Hyperspectral Imaging Read Me
Version 2.2

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Contents

1 ScannerGUI

1.1 Introduction and Installation

The ScannerGUI software is for acquiring images by the hyperspectral reflectance imaging device, to acquire sets of images necessary for analysis of pigment spectra. It is installed primarily by the "scannerGUI.mlappinstall" file found within the Hyperspectral Imaging Folder, adding the app to the Matlab software, such that it can be opened solely by clicking the app in the app toolbar, without regard to the MATLAB working directory, and needing no external files. On the other hand, it is noted that the package comes with all files needed to add to or modify the software.

1.2 Connecting

After the camera and filters are plugged in to the computer securely, within the connect section of the software, the connect button can be pressed, and should immediately open up a camera preview window as it connects, as well as a message of success. If this does not occur, it is due to a connection error, such that the solution is to click the disconnect button, click through any error messages that appear, and then click the port error button within the advanced settings, after which it can be reconnected normally. After all images are acquired, it can be disconnected fairly easily by pressing the disconnect button within the same section as the connect button, after which the preview window should close automatically, and software itself can be closed.

1.3 Settings

Prior to acquiring images, the device must be set to the correct parameters. The manual constant settings box within the advanced can be clicked to take all images by the gain and exposure setting parameters within the device settings box, rather than use the preset gain and exposure function. As a result, the device settings box can be used to change the constant gain and exposure values, as well as the gain, exposure, and wavelength values for a single image taken. The averaging factor value within the series capture box determines how many sets of images of each type are taken for averaging the pixel values, while the wavelength step within the same box determines the amount of change in wavelength between each image taken. The approximate button within the device settings box uses the wavelength inputted into said box, along with the preset gain and exposure curves, to set the camera to the cooresponding preset gain and exposure values.

1.4 Acquiring Images

The single image button within the series capture box takes a single image of the parameters specified within the device settings, used in case of image error, to take a replacement without a need for an entire new image series. For a proper acquisition scan of an object, four separate scans must be taken, each with their own button within the series capture box. The main series is a normal scan of the object with the reflectance standard (of 99% white reflectiveness to account for wavelength detection variation by the camera) in the image, while the white referense is of a white, reflective surface that encompasses the space of the object to account for lighting variation and camera pixel sensitivity. The dark reference is a scan taken without light and with the camera cap

on to account for electron noise. It is noted that the series title must be the same for all images and sets of the same object, and the gain and exposure settings must also be the same (whether by the preset functions or not) for all. While scanning, the current settings box displays the current wavelength being scanned, as well as the current gain and exposure, changing each time the camera automatically changes its settings.

1.5 File Storage

The main bar within the file storage box is the folder in which the images are stored, written only absolutely in terms of the drive, not the MATLAB working directory. The images are then saved with four different data pieces in the filename, within a PNG file, the first being the series title, the second the set type ID, the third as the wavelength in that image, the final one as the set number, starting from 1, to be averaged, with the number 0 for all those averaged/processed already. Single images are saved with five data pieces in the filename in the location given. The given series title as the first data piece, then the date, then the wavelength, then the gain, then the exposure.

2 ProcessorGUI

2.1 Introduction and Installation

The ProcessorGUI software is used to convert the acquired images into datacubes, ENVI format, and to correct them, such that it is able to graph and save the spectra for pigments at locations within the image. It is installed and packaged identically to the ScannerGUI file, with the same file formats available within the package.

2.2 Processing Images

After the series location and title is specificed within the file upload box identically to the file storage box, the wavelength step and averaging factor must be set to the same values as used when the series was acquired. After, the images must be converted to .mat data cube files, each storing a 520 by 696 by the number of images matrix, by clicking the "Convert to Cube" button within the Series Processing box. This file is then stored with three pieces of data, rather than the four for the images, consisting of the series title, the set type, and the set ID number, by the same system as used in ScannerGUI. After, the "Average Series" button can be used to average the multiple sets for each image type together by pixel, to adjust to some degree with random fluctuations and noise. After that, the binning factor must be set to some number from 0 to 3, decreasing the resolution of the image by 2 to the power of the binning factor, averaging squares of that dimension to further remove fluctuations and noise. After, the "Dark Subtract Series" button within the same box can be used to remove the electron build up in the camera by subtracting out the dark reference sets, to eliminate noise caused by that. After, the "Flat-Field Series" button can be used to account for the variation in pixel sensitivity in the camera, as well as lighting variation on the object, equalizing those factors. Finally, the "Color Correction" button within the same box can be used to account for the pixel sensitivity variation in picking up different wavelengths of light, equalizing it to produce the fully processed image. This must be done by first clicking the "Display" button within the Advanced Commands to display the reflectance standard within the

regular image, after selecting a wavelength band by the Band option in the Advanced Commands box. After this is done, the "Center X/Y" and "X/Y Radius" settings within the Graph Settings box are used to pick a region to use as the reflectance standard for the color correction using the pixel coordinate markings around the image. Lastly, after the images have been fully corrected, the data cubes can be converted to ENVI data format by the "Convert to ENVI" button within the Advanced Commands, for if using with separate ENVI software, saved with the same file name as the data cube.

