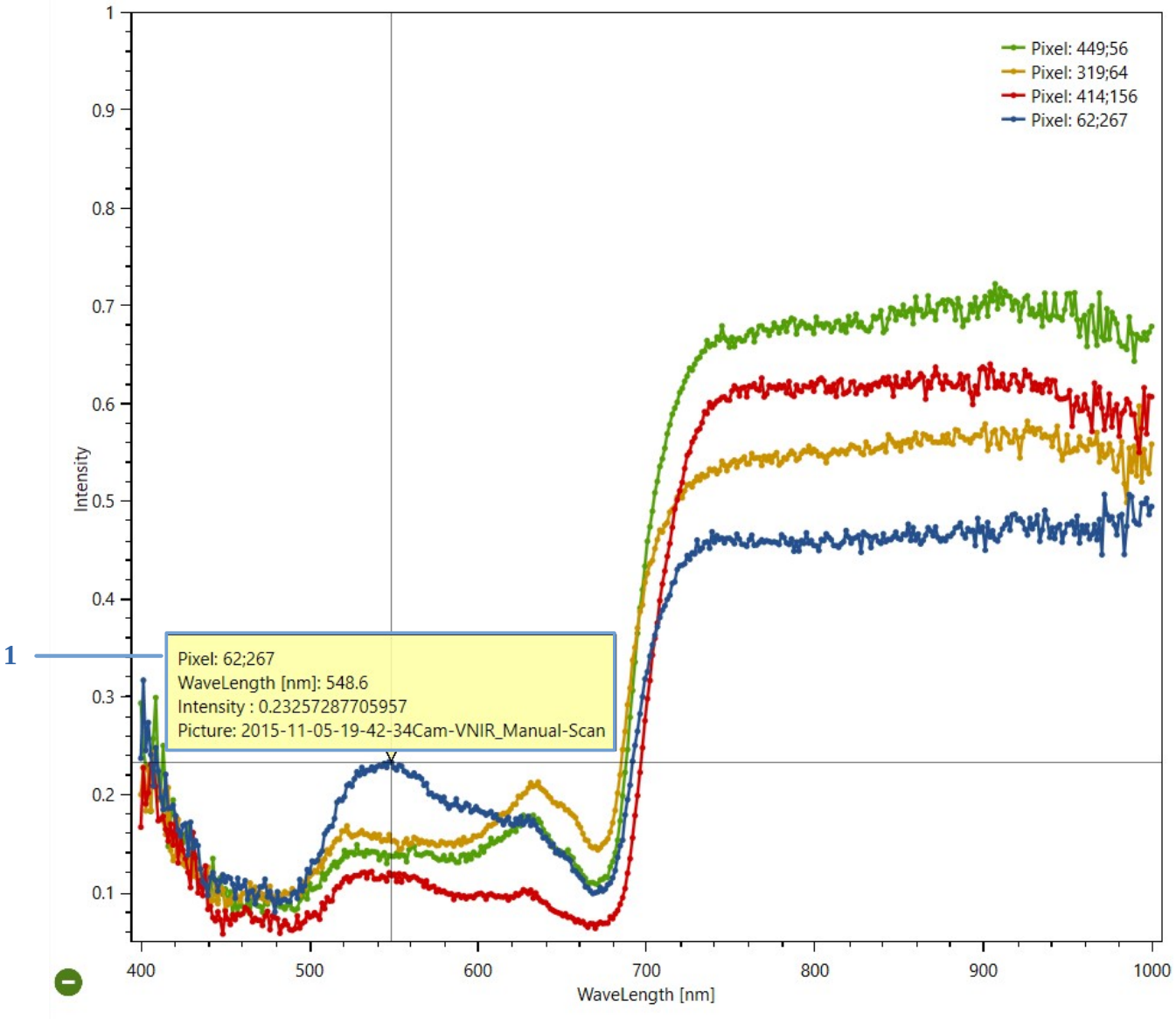

Fig 21: Chart

1.6 Table

Table display actual computed parameters for selected point/aoi and locked points/aoi in chart. *Parametr Selection* (Fig 22-2) button shows dialog for selecting parameters displayed in table, parameters is also possible edit in *Edit Parameters* (1.6.1) window. Buttons *Clear Table (Fig 22-4)* clears data from table and *Save Table (Fig 22-1)* save data to file as .xlsx or .csv format.

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Fig 22: Table tab

Data in table are separated under selected parameters, checkbox control(Fig 23-1) show/hide parameter rows.

