FMIPROT
Finnish Meteorological Institute Image Processing Tool
User Manual

Contents

Introduction

FMI Image processing tool (FMIPROT) is software designed as a toolbox for image processing for phenological and meteorological purposes, under the MONIMET Project, funded by EU Life+ Programme (2013-2017) (http://monimet.fmi.fi). The purpose of the software was to create a platform that communicates with the MONIMET project camera network in Finland, as linking the cameras from the network and downloading images according to temporal criteria automatically. At the moment FMIPROT can communicate with multiple camera networks. The software provides a graphical interface to select all relevant criteria to analyze the images and view results on plots and maps. The software is expandable by adding various processing algorithms of images taken by cameras by users. Current functions of the software are,

(1) Communication with multiple camera networks
(2) Storing scenario conditions as files
(3) Generating reports for scenario options and analyses results
(4) Multiple scenarios
(5) Multiple analyses in each scenario
(6) Mask/ROI creation by selection with GUI
(7) Filtering images according to different means of thresholds
(8) Downloading and handling images
(9) Quantitative image archive check
(10) Expandable algorithms by plugin system
(11) Customizable Plotting/Mapping of results
(12) Windows and Linux support.

The software has two processing algorithms:

(1) Color Fraction Extraction: Calculates red fraction index, green fraction index, blue fraction index, brightness, luminance, red channel mean, red channel median, red channel standard deviation, green channel mean, green channel median, green channel standard deviation, blue channel mean, blue channel median, and blue channel standard deviation.
(2) Vegetation Indices: Calculates red fraction index, green fraction index, green-red vegetation index, green excess index.
(3) Custom Color Index: Calculates an index from a mathematical formula entered by the user using average values of red, green and blue channels in ROIs. The formula supports sums, differences, multiplication, and division and operation priority by using parentheses.

Version Issues

The product is currently a beta version, thus it may crash unexpectedly. User should always save the setup file when there is a change in the setup to prevent losing the changes and wasting effort. On unexpected crashes, please send the log file and output from the terminal/console to cemal.melih.tanis () fmi.fi.

Known Bugs

- Minor, always - "Enable" checkboxes in the various menus displays unchecked when switching scenarios. Although the visibility is unchecked, values are actually checked, so it does not change and mess up with the scenario options. Checkboxes display checked again when mouse cursor moves over them.
- Minor, often - the previous menu button shows "Customize Graph" instead of showing nothing when user is in the main menu.
- Minor, very rarely - Connection to FTP servers fail. Restart the program to solve.

Installation

Extract the zip archive ("fmiprot_#_setup.zip") to any directory. Run "install_linux" in Linux systems and "install_win" in Windows systems to run the installation. Installation dialog is simple and straightforward. (Optionally) Choose the directory to for the software to be installed, the local image directory where images from online camera networks will be downloaded when using the software and the directory where analysis results will be saved when using the software. Choose directories that your user in your computer has the permission to write. If you do not know what that means, you can leave the default directories as chosen. Click "Install". Read the license agreement and click "Accept" if you accept it.

If the installer finds any older installation of the software, it will ask a few options. Choose them accordingly and continue installation.

In Ubuntu, installer also creates a link where the program can be started in "Dash". Simply search your applications to find the link.

In Windows, installer also creates a link in your desktop where the program can be started.

In others systems, or if somehow you have lost the links, Run "fmiprot" from the directory you have installed FMIPROT to run the software.

Quick Guide for Analyzing Image Time Series in PC

- From the menubar, click "Camera Networks" -> "Single Directory Wizard".
- Click "OK".
- Click "I want to add a directory"
- Click "OK".
- From the dialog, choose the directory where your images are. Click "OK" <u>when you are inside the directory, not when just choosing it.</u>
- In the next dialog, enter the filename convention of your images. For the time directives, visit "Filename convention of the images" section. For example, "hyy_pin_crown_%Y%m%d_%H%M%S.jpg" will read images like "hyy_pin_crown_20160231_123145.jpg".
- In the next dialog, the program will tell if it has found images or not. If it did not, it will ask you to choose the directory and enter the filename convention again, considering that you have made a mistake. If the images are found, click "OK".
- Enter a camera network and camera name. For example, Network name: "Central Park", Camera name: "North 1".
- Click "OK".
- From the main menu, click "Camera".
- From the camera network option, choose the camera network you have created.
- The program will ask if you want to fetch a preview image. Click "Yes".
- Click "Preview" to check if you can see the preview image. (You choose one manually from the menu which comes when you click "Choose Picture for Preview" button.
- Click "Back" to go to the main menu.
- Click "Temporal". Click "Dates" and enter date interval for images to be analyzed if you have any. Click "Back". Click "Time of the day" and enter time of the day interval for images to be analyzed if you have any. Click "Main menu" to go to the main menu.
- Click "Masking/ROIs". Click "Display preview with polygons".
- Click "Pick points" and click on the image to create a polygon. If you have multiple polygons, navigate through the menu to set it up accordingly. When you are finished with masking, click "Back".
- Click "Analyses" from the main menu. Choose the algorithm/analysis you want to run from the menu and choose your parameters. Create and set up multiple analyses if you need to. Click "Back".
- (Optional, but advised) From the menubar, click "Setup" -> "Save". Choose a directory and enter a filename to save your setup (setup is the analysis options, your camera network is created permanently already.). If the program crashes or if you just want to, you can load this file next time instead of setting up the options again.
- Click "Run All" from the main menu.
- (Optional) Follow what is going on from the terminal and/or log pane.
- When the analysis is complete "Results" menu will show your results. Also a post processing report will be opened in your default browser if you click "Yes" to the question about it.

Background

Main Terminology

ROI (Region of interest): A portion of an image (selection of pixels) that is being analyzed.

Polygonic Mask Coordinates: Coordinates of the polygons which are used to select ROIs.

Camera network: A system of one or more cameras producing time series images.

CNIF (Camera network information file): A file that has information about one or multiple cameras. The information includes the parameters for the FMIPROT to download/read images of the cameras. Each camera network has to have a CNIF to be added to FMIPROT.

Online CNIF: A CNIF in an online location, e.g. an FTP server directory or webpage.

Single directory (for camera networks): A local directory that has time series images from a camera.

Filename convention: A convention of the naming of filenames to indicate information changing for each file. For FMIPROT, the files are the images from the cameras and the information is the time of the image taken.

Quantity report: Analysis of number of images existing for each day for cameras.

Preview picture (or picture for preview): The image that is shown in the GUI to see the camera view when selecting cameras and ROIs.

Local images directory: The directory which the images downloaded from online cameras/camera networks will be stored in.

Results directory: The default directory for the directories to be written and read which results of the analyses to be stored in.

Plugin: A program coded independently by the users to analyze images by using the features of FMIPROT.

Analysis: The collection of the selection of the algorithm and the algorithm options to be run.