2.3 Graphing Data

Similarly to how a region from the main image as the reflectance standard can be specified, a location of the band image from the first main series set can be specified. After this, it can be graphed by clicking the "Graph" button in the Graph Settings box. It can also be graphed as only a portion of the overall maximum 400-720 range by the Graph Minimum and Graph Maximum parameters in the Advanced Commands box, choosing the starting and ending bands of the graph to use. After graphing, the "Save" button within the Graph Settings box can save the graph image as .tif file with five pieces of information in the filename, the series title, the X/Y Center, and the X/Y radius that was graphed. By clicking the "Original Series Graph" box in the Advanced Commands box, it will graph the dark subtracted main series instead, while checking the "Flat-Field Graph" box in the Advanced Commands box will graph the flat-fielded main series instead.

3 Version Changes

3.1 From Version 1 to Version 2

The dark reference subtraction was separated from the flat-fielding, and the flat-fielding formula was corrected. In addition, the color correction and binning processing techniques were added, as well as the acquiring of a reflectance standard image set for the color correction. Further, aside from certain aesthetic changes in the software, the number of images in a set parameter was changed into a wavelength step parameter in both pieces of software. In the ScannerGUI software, the Current Settings box to show progress within acquiring an image set, as well as the parameters at that moment for non-static gain and exposure was added. In the ProcessorGUI software, the conversion into a datacube before processing was added, as well as the option to display one of the acquired images in the window, and to graph only a specific region of the spectra. Finally, the ReadMe file was written and added.

3.2 From Version 2 to Version 2.1

There was a modification in the workflow, such that the reflectance standard would be put in the main image instead of its own separate image.

3.3 From Version 2.1 to Version 2.2

Modification of the preset gain and exposure curves were allowed to be done within the defaults.m file, with the predetermined camera settings placed in comments.

3.4 Individual Versioning and Files

The camera.m class handles camera functionality and usage, while the filter.m class controls filter functionality and usage. The processor.m and scanner.m are the central class files for each piece of software, coordinating between the filter/camera and the GUIs. The processorGUI.m and scannerGUI.m are executable files containing the code to generate the GUI and run it. The defaults.m file is a completely static class with functions to return constants and file strings. The enviwrite.m file is not produced here, but is taken from a Github package, used to convert the datacubes to ENVI files. The private folder contains all built-in camera function files. Finally, the mlappinstall files add the premade applet into MATLAB, while the .prj files allow generation of a new premade applet file from the other .m files within the folder, for future versions.

In addition, the preset curves can be modified in the defaults.m file, such that it can be modified to take into account the lighting and curve noise.

3.5 For Future Addition

- More choice in the photo viewed, as well as viewing post processing photos
- Removal and saving of photo forms of data options
- Selecting of center pixels by clicking image
- Automatic file production of acquesition paramters with acquesition
- Single flat-field image option
- Binning during image acquisition rather than during post-processing option
- Fix Current Settings manual modification bug
- Add automatic exposure determination

4 Set Types

Set Name	Set Description
reg	Main Image Series
dark	Dark Reference Set
white	White Reference Set
avg	Main Image Series Averaged
darkavg	Dark Reference Set Averaged
whiteavg	White Reference Set Averaged
bin	Main Image Series Binned
darkbin	Dark Reference Set Binned
whitebin	White Reference Set Binned
darksub	Main Image Series Dark Subtracted
darkwhite	White Reference Set Dark Subtracted
flatfield	Main Image Series Flatfielded
correct	Main Image Series Color Corrected

5 Hardware

The hardware consists of a camera, a series of lenses, and liquid crystal tunable filter mounted together with a mounted light source nearby, connected to the laptop running the software by USB cables. It is noted that the filter must be connected to the higher voltage USB port on the laptop to be able to be connected properly. The camera is an Luminera Infinity 2 while the filter is a Varispec VIS filter with a wavelength range from 400 to 720, both of which the software is specifically configured to. Finally, it is noted that the lights must be kept on for some amount of time until they are fully stabilized, to avoid unnecessary lighting fluctuation.