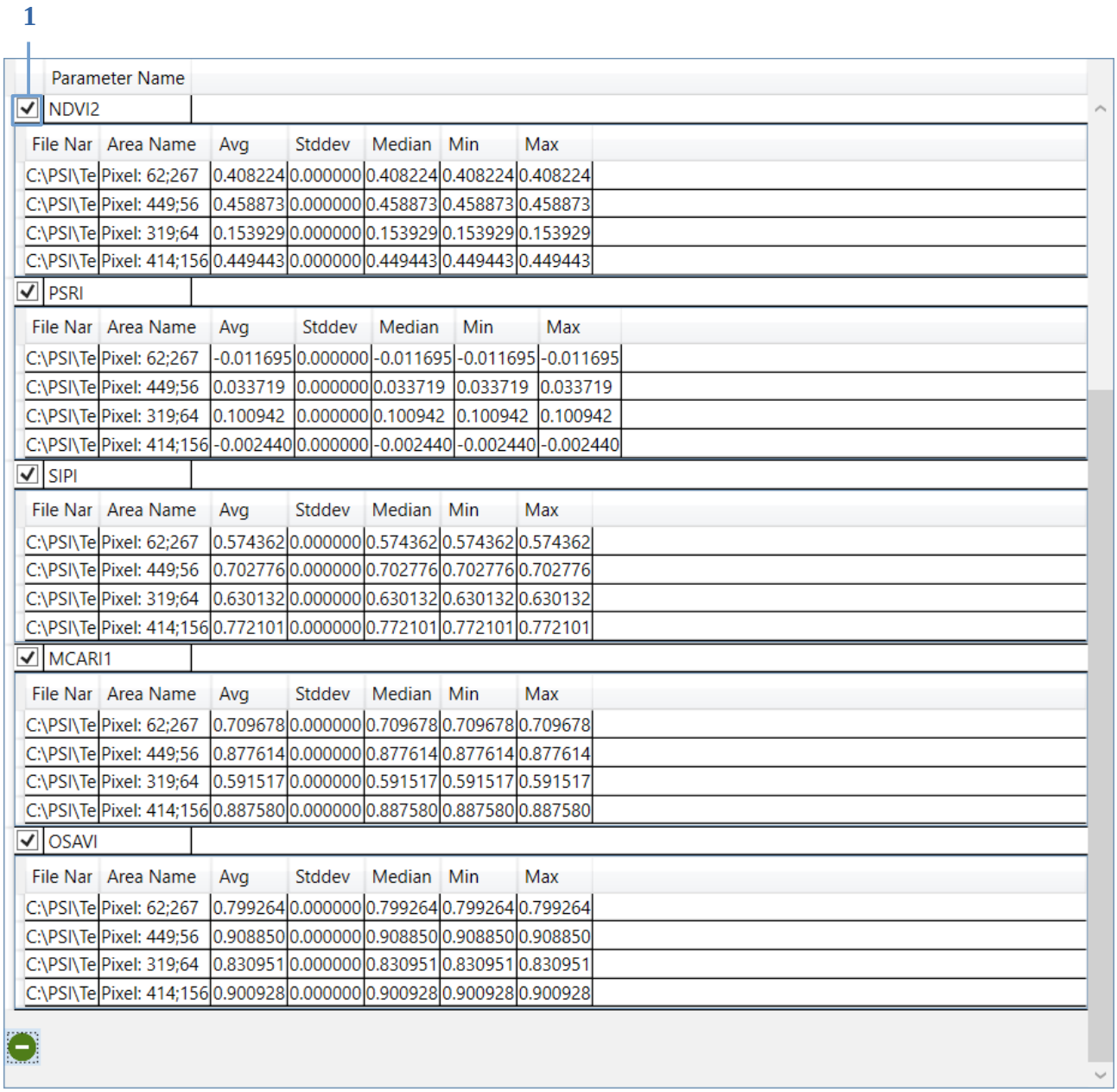

Fig 23: Table

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1.6.1 Edit Parameters

Edit parameters window adds, creates and deletes parameters. On start is enabled only *Remove* (Fig 24-2) button, to enable *Edit* button it requires edit formula or description and Add button is enabled after change parameter name.

Formula can contain constants (1, 2, 3, …), operators (+, -, *, /, min, max, ln, log, sqrt, ^) and variables (R740, R672, ...), which define wavelength used. Variables wavelengths must be from valid range defined by the camera.