Scenario: The collection of the *Analyses* and the set of all other options (camera selection, temporal filtering, ROI selection etc.) for the analyses to be run accordingly.

Setup: The collection of multiple *Scenarios*.

Setup report: A report in HTML format that includes all the options for all the scenarios in a setup. The report also includes results of the analyses if it is created at the end of analyses (automatically).

Camera Networks

Camera networks are the systems that include one or more cameras, an environment to store the images from the camera(s) and the communication protocol of this environment. For example, two cameras uploading images periodically to an FTP server or a directory of series of images in a computer that are obtained from a camera or an archive of images from cameras that are accessible in a website (over HTTP) are camera networks.

To use a camera network in FMIPROT a camera network information file (CNIF) is needed. This file bears the information to get the images from the camera network. This information includes camera names, host addresses, paths to the images, file name conventions etc. CNIFs can be created automatically with the camera network manager or single directory wizard of FMIPROT (see interface section) or manually using the file structure information (see next section). CNIFs can be stored in the local computer, on a website (HTTP/HTTPS) or in an FTP server and this choice does not have be the same as the communication protocol of the image archive host.

Camera network information file structure

CNIFs are text files with extension of ".ini". The lines starting with '#' are comment lines and they are discarded. The lines starting with '!' are the headers for the information in following lines until another header line is present. Lines that do not start with those two characters carry the information according to the header above them.

Each line has values divided by tabs (\t) for both header lines and the normal lines. These values in header lines are the keys for the following lines and the values in normal lines are the values for those keys. The values in the entry lines can have different types. If the value is inside single quotation marks, ('value') the type is string. If it has a dot inside (23.5) the type is float. If the value is inside brackets and divided by commas ([value1,'value2',]) it is a list of values. Otherwise the type is integer. The values in lists can also be string, float or integer.

The keys used for CNIFs are seen below:

name	Camera Name
network	Camera Network (used only in older versions older than 0.15.0)
protocol	Communication protocol for the host
host	Host address for the images
username	Username for the host
password	Password for the host
path	Path of the images on the host
filenameformat	File name convention of the images
Timezone	Time zone offset from UTC (Metadata)
channels	Channels (Metadata)
firstimagetime	Time of the earliest image (Metadata)
lastimagetime	Time of the latest image produced (Metadata)
sharedsources	Other image sources that produces image including any shared location (Metadata)
numberofimages	Number of total images (Metadata)
devicetype	Device type (Metadata)
devicestate	State of the device (if new images are taken) (Metadata)
previewimagetime	Time of the image to be used as preview image (Metadata)

Important points about the keys and values:

Username and password for the host

If the username and/or the password is '*', it means that FMIPROT will ask for the username and/or the password when the program is connecting to the host for the first time in each program run. If the username and/or the password is entered correctly, it will be used until the program is restarted. This option is due to security since these values are stored in CNIFs. By using '*', usernames and/or the passwords will not be saved anywhere.

File name convention of the images

File name convention is how the files are named according to the time of the image. For example, if the file name convention is 'researchsite_1_north_%Y_%m_%d_%H:%M:%S.jpg' and an image is named as 'researchsite_1_north_2016_09_24_18:27:05.jpg', then the time that the image taken is 24 September 2016 18:27:05. Do not forget to include the extension (e.g. '.jpg', '.png'). The meanings of time directives are as in the table below:

Time directives (https://docs.python.org/2/library/datetime.html#strftime-strptime-behavior)

Directive	Meaning	Example	Notes
%a	Weekday as locale's abbreviated name.	Sun, Mon, ..., Sat (en_US); So, Mo, ..., Sa (de_DE)	(1)
%A	Weekday as locale's full name.	Sunday, Monday, ..., Saturday (en_US); Sonntag, Montag, ..., Samstag (de_DE)	(1)
%w	Weekday as a decimal number, where 0 is Sunday and 6 is Saturday.	0, 1, ..., 6	
%d	Day of the month as a zero-padded decimal number.	01, 02, ..., 31	
%b	Month as locale's abbreviated name.	Jan, Feb, ..., Dec (en_US); Jan, Feb, ..., Dez (de_DE)	(1)
%B	Month as locale's full name.	January, February, ..., December (en_US); Januar, Februar, ..., Dezember (de_DE)	(1)
%m	Month as a zero-padded decimal number.	01, 02, ..., 12	
%y	Year without century as a zero-padded decimal number.	00, 01, ..., 99	
%Y	Year with century as a decimal number.	1970, 1988, 2001, 2013	
%H	Hour (24-hour clock) as a zero-padded decimal number.	00, 01, ..., 23	
%I	Hour (12-hour clock) as a zero-padded decimal number.	01, 02, ..., 12	
%p	Locale's equivalent of either AM or PM.	AM, PM (en_US); am, pm (de_DE)	(1), (2)
%M	Minute as a zero-padded decimal number.	00, 01, ..., 59	
%S	Second as a zero-padded decimal number.	00, 01, ..., 59	(3)
%f	Microsecond as a decimal number, zero-padded on the left.	000000, 000001, ..., 999999	(4)
%z	UTC offset in the form +HHMM or -HHMM (empty string if the the object is naive).	(empty), +0000, -0400, +1030	(5)
%Z	Time zone name (empty string if the object is naive).	(empty), UTC, EST, CST	
%j	Day of the year as a zero-padded decimal number.	001, 002, ..., 366	
%U	Week number of the year (Sunday as the first day of the week) as a zero padded decimal number. All days in a new year preceding the first Sunday are considered to be in week 0.	00, 01, ..., 53	(6)
%W	Week number of the year (Monday as the first day of the week) as a decimal number. All days in a new year preceding the first Monday are considered to be in week 0.	00, 01, ..., 53	(6)
%c	Locale's appropriate date and time representation.	Tue Aug 16 21:30:00 1988 (en_US); Di 16 Aug 21:30:00 1988 (de_DE)	(1)
%x	Locale's appropriate date representation.	08/16/88 (None); 08/16/1988 (en_US); 16.08.1988 (de_DE)	(1)
%X	Locale's appropriate time representation.	21:30:00 (en_US);	(1)

Directive	Meaning	Example	Notes
		21:30:00 (de_DE)	
%%	A literal '%' character.	%	

Keys with time information

The format for the keys with time information (e.g. time of the last image taken) is as %Y%m%d_%H%M%S (e.g. 20160621_120000 for 21.06.2016 12:00:00).

Time zone offset from UTC

Format is as "<sign>HHMM", e.g. "+0000", "+0200", "-0500", "-0630". This key is metadata, thus it is not compulsory, but if it is supplied, by enabling "Time zone conversion", the time stamps from filenames in the analysis are converted to the time zone that is set up from the settings. The feature is designed to equalize the timezone of different cameras for better comparison of analysis results from multiple cameras in same time zone with different time zone settings.