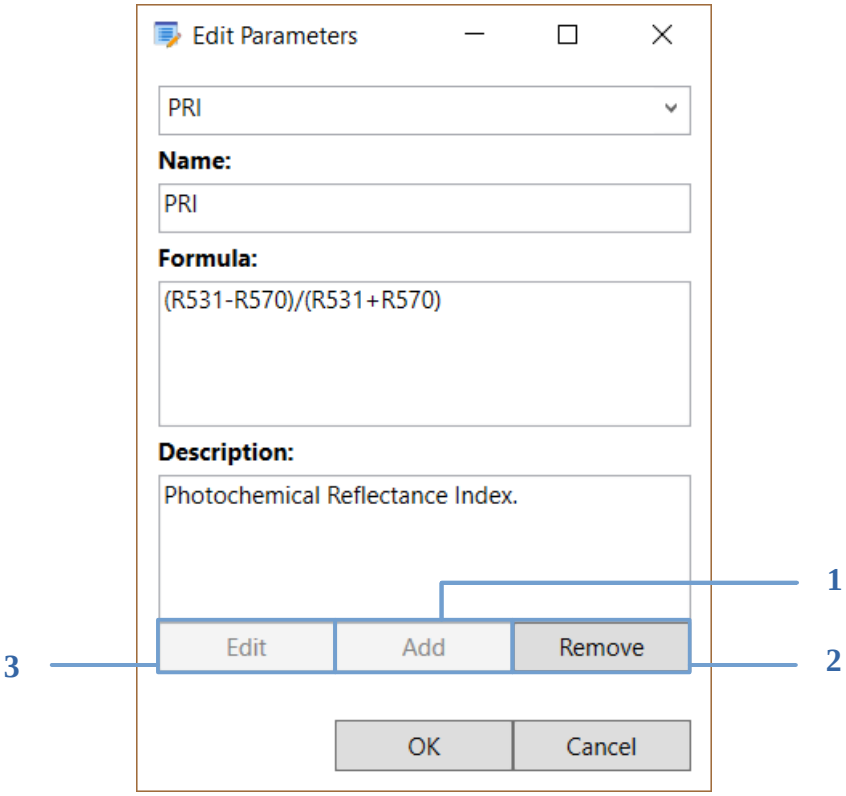

Fig 24: Edit Parameters Window

1.7 Analysis

Analysis window analyzing selected files singly or in bulk. Result of the analysis are computed parameters, parameters images and rgb image, editing and selecting analysis parameter is same as in table part described in 1.6.1 - Edit Parameters and 1.8.1 - Parameters Selection, another analysing settings are described in Tab. 1-Analysis Settings. Analysis parameters are computed from plants finded in area of interest, to find plant in area of interest is used plant mask formula, at default application contains formulas designed for VNIR and SWIR cameras, but is possible to edit,create or remove it in edit window (Fig 25-9), which works same as edit parameters window described in chapter 1.6.1 Edit Parameters.

Areas of interest created in image part and added to tree structure under analysed files are transferred to analysis window. Area of interes is possible to create in analysis window too. Area of interest are used as Tray mask in default, but radio buttons Fig 25-14 allows switch it to Plant mask.

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In case when is selected Plant mask are all points area of interest used for analysis, if is selected tray mask analysis finding plant mask at first.

If checkbox *Compute Areas Spectrum* (Fig 25-14) is checked, analysis also compute average values of areas of interest, result values are exported with rest of analysis values.

Control	Description
Red (Fig 25-1)	Wavelength used as red color for RGB image
Green (Fig 25-1)	Wavelength used as green color for RGB image
Blue (Fig 25-1)	Wavelength used as blue color for RGB image
Surrounding (Fig 25-2)	Parameter for camera noise reduction. Defines number of neighboring pixels (in spectral dimension), which are averaged and resulting value is used for the parameter computation. If set to 0, the original pixel value is taken.
Flip X (Fig 25-3)	Parameter indicates that data will be flipped in X axis for analysis.
Flip Y (Fig 25-3)	Parameter indicates that data will be flipped in Y axis for analysis.
Rotate CCW (Fig 25-3)	Parameter indicates that data will be rotated CCW for analysis.
Plant Mask Treshold (Fig 25-4)	Threshold for picking plant points while plant region of interest creating.
Plant Mask Median Size (Fig 25-5)	Size of median filter for plant region of interest creating.
Plant Mask Erosion Level (Fig 25-6)	Sets erosion level for used plant region of interest.
RGB Image Multiplier (Fig 25-7)	RGB value multiplier. If greater than 1, image is brighter, if lower, image is darker.

Table 1: Analysis Settings

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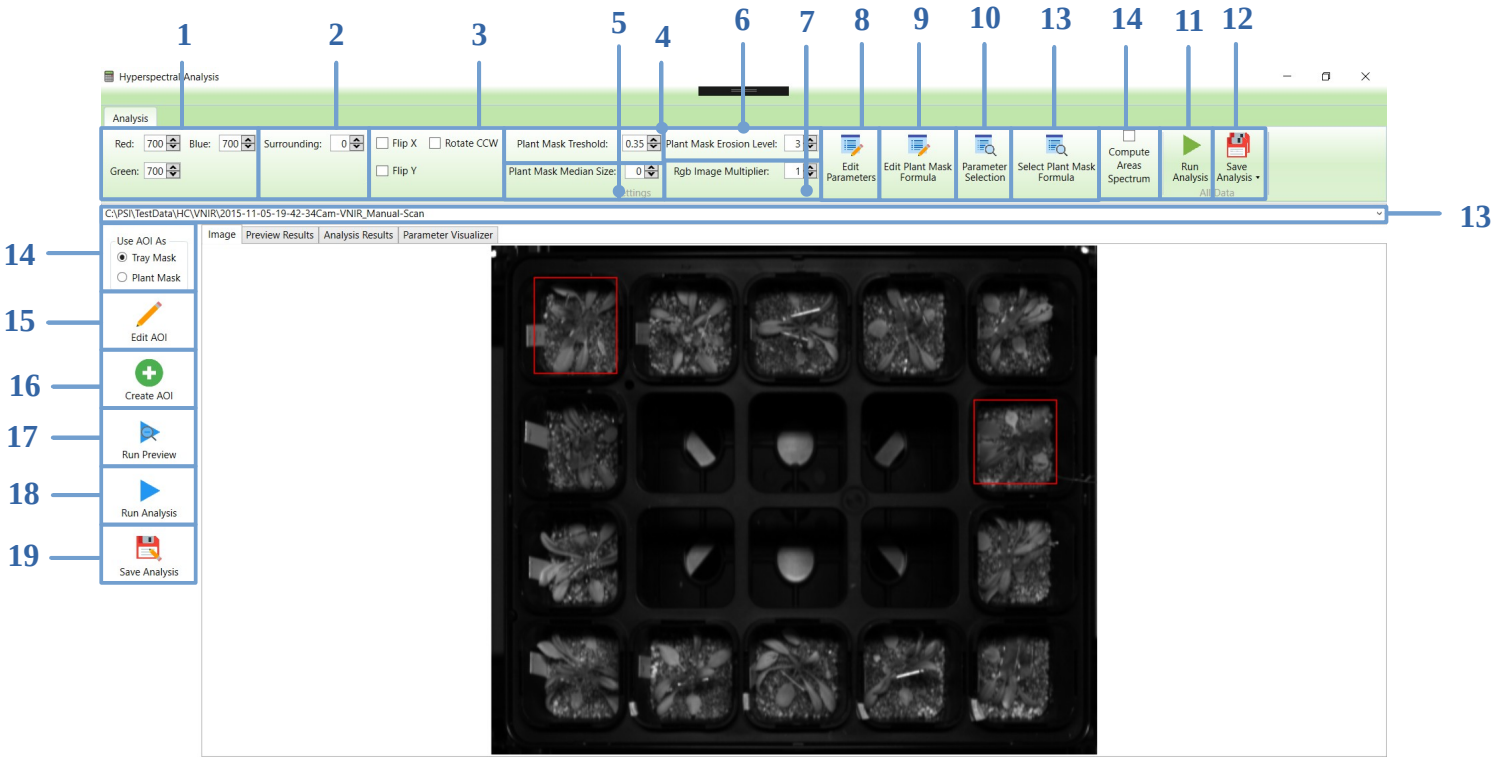