Warning: If a setup file from an old version is used, and there is no metadata information in the setup file, time zone information is not used since the info from setup file is used in the analyses. To add time zone information from the camera network, user can go to camera selection menu and select the same camera again for each analysis. Camera information, including time zone information, will be updated in the setup.

Metadata

Metadata keys are not compulsory. They are only for information to be shown (for now). Thus, even the keys that are not in the list above can be used. They will be shown in metadata in the interface with key names.

Metadata input to CNIFs can be done manually at the moment. Metadata input from camera network manager in the interface will be in the incoming versions of FMIPROT.

An example from MONIMET Camera Network

For example, the header and one line from MONIMET CNIF (see next section) (between two horizontal lines one line for setup file is shown):

```
!network      protocol      host    username      password        device channels      name
      path     filenameformat numberofimages devicestate     lastimagetime sharedsources
'MONIMET'    'FTP'   'litdb.fmi.fi' 'monimet_user' '*'      'camera'        'red','green','blue'
        'Kenttarova Spruce Canopy'    'cameras/kenttarova_spruce/canopy'
        'ken_spr_canopy_%Y%m%d_%H%M%S.jpg'  '13592''ON'    '20160621_120000'
```

First line is the header for the cameras. In the second line a camera is seen. The parameters of the camera are:

Camera Name: Kenttarova Spruce Canopy
Camera Network: MONIMET
Host address for the images: litdb.fmi.fi
Communication protocol for the host: FTP
Username for the host: monimet_user
Password for the host: * (see keys above)
Path of the images on the host: cameras/kenttarova_spruce/canopy
File name convention of the images: ken_spr_canopy_%Y%m%d_%H%M%S.jpg (see keys above)
Time of the latest image produced: 21.06.2016 12:00:00
Number of total images (Metadata): 13592
Device type (Metadata): Camera
Channels (Metadata): red, green and blue
State of the device (if new images are taken): Online

MONIMET Camera Network

The MONIMET Camera Network which consists of 28 cameras (26 operating) producing 30 image series from 14 different locations in Finland (Peltoniemi et al., 2017) (http://monimet.fmi.fi?page=Cameras). The CNIF of MONIMET Camera Network is located at http://monimet.fmi.fi/cameras/cnif.ini .This file is automatically updated each half an hour to update the metadata, which includes number of total images, times of the latest images and if the cameras are online. The file can be added to FMIPROT to add MONIMET Camera Network to it but it does not have username and password to connect to the network. An account is needed to use MONIMET camera images in this way but distribution of such accounts is not decided yet. A user can follow the MONIMET Camera Network webpage for the news about such distribution.

Currently, MONIMET Camera network images are distributed over Zenodo, under "Phenological time lapse images and data from Monimet EU Life+ project (LIFE12 ENV/FI/000409)" community (https://zenodo.org/communities/phenology_camera). User can download the images and set FMIPROT accordingly to use them from his/her local disks (See "Camera network manager" section and "Single directory wizard" section).

A portion of images from MONIMET Camera Network is already in FMIPROT by default. They are included in the camera networks as "MONIMET Demo". The network has about 5 images per day for the year 2016, from 4 cameras in located in Sodankylä.

Setup – Scenario - Analysis

The software runs on the basis of setups, which is the total of settings and conditions of multiple analyses on images from multiple cameras. A setup can be saved as a file and loaded back to the software.

A setup contains multiple scenarios. Number of the scenarios a setup file can include is virtually infinite. Each scenario in a setup contains,

- Selection of the camera and camera information from CNIF
- Temporal selection
- Polygonic Mask Coordinates
- Thresholds values for 8 different threshold options
- Multiple analyses and parameters for each analyses

Setup files gives user the ability to store their settings and conditions for analyses, to be run on a different computer and/or by another user.

Setup File Structure

To be able to use FMIPROT, that information is not needed. Only in some cases, it might be efficient for user to edit setup files manually, e.g. changing singles values for many analyses which will take too much time to edit in the software instead of replacing strings in a text editor, although it can be done from the interface.

Setup files are text files with extension of ".cfg". The lines starting with '#' are comment lines and they are discarded. The lines starting with '!' are the headers for the information in following lines until another header line is present. Lines that does not start with those two characters are carry the information according to the header above them.

Each line has values divided by tabs (\t) for both header lines and the normal lines. These values in header lines are the keys for the following lines and the values in normal lines are the values for those keys. The values in the entry lines can have different types. If the value is inside single quotation marks, ('value') the type is string. If it has a dot inside (23.5) the type is float. If the value is inside brackets and divided by commas ([value1,'value2',]) it is a list of values. Otherwise the type is integer. The values in lists can also be string, float or integer.

indicates an entry with 'name' as 'Kumpula North', 'network' as 'MONIMET', 'number' as 32, 'channels' as 'red','green' and 'blue', 'latitude' as 60.2037 and 'longitude' as \t24.9605.

There is a special value format for the normal lines. If the value is 'NE#' ,as '#' is an integer number, it indicates that this value is actually the next #th entry. For analysis parameters, that value is used.

The keys used in the setup files are below:

source	The camera used in the scenario. Value of this key is given as lines using NE# value. For the keys used for cameras, see "Camera network information file" section.
name	The name of the scenario or the name of the analysis. Scenario names are appointed automatically (for now).
temporal	The list of the temporal selection.
thresholds	The list of the thresholds.
polygonicmask	The list of the lists of the coordinates of the polygons.
analyses	The list of analyses. Analyses names are appointed automatically.
analysis-#	Parameters for the analysis number #. Value of this key is given as lines using NE# value. Keys used in analysis parameters are 'id', 'name' and the parameters from

	the analysis. They change according to the analysis and have names that are used in the interface.
id	ID of the analysis. This is appointed automatically.

For example (between two horizontal lines one line for setup file is shown, "\t" characters are tabs):

!name\tanalysis-1\tthresholds\tpolygonicmask\tsource\tanalyses\ttemporal

---

'Scenario-2'\tNE1\t0.0,1.0,0.0,1.0,0.0,1.0,0.15,1.0,0.0,254.0,0.0,254.0,0.0,254.0,0.0,1.0\tNE2\tNE3\t'analysis-1'\t'01.09.2015','31.08.2016','10:15','14:15'

!Exclude burned pixels\tname\tGreen Excess Index\tRed Fraction\tGreen Fraction\tid\tGreen-Red Vegetation Index
'1'\t'Vegetation Indices'\t'1'\t'0'\t'0'\t'PHENO000'\t'1'

!1\t0
0.1208,0.1569,0.2333,0.15,0.3698,0.1583,0.4688,0.2264,0.3625,0.2556,0.2396,0.2319,0.1479,0.2181\t0.9938,0.2056,0.9917,0.275,0.5115,0.2458,0.5104,0.1792

!username\tnetworkid\tprotocol\tchannels\thost\tdevice\tpath\tpassword\tdevicestate\tname\tnetwork\tlastimagetime\tfilenameformat\tnumberofimages

---

'monimet_user'\t'1'\t'FTP'\t'red','green','blue'\t'litdb.fmi.fi'\t'camera'\t'cameras/kenttarova_spruce/canopy'\t'*'\t'ON'\t'Kenttarova   Spruce Canopy'\t'MONIMET'\t'20160621_120000'\t'ken_spr_canopy_%Y%m%d_%H%M%S.jpg'\t'13592'

The lines above indicates a setup. First line is headers of the setup for scenario(s). In the second line a scenario is seen. The parameters of the scenario are:

Name of the scenario: Scenario-1

Parameters of Analysis 1: NE1, meaning next 1st entry. (see below)

Thresholds: 0.0,1.0,0.0,1.0,0.0,1.0,0.15,1.0,0.0,254.0,0.0,254.0,0.0,254.0,0.0,1.0 (See thresholds section)

Polygon coordinates for the mask: NE2, meaning next 2nd entry. (see below)

Camera parameters: NE3, meaning next 3rd entry. (see below)

Temporal selection: 01.09.2015, 31.08.2016, 10:15, 14:15

Third line indicated the keys are changed for the following lines. Next line indicates an entry with the parameters below:

Exclude burned pixels: 1

Name: Vegetation Indices

Green Excess Index: 1

Red Fraction: 0

Green Fraction: 0

Id: PHENO000

Green-Red Vegetation Index: 1

Since this entry is the next 1st entry after a NE# value, it is actually NE1, which is "Parameters of Analysis 1".

Fifth line indicated the keys are changed for the following lines. Next line indicates an entry with the parameters below:

0: 0.1208,0.1569,0.2333,0.15,0.3698,0.1583,0.4688,0.2264,0.3625,0.2556,0.2396,0.2319,0.1479,0.2181

1: 0.9938,0.2056,0.9917,0.275,0.5115,0.2458,0.5104,0.1792

Since this entry is the next 2nd entry after a NE# value, it is actually NE2, which is "Polygon coordinates for the mask". '0' is the first and '1' is the second polygon coordinates.

Seventh line indicated the keys are changed for the following lines. Next line indicates an entry with the parameters below:

username: monimet_user

networkid: 1

protocol: FTP

channels: red, green and blue

host: monimet.fmi.fi

device: camera

path: cameras/kenttarova_spruce/canopy

password: *

devicestate: ON

name: Kenttarova Spruce Canopy

network: MONIMET

lastimagetime: 20160621_120000

filenameformat: ken_spr_canopy_%Y%m%d_%H%M%S.jpg
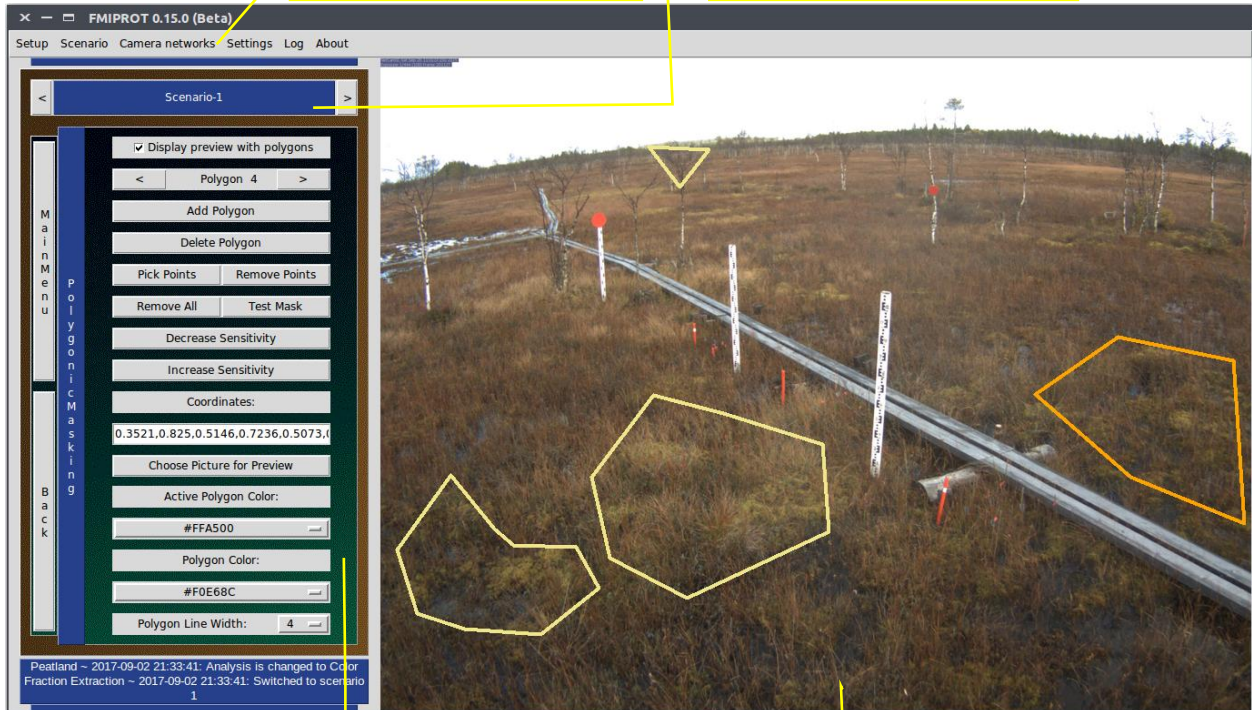
numberofimages 13592

Since this entry is the next 3rd entry after a NE# value, it is actually NE3, which is "Camera parameters". (See CNIF section for the meanings of keys)