Fig 25: Analysis Window

1.7.1 Preview

Analysis preview contains elements for displaying results of plant mask detection with the current settings of the analysis. It is designed to quickly find the best mask detection settings on selected file before running the analysis.

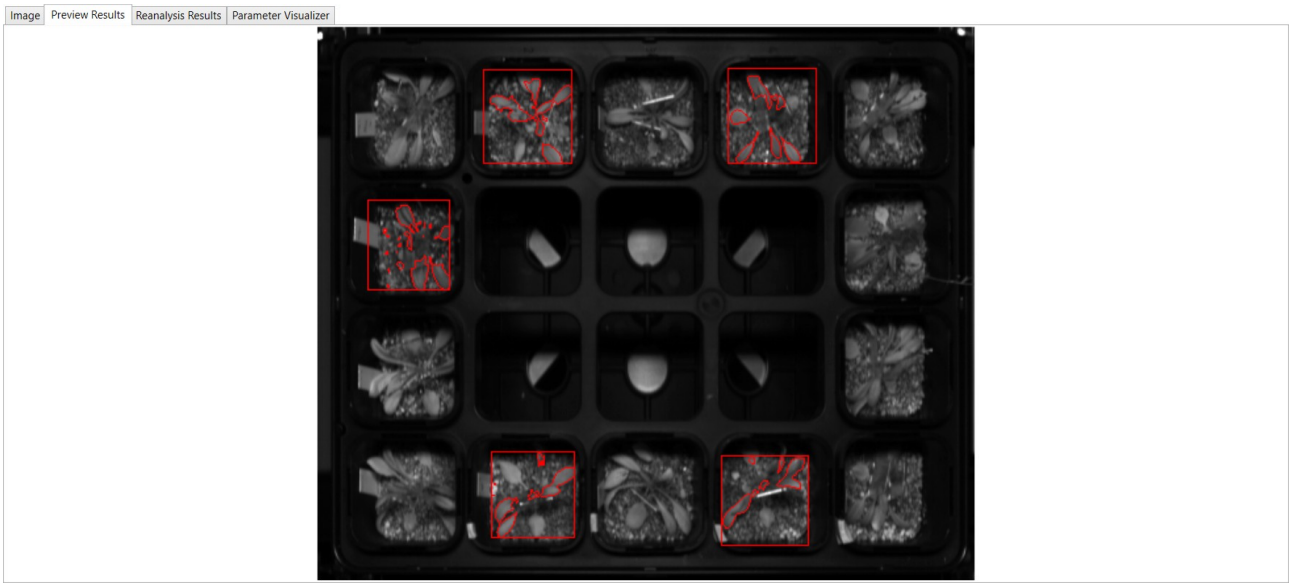

Fig 26: Prewiev Results Tab

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1.7.2 Analysis Results

Analysis result tab displays result values in table for areas of interest.