Warning! Do not edit analysis names and IDs. That can corrupt the setup file.
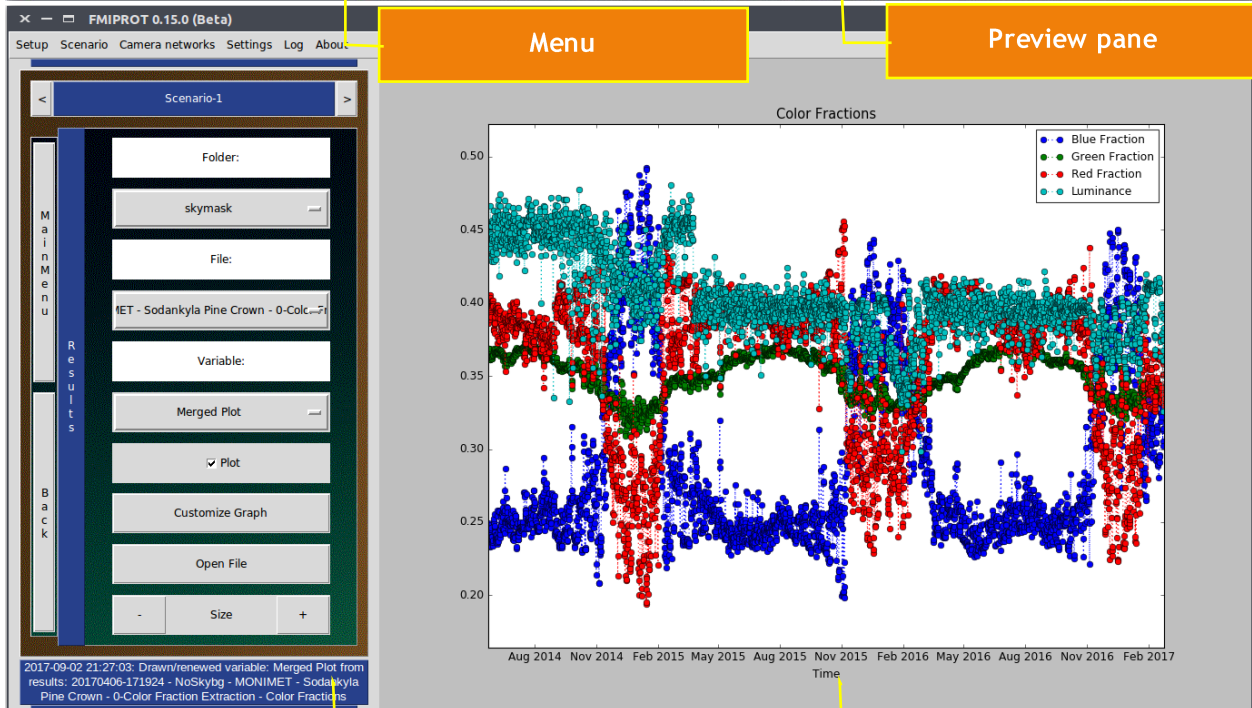
Interface

Menubar

Scenario selector

Menu

Preview pane

Log pane

Plotting page

Menu

Setup

New

Resets all the setup.

Load...

Opens a dialog to choose a setup file to be loaded.

Save

If the setup file is already on the disk, saves the changes. If it is a new setup, opens a dialog to choose the directory and file name to save the setup as a setup file.

Save As...

Opens a dialog to choose the directory and file name to save the setup as a different setup file.

Generate Report

Opens a dialog to choose the directory and the file name to generate a report of the setup in HTML format.

Run all scenarios...

Runs all scenarios in the setup. The software may seem like not responding when it is running analyses. User can follow what is going on from the terminal/console if there is any outputs during the analyses. Saves the results and makes a copy of the setup file in the results path.

Scenario

Add New

Adds a new scenario with default values to the setup.

Delete

Deletes the current scenario from the setup.

Duplicate

Creates a scenario with the same values of the current scenario.

Duplicate without masking

Creates a scenario with the same values of the current scenario except the masking options.

Run current scenario...

Runs the current scenario in the setup. The software may seem like not responding when it is running analyses. User can follow what is going on from the log/terminal/console if there is any outputs during the analyses.

Saves the results and makes a copy of the setup file with only the current scenario in the results path.

Camera Networks

Camera network manager...

Camera network manager is the option to add, remove and edit camera networks and their cameras. When the option is clicked, "Network Manager" is invoked.

Network Manager

Network manager window lists the camera network that FMIPROT communicates with. The user can add, remove or edit camera network parameters here. These parameters include network name, communication protocol for CNIF, the host of CNIF (if applicable), username and password to the host to read CNIF (if applicable) and the path to CNIF.

Read CNIF and load cameras...
This option is used when adding a new camera network. After setting up the parameters of the network, if CNIF is already present, this button can be used to read CNIF to add the cameras to the network. The cameras can also be edited after that by using "**Set up cameras and create/update CNIF...**"

"**Save changes**" is used to save the changes made in camera networks. If the changes are saved by using that option without **Read CNIF and load cameras...** option, CNIF will be read in the next run of FMIPROT. To discard the changes done after opening the window or last time saves are changed, the user can use "**Discard changes**" option or simply close the window.

Set up cameras and create/update CNIF...
Opens "**Edit Sources**" window. Parameters of cameras in a camera network are set up here. The parameters includes the communication protocol, host of the archive (if applicable), the username and the password to the host, the path to the images and the file name convention of the images. These parameters are explained in "Camera Networks" section.

To save changes, "**Save changes**" in "**Edit Sources**" window option is used. If the communication protocol of the camera network is 'LOCAL* (i.e. CNIF is in the local computer) the CNIF is updated. If not, program exports a CNIF file so that the user can update the one in the FTP or HTTP server with that one. User should notice that it may take some time to read the updated file over HTTP since most platforms cache files for some time over HTTP. To discard the changes done after opening the window or last time saves are changed, the user can use "**Discard changes**" option or simply close the window.

"**?**" Buttons near the parameters can also be used for help through the network manager.

Add camera network from an online CNIF...

This wizard helps user to add a camera network by using a CNIF in an online location, such as a website or FTP server. Dialog will ask a name for the camera network, the link to CNIF, username and password for the host. Link to the CNIFs should be entered in a complete format, e.g.
"http://mycameranetwork.com/files/nfile.ini" or
"ftp://ftp.mycompany.com/files/mycamnetcnif.ini".

Single directory wizard...

This wizard helps the user to add or remove a directory of images to or from the toolbox. In such case, it is much easier to use the wizard instead of setting up a network in the network manager. The wizard asks input from the user one by one to complete the task. At the end, the directory is saved as a camera/camera network, and it is ready for analyses.

Quantity Report

Starts analyzing the images in the camera networks according to the selection to have quantified results for the status of the images for every camera in every camera network. The selection includes cameras individually and a common temporal selection. It creates two different results for each camera: Number of pictures for each day and number of pictures for each 30 minutes, starting from 00:15 of the earliest date. It saves the results under "diagnosis" directory. User needs to load this results from under results menu to see them on plots. This process may take a lot of time depending on the number of images and connection speed.

Download Images

Downloads images from the cameras in the camera networks according to the selection. The selection includes cameras individually and a common temporal selection. This process may take a lot of time depending on the number of images and connection speed.

Tools

Add Plugin...

Opens a wizard to add a plugin to FMIPROT. The wizard asks user to select the compiled binary file of the plugin (See "Plugins" section) and some other options to add it to the program.

Remove Plugin...

Opens a wizard to remove a plugin from FMIPROT. It does not only removes the plugin from the algorithm list, but also removes files from the plugin directory. (See "Plugins" section)

Settings

Storage Settings...

Images
The software downloads images from the FTP archive to a local directory. For analyses, software reads the images from this directory. If required images are already in that directory (downloaded before by another or same scenario), the software does not download them again, saving time for the user. This directory is a common directory for all cameras, which software creates subdirectories for each camera. User can select the directory for the camera images to be downloaded here. By default, this directory is "images", under the directory user has installed the software.
Use "**Browse...**" button to set up the directory.
Results
Shows the directory which the results of the analyses will be saved under.
Use "**Browse...**" button to set up the directory.

User "**Save**" button to make the settings permanent, "**Cancel**" to cancel the modifications and "**Defaults**" to load default settings.

Proxy Settings...

Opens the proxy settings menu. Fields should be left blank to disable proxies. "Save" button should be used to make the proxy settings active and make permanent.

If your proxy uses different ports than defaults, include it to address followed by a colon. Example: "proxygate.mycompany.com:81".

Connection Settings...

Opens the connection settings menu.

Check and Download new images from the camera network server option enables/disables downloading images from the FTP server. If disabled, software will not download any images, so it will use only the images in the local images directory.

User passive mode for FTP connections toggles between passive and active mode for FTP connections.

Number of FTP connections for download (1-10): Enables multiple connections (by threading) to FTP servers when downloading images. Greatly increases download speed, but some servers may not accept too many connections at once. Number of connections can be set up to 10.

Processing Settings...

Opens the processing settings menu.

Time zone (UTC Offset) and Convert time zone of timestamps: Sets up the time zone which the timestamps of the images will be converted to, if filenames or CNIF metadata contains time zone information. Result files will include the time zone information if the feature is used.

Export Settings...

Opens a dialogue to select a file path to export settings to a file.

Import Settings...

Opens a dialogue to select a file to import settings from.

Help

FMIPROT on web...

Opens FMIPROT webpage with the default browser.

Open user manual...

Opens user manual with the default PDF viewer.

Open Log

The software keeps a log while running. When the program is run, log is visible near the main window. To open it again, use this option. Entries for the log also can be seen in the console/terminal window.

Open Log File

Opens the current log file with the default application.

About...

Opens the about dialog.

Licence agreement...

Opens license agreement.

MONIMET Project...

Opens MONIMET Website with the default browser.

Scenario selection

Navigates between scenarios by the down and up arrow buttons.
Between the arrow buttons, scenario name can be edited. Scenario name should not be as same as any other scenario in the current setup. If that happens, GUI will warn the user and request a different name.

Camera

Camera Selection

Lists the cameras in the camera network. Selected camera is used in the analyses.

Preview

Enables or disables the preview of the camera images, which a picture taken by the camera is shown at the right of the software window.

Choose Picture for Preview

Opens the menu to change the picture to be shown for the preview.

Picture selection

Lists the available (downloaded) images for the camera to be selected for the preview. User can double click on the image names to switch to the pictures.

Filter by keywords

Filters the list of the available (downloaded) images for the camera to be selected for the preview. Keywords separated by spaces will be used in the filtering with "OR" logic. E.g. if the user is using the string "2015 05", any image name containing "2015" or "05" will be shown in the list.

Download pictures from FTP

Opens a dialog to select date and time of day intervals to download images for the current camera so that user can choose those pictures from the camera for the preview.

Open local image directory

Open the local image directory for the camera. The local directory is where the images are downloaded if camera network communication protocol is HTTP or FTP and the local directory of the camera network if protocol is local. This option can be used to merge the images the user has/downloaded beforehand with the new ones easily.

Camera metadata…

Lists metadata of the camera (not the images) if it exists in CNIF. Metadata can includes information such as time of the first image taken", time of the last image taken, if the camera is taking new images etc.

Temporal

Temporal selection:

User can select the mode to determine the temporal selection of the images:

All: Use all images available for the analyses. (If "Check and Download new images from the camera network server" is enabled, it will download all the images (of the selected camera) in the server.)

Date and time intervals: Images will be filtered according to the start and the end of selected dates and time of the days.

Earliest date and time intervals: Images will be filtered according to the start of selected dates and the start and the end of time of the days.

Latest date and time intervals: Images will be filtered according to the end of selected dates and the start and the end of time of the days.

Yesterday only: Only images from yesterday (according to the user's computer's date) will be used.

Today only: Only images from today (according to the user's computer's date) will be used.

Latest 1 hour only: Only the latest image and the images taken not older than 1 hour from the latest image will be used.

Latest image only: Only the latest image will be used.

Dates

Opens the menu for the selection of the dates of the pictures to be used in analyses. Format for the dates in this menu is as "dd.mm.yyyy".

This menu is available only for Temporal selection modes: Date and time intervals, Earliest date and time intervals and Latest date and time intervals.

Time of the day

Opens the menu for the selection of the time of day of the pictures to be used in analyses. Format for the timestamps in this menu is as "hh:mm" (24H).

This menu is available only for Temporal selection modes: Date and time intervals, Earliest date and time intervals and Latest date and time intervals.

Thresholds

User can set up thresholds to filter images and/or pixels in the images. There are three different groups for thresholds.

Image Thresholds

Thresholds for the values that are calculated on the images, without the masking.

Brightness

Opens the menu to set up maximum and minimum levels of the brightness of the images on the scale of 0 to 1. Brightness is calculated as the average of all pixel values of every channel, normalized to 1.

Luminance

Opens the menu to set up maximum and minimum levels of the luminance of the images on the scale of 0 to 1. Luminance is calculated as the average of the value calculated as below for all pixels:
Luminance= 0.2989 Red + 0.5870 Green + 0.1140 Blue

ROI Thresholds

Thresholds for the values that are calculated on the region of interest.

Red Fraction

Opens the menu to set up maximum and minimum levels of the average red fraction value of the masked area of the images on the scale of 0 to 1. Red fraction is calculated as below:
Red Fraction = Red / (Red + Green + Blue)

Green Fraction

Opens the menu to set up maximum and minimum levels of the average green fraction value of the masked area of the images on the scale of 0 to 1. Green fraction is calculated as below:
Green Fraction = Green / (Red + Green + Blue)

Blue Fraction

Opens the menu to set up maximum and minimum levels of the average blue fraction value of the masked area of the images on the scale of 0 to 1. Blue fraction is calculated as below:
Blue Fraction = Blue / (Red + Green + Blue)

Pixel Thresholds

Thresholds for the pixels to be excluded from the images.

Red Channel

Opens the menu to set up maximum and minimum levels of the red channel value of the pixels in the images.

Green Channel

Opens the menu to set up maximum and minimum levels of the green channel value of pixels in the images.

Blue Channel

Opens the menu to set up maximum and minimum levels of the blue channel value of the pixels in the images.

Masking/ROIs

User may set up the mask to be used on the images in that menu. At the moment there is only polygonic masking, i.e. a polygon or union of multiple polygons is used in masking.

Analyses will be run for each polygon as different ROIs and also for the whole selected area (union of the polygons) by default. To analyze only for the whole ROI, "Run analyses also for each polygon (ROI) separately" option can be disabled.

Display preview with polygons

Toggles between displaying and not displaying the preview picture with polygons on it.

Polygon Selector

Navigate between polygons.