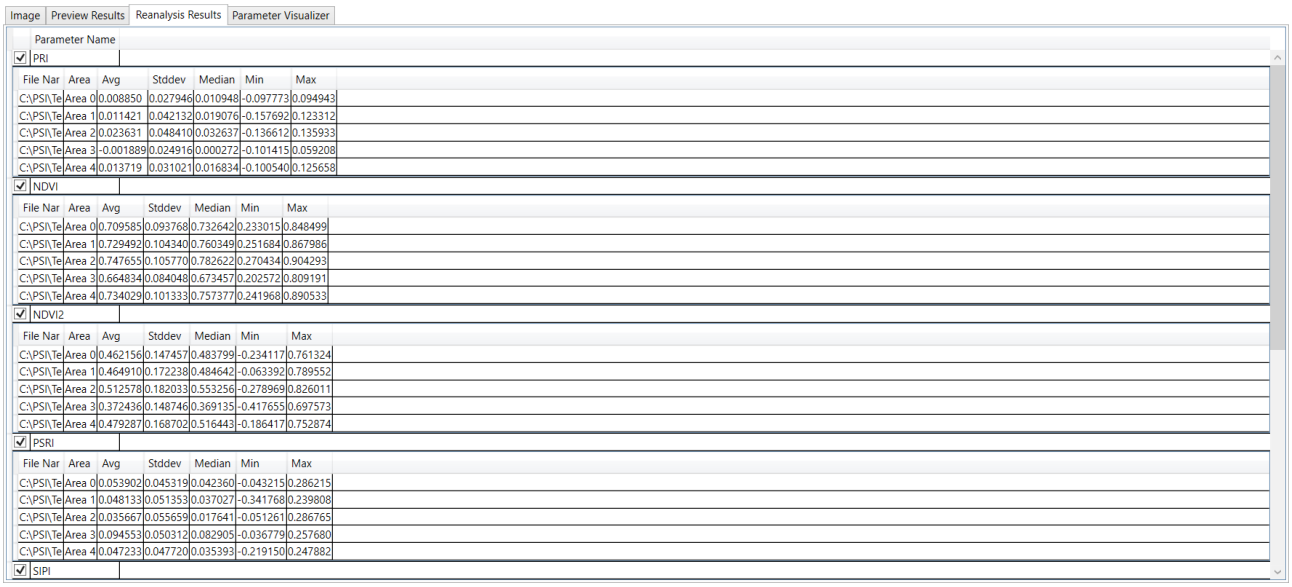

Fig 27: Reanalysis Results Tab

1.7.3 Parameter Visualizer

Parameters Vizualizer shows analyzed parameters images. Combobox (Fig 28-1) switching between parameters images. Image Settings group box contains controls for image scale, image range and mask showing controls. Image range is divided to *Auto Range* (Fig 28-4) by min,max values, *Auto Range By Mask* (Fig 28-5) min,max values and *Manual Range* (Fig 28-6). Auto Range by Mask includes checkbox control *Remove Outliers* which remove outer points from histogram. Actual range is displayed in right side of the image and image range shows *Image Info*(Fig 28-2) control. After finish is necesary to confirm changes by Apply *Image Settings* (Fig 28-7) and button *Save Image* saves actual image to file (Fig 28-8).

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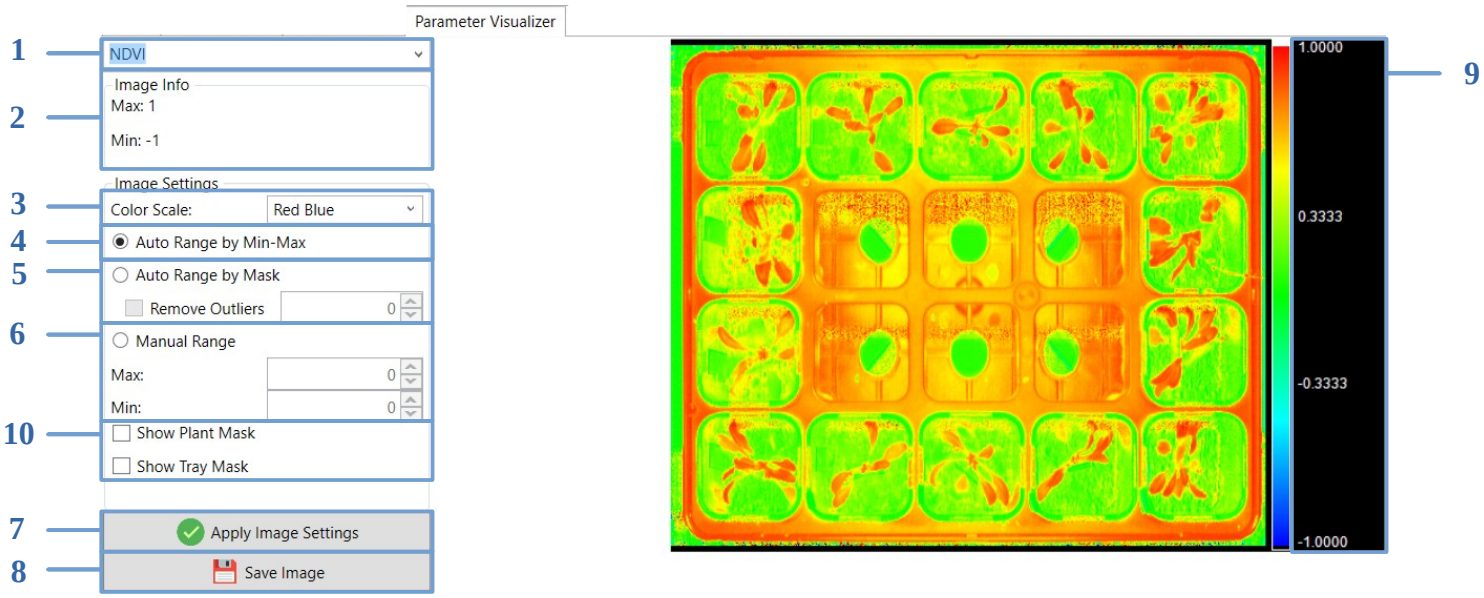

Fig 28: Parameter Visualizer

1.8 Settings

Settings window has controls for general application settings. Data can be saved to .xlsx or .csv file format, general settings allows to change .csv separator Fig 29-1. *Image Export Format* (Fig 29-3) combobox control changes exported image data type. When file is opened, application automatically try find calibration files, to swith on/off this action is used *Auto Find Calibration Files* (Fig 29-4) checkbox. Table part displays online computed parameters, checkbox *Table Auto Compute* (Fig 29-2) can switch off/on this feature.