Add Polygon

Add a new polygon the mask.

Delete Polygon

Delete current polygon from the mask.

Copy polygons from other scenarios…

Opens a dialog to copy polygons from other scenarios in the current setup or from scenarios in setup files in the disk.

Run analyses also for each polygon (ROI) separately

Enables running the analyses also for each polygon separately as different ROIs.

Pick Points

Changes/Activates the system pointer to pick points for the selected point. By default picking points is deactivated. User must click this button first to pick points on the image.

Remove Points

Changes/Activates the system pointer to remove the closest point to the clicked location on the image. By default picking points is deactivated. User must click this button first to remove points on the image.

Remove All

Removes all points for the current polygon.

Test Mask

(Un)Applies the mask to the image on the preview pane to see if the mask is selected as desired.

Sensitivity +

Decreases the sensitivity of the masking by decreasing the resolution of the preview image. As the image is getting smaller, the error between the selected pixel and desired pixel increases. By default, the preview picture is resized as 640x480 pixels.

Sensitivity –

Increases the sensitivity of the masking by increasing the resolution of the preview image. As the image is getting larger, the error between the selected pixel and desired pixel decreases. By default, the preview picture is resized as 640x480 pixels.

Coordinates

Lists the coordinates of the points on the polygons of the mask as an entry. The coordinates are given as the fraction of the image height and width instead of pixel numbers (e.g. coordinate (0.25, 0.2) corresponds to (160, 96) for an image that has a size of (640,480)). User can control the locations of the pixels from the list.

Choose Picture for Preview

Opens the menu to change the picture to be shown for the preview.

Picture selection

Lists the available (downloaded) images for the camera to be selected for the preview. User can double click on the image names to switch to the pictures.

Filter by keywords

Filters the list of the available (downloaded) images for the camera to be selected for the preview. Keywords separated by spaces will be used in the filtering with "OR" logic. E.g. if the user is using the string "2015 05", any image name containing "2015" or "05" will be shown in the list.

Download pictures from FTP

Opens a dialog to select date and time of day intervals to download images for the current camera so that user can choose those pictures from the camera for the preview.

Selected Polygon's Color

Sets the color of the selected polygon.

Polygon Color

Sets the color of the polygon(s) that are not selected. This color is also used in preview images in setup reports.

Polygon Line Width

Sets the width of the edges of the polygons.

Analyses

Menu to set up the analyses in the scenarios. One scenario can have multiple analyses.

Analysis Selector

Navigates between analyses in the scenario by the left and right arrow buttons.

Analysis

Sets the analysis to be run for the selected analysis number.

Analysis Definition

Shows the definition of the selected analysis.

Delete

Deletes the current analyses from the scenario.

Add New

Adds a new analysis to the scenario.

Set Parameters

Opens the menu to set the parameters of the selected analysis."?" Button on the right of each parameter opens a window that explains the parameter.

Results

Opens the menu related to options for the results to be produced by the analyses. Options in this menu are not stored in setup files. Also, they are not remembered on the next run of the program. These settings are set only for the analyses to be run for the instance running.

"Where to store the analysis results"

User can select the mode to store the analysis results in this option. By default, **"New directory in results directory"** is selected and a directory under results directory is (to be) created. Name of the directory is created using the time of the computer, so that there is no conflict with other runs.

"Existing empty directory" lets the user to store the results elsewhere. An empty directory should be selected after choosing option.

"Merge with existing directory" is a more special option where a directory with results already produced is selected by the user. Results in the selected directory should be produced using the exact same setup (with current one loaded in the program) before. The program will automatically test that and direct the user accordingly. This option allows the user to run setups or scenarios without analyzing the images that are already analyzed before with the same setup or scenario. For example, after a scenario has analyzed all the images for a camera, a few days have passed and there are new images produced in the camera directory/server. When this mode is used, old results will be read from the directory and only the images that are taken after the analysis will be analyzed and merged with the old results. Such situation would save a lot of time considering that there would be lots of images to be analyzed again.

"Directory to be stored in" shows or lets the user choose the directory which the results of –to be done- analyses will be stored in, according to the chosen mode. If **"Existing empty directory"** or **"Merge with existing directory"** is selected, **"Browse…"** button can be used to reselect the directory.

"Generate setup report with analysis results" option enables/disables the generation of setup reports where the setup options and the results of the analyses with the links to open/download the CSV result files in HTML format.

Run All

Runs all the scenarios.

Result Viewer

Menu to select results and preview them.

Directory

Lists the directorys under the results directory and the directory itself. User can select a directory to list the files under it.

By default, each time running a scenario(s), a directory as "yyyymmdd_hhmmss" is created under the "results directory", the timestamp showing the time that the program is run, running scenario(s) is (are) completed or the temporal selection mode is changed. The results directory can be set up in "Settings > Storage Settings" menu.

"(Choose) Custom directory" option lets user to select a directory anywhere is the local disks to be loaded to the results viewer.

File

When a directory is selected, the result files under the directory will be listed here. User can select a file to list the variables inside the file.

Variable

If there is any variables to be shown in selected results, they will be listed in this menu. Upon selection of the variable, the values will be loaded to be plotted.

Plot

Enables/Disables the plotting of the loaded values of variables selected from the menu above. Upon enabling the plotting, the software window will be expanded to the right (additional 480 pixels by default) to plot the results.

Customize Graph

Opens the menu to customize the plot of the selected variable(s). This menu is enabled only if the plotting is enabled.

Legend/Color bar

Enables/Disables the legend or color bar of the plot.

Variables

Opens the menu to select which of the variables to be drawn on the plot. This menu is visible for only plotting the "Merged Plot" for single dimension results.

Extent

Opens the menu to set the extent of the plot.

X Axis Start

Sets the start value of X Axis. Returns to default if the value is out of bounds.
The format for

X Axis End

Sets the end value of X Axis. Returns to default if the value is out of bounds.

Y Axis Start

Sets the start value of Y Axis. Returns to default if the value is out of bounds.

Y Axis End

Sets the end value of Y Axis. Returns to default if the value is out of bounds.

Axes

Has options to toggle axes for logarithmic scale and inversion.

Defaults

Sets the extent to default values.

Style

Opens the menu to change the style of the plot.

Line

Sets the line format of the plot for single dimension results. This menu is available only for single dimension results.

Marker

Sets the marker shape of the plot for single dimension results. This menu is available only for single dimension results.

Color

Sets the color of the line on the plot for single dimension results. This menu is available only for single variable plots of single dimension results.

Color Maps (Sequential, Diverging, Qualitative, miscellaneous)

Sets the color map of the plot. This menu is available only for multi dimension results.

Save Plot as PNG Image

Opens a dialog to select directory and file name to save the plot as a PNG format image.

Open File

Opens the file for the selected results with the default application.

Size

Changes the size for the plots.

Log Bar

Shows the last event happened.