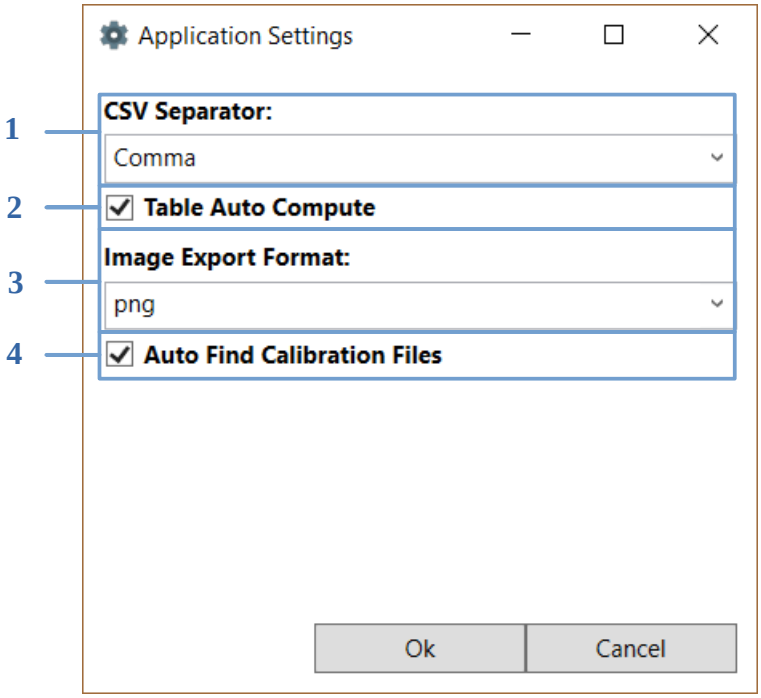

Fig 29: Application Settings

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1.8.1 Parameters Selection

It selects parameters for computing. Parameters is selected when checkbox in left side is checked. After row mouse hover it displays tooltip with parameter description (Fig 30).

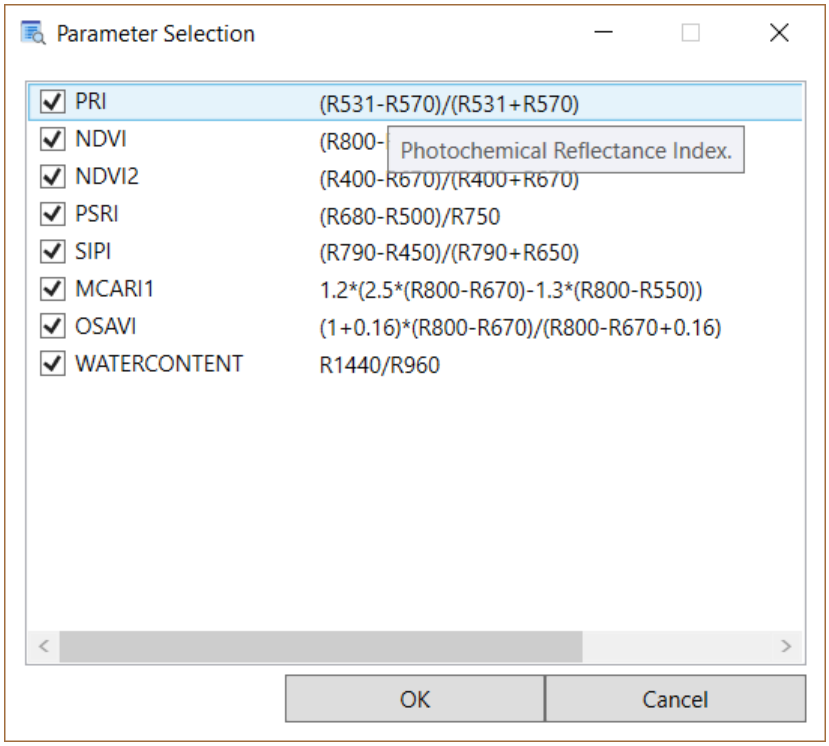

Fig 30: Parameters Selection

1.9 Update

It displays information about new version of the application. Update button (Fig 31) starts the update process. Remind me later button (Fig 31) opens remind window (Fig 33) which allows to set automatic update notification after specified time. Cancel button (Fig 32) stops the update and closes the process window.