Plugins

The software supports analyses developed by other people. User can code a certain algorithm in any language that can be compiled to binary files, and then add it to the analyses in the software. The user-compiled binary file, which is programmed to analyze one image, is called by the program for each image during the analyses. When the program is calling the plugin, full path to the image file and full path to the mask file is passed as arguments like in the example:

```
$ ./plugin /home/john/FMIPROT/images/image_001.jpg /home/john/FMIPROT/tmp/pluginmask.jpg
C:> plugin.exe C:\users\john\FMIPROT\images\mage_001.jpg C:\users\john\FMIPROT\tmp\pluginmask.jpg
```

The user should code the plugin so that it reads the input image and the masking image to do the desired calculation. The result is then read by FMIPROT from the standard output as produced by the plugin. The output should include the name for the analysis or result, and then names and values of each parameter, all separated by commas, like in the example:

```
Color fraction indices,Red Fraction,0.342,Green Fraction,0.432,Blue Fraction,0.226
```

A plugin can be added to FMIPROT by using "Add plugin..." option under "Tools" menu. The wizard will guide the user through the process. It will test the plugin first by a random image and mask to see if it produces an output in the correct format. If it passes the test, it will copy the plugin file (and other files if it is chosen by the user during the process) to the plugins directory.
The user also should consider the following:
- Format and the file extension of the masking image is always as same the original image. If the camera image is JPG (.jpg), then also masking image is the same.
- Masking image does not have only one dimension; it has same dimensions (3 x height x width) as the image file, for each image. If the resolution changes, the masking image also changes.
- Masking image has pixel value 255 for unmasked pixels and 0 for masked pixels.

The plugin system is kept simple by analyzing one image per time with the plugin so that it is usable even for beginner coders. As a start, following example in python language can be used.

```python
import mahotas as mh              #import image handling/processing library
import numpy                      #import numerical library
from os import sys                #import sys for reading arguments

imgf = sys.argv[1]                #get file path of image file
maskf = sys.argv[2]               #get file path of masking image file

img = mh.imread(imgf)             #read image
mask = mh.imread(maskf)==255      #read mask and convert it to Boolean

(r,g,b) = (img*mask).transpose(2,0,1)   #mask the image, transpose and handle channels
r = r.astype(int)                 #convert arrays (uint8) to
g = g.astype(int)                 # int not to overflow
b = b.astype(int)                 # in operations
rs = numpy.sum(r)                 #calculate sums of channels
gs = numpy.sum(g)
bs = numpy.sum(b)
tot = (rs + gs + bs).astype('float64')  #calculate sums of all channels
r = rs / tot                      #calculate averages
g = gs / tot
b = bs / tot
#construct and print output
print 'Color fraction indices,Red Fraction,'+str(r)+',Green Fraction,'+str(g)
```

Algorithms

Color Fraction Extraction

Ratio of a color index is the ratio of the sum (or mean) of the indices of that color in a selected area to the sum (or mean) of all color indices in that area in an image. Below are the formulas for red fraction (RF), green fraction (GF), blue fraction (BF), brightness (W) and luminance (L) where R, G and B are reflectance values for red, green and blue channels. Brightness and luminance are normalized to 1.

$$RF = R / (R + G + B)$$

$$GF = G / (R + G + B)$$

$$BF = B / (R + G + B)$$

$$W = (R + G + B) / 3$$

$$L = 0.2989R + 0.5870G + 0.1140B$$

"Exclude burned pixels" option excludes the pixels which value of any channel is 255 from the analysis. The analysis also calculates statistical information (mean, median and standard deviation) in the ROI for each channel if selected.

Vegetation Indices

Includes some indices that are used in vegetation phenology.
Red fraction and green fraction are explained in the previous section.
Green-Red Vegetation index is calculated as in the formula below. (Mizunuma et.al., 2011)

$$GRVI = (G - R) / (G + R)$$

Green excess index is using the difference between both green-red and green-blue. The formula for GEI is given in equation 4.6., where R, G and B are reflectance values for red, green and blue channels. It should be noted that GEI can have values between 512 and -512. (Mizunuma et.al., 2011)

$$GEI = 2G - (R+B)$$

"Exclude burned pixels" option excludes the pixels which value of any channel is 255 from the analysis.

Custom Color Index

The algorithm calculates an index from a mathematical formula entered by the user using average values of red, green and blue channels in ROIs. The formula supports sums, differences, multiplication, and division and operation priority by using parentheses.

The formula to be calculated should be set in "Set parameters" menu. When constructing the formula, only numbers, "." for decimal numbers, letters R, G, B for average values of colors and characters "(", ")", "+", "-", "*" and "/" for operations should be used, like in the examples:

$$(G - R)/(G + R)$$

$$2*G-R-B$$

$$(B-R)/(R+G+B)$$

$$(0.28*G + 0.5*R + 0.22*B) / (0.33333*G + 0.33333*R + 0.33334*B)$$

If values go too high during mid-steps, incorrect results will occur. 64-bit integer data types are used if there is no division in the operation and 64 bit floating point data types are used if there is a division. Color averages are taken by summing all the pixels. (Unless the formula requires multiplication of two or more colors with each other, there should not be a problem.

Results

Previewing results

The results can be previewed in the "Results" menu as explained in the "Usage" section.

Format

Results are produced as one file for data and one file for metadata for each output of every analysis in the setup. Data files have the extention ".dat" and metadata files have the extension ".ini". Additionally, a comma separated values (CSV) file and a post processing report is generated.

The report is in HTML format and it includes the setup which is run and interactive plots of the results (only one scenario results are included is only one scenario is run) for a more detailed preview.

Data files (.dat)

Data files are tab ("\t") seperated text files that each column corresponds to a variable. The first line of the file is reserved for the data indices as 'var1', 'var2', 'var3' etc. The first column can be any type of data (time,date,integer,float), although the builtin analyses only provide time series at the moment, thus, the first column is always time for the analyses. "Quantity report" also produces results in the same format, also in the date format for the first column.

Metadata files (.ini)

Metadata files are also tab ("\t") seperated text files that has a similar format as setup files. They contain information about the resulting data in the data file with the same name and about the analysis which have produced the results.
The columns named as 'var1', 'var2', 'var3' etc. corresponds to the names of the variables in the data file. Other columns indicate the scenario name (e.g. Backyard-1), the analysis name (e.g. Color Fraction Extraction), the camera network name (e.g. Home), the camera name (e.g. Backyard) and the title of the result (e.g. Color Fractions).

References

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Related Publications

Arslan, A. N., Tanis, C. M., Metsämäki, S., Aurela, M., Böttcher, K., Linkosalmi, M. and Peltoniemi, M.: Automated Webcam Monitoring of Fractional Snow Cover in Northern Boreal Conditions., Geosciences, 7, 55, 2017. http://dx.doi.org/10.3390/geosciences7030055

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