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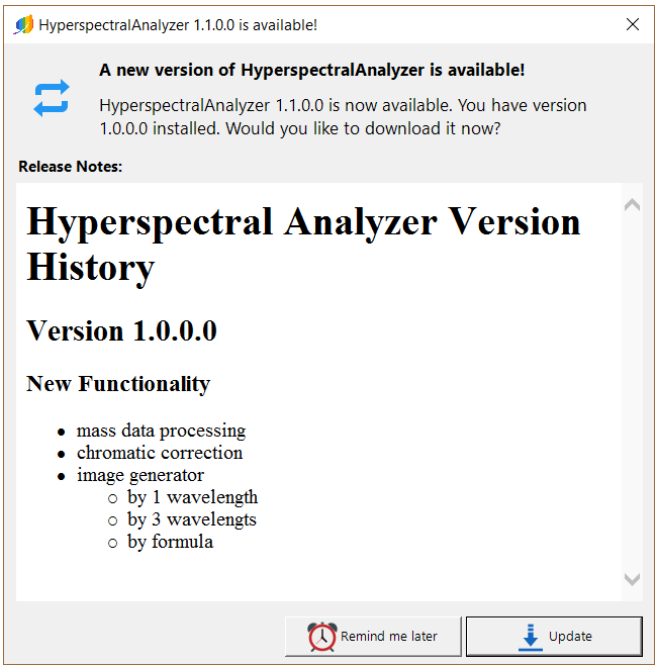

Fig 31: Update Window

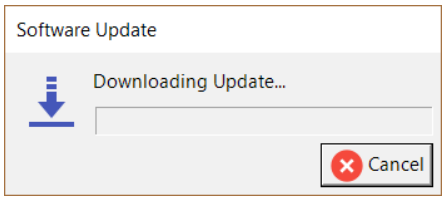

Fig 32: Progress Window

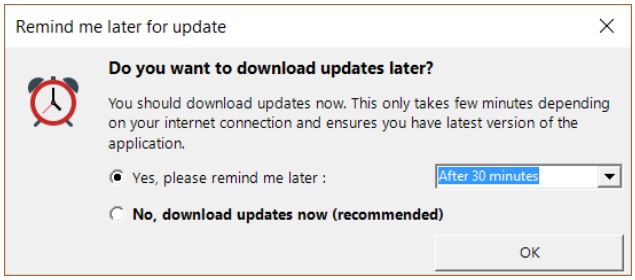

Fig 33: Remind me later window

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2 List of Figures, Tables

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3 Apendix 1 Format Description

3.1 Format.bil (Band Interleaved by Line)

Format is used to save hyperspectral data – commonly referred as hypercube. Data have three dimensions – image width, height and light spectral band. One .bil record has two files:

- data file (.bil) with raw data in binary form
- header file (.hdr) with data format description

Structure of the .hdr file
File contains description of the hypercube data. It can be opened by any text editor.

File content description:

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BYTEORDER	I	*byte order, I = Intel byte order (least significant byte first))*
LAYOUT	BIL	*band interleaved by line*
NROWS	420	*number of rows*
NCOLS	500	*number of columns*
NBANDS	408	*number of spectral bands*
NBITS	12	*bit depth*
BANDROWBYTES	1000	*number of bytes for one row for one spectral band*
TOTALROWBYTES	408000	*number of bytes for one row for all spectral band*
BANDGAPBYTES	0	*number of padding bytes between spectral bands*
STARTWAVELENGTH	399.8	*start wavelength [nm]*
ENDWAVELENGTH	999.5	*end wavelength [nm]*
INTEGRATIONTIME	90000	*measurement integration time [us]*
Following parameters are optional and only some of the cameras use them:		
WAVELENGTHS		*start of the wavelength bytes flag*
VALUES	349.79 350.95	*pixel wavelength values*
WAVELENGTHS_END		*end of the wavelength bytes flag*

Table 2: Header File Structure

Structure of the .bil file
File contains uint16 binary values.

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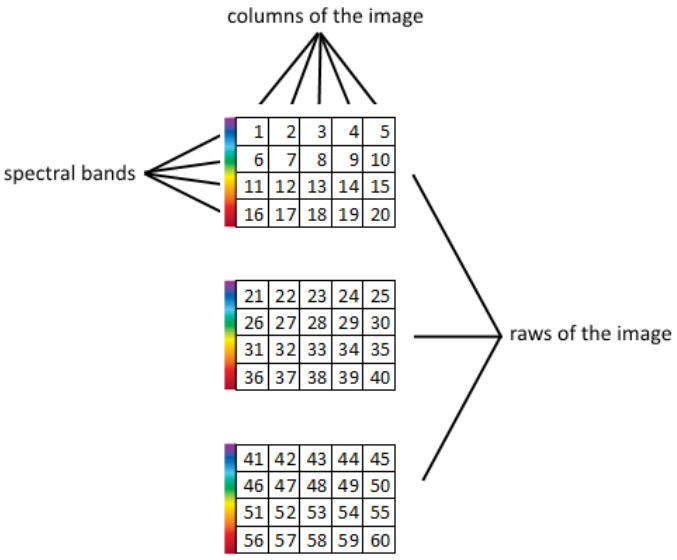

Fig 34: Values Order

Images shows uint16 values order in the .bil file. Number in the table shows value order in the file. Hypercube in the image is5px wide, 4px high and has 4 spectral bands.

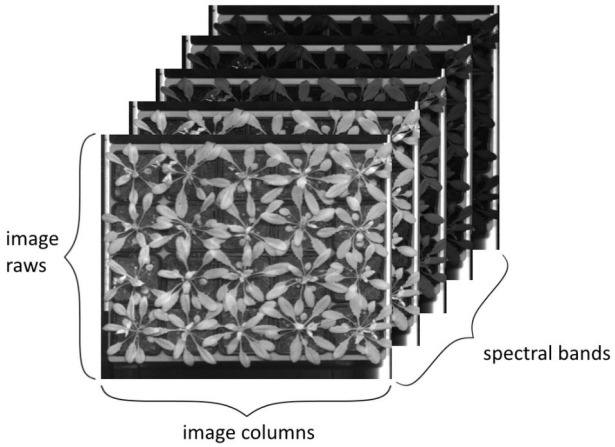

Fig 35: Hypercube Visualization

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3.2 Format .fimg(Float Image)

Format is used for FluorCam and Hyperspectral parameter images.

Format structure:

Width(int32)	4 bytes
Height(int32)	4 bytes
Data (float)	Width * Height *4 bytes

Table 3: Format .fimg Structure

4 Procedure of obtaining Chromatic Correction values

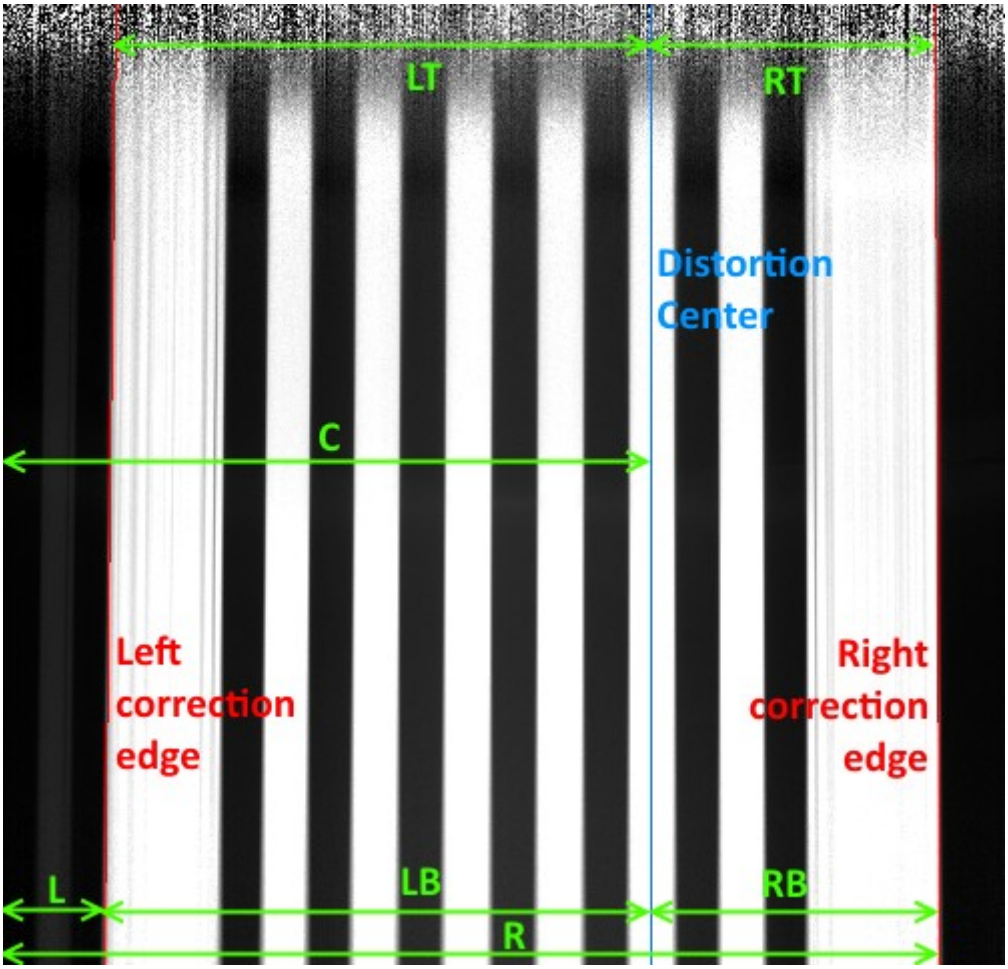

Fig 36: Chromatic Correction Settings Picture

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Capture chessboard or different pattern with contrasting edges (Fig 36) + dark and white calibration file

1. Display in Hyperspectral Analyzer application image (right click on picture and "Show Frame Image"
2. Save the image and open in arbitrary image editor (Paint.net)
3. Find disortion center – edges are verticaly and from the center to image edges gradually fall (blue in Fig 36)
4. Find appropriate contrasting edges – red correction edges in Fig 36
5. Measure distance in pixels:
    1. down distance left edge from left edge of the picture (L)
    2. down distance right edge from left edge of the picture (R)
    3. distance between disortion center and left edge of the picture (C)
    4. upper distance left edge from disortion center (LT)
    5. upper distance right edge from disortion center (RT)
    6. down distance left edge from disortion center (LB)
    7. down distance right edge from disortion center (RB)
6. W = width of the image (500px)
7. Compute values:
    1. center = C / (W – 1)
    2. left_point = L / (W – 1)
    3. right_point = R / (W – 1)
    4. left_resize_ratio = LT / LB
    5. right_resize_ratio = RT / RB