

# Spectral imaging: Instructions

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## Introduction

In this laboratory practise we will be using a Nuance Ex-VIS spectral camera with Spectralight-III Light Booth to image objects under simulated daylight 65. The goal is to learn what are spectral images, how they are acquired, and what data can we extract from them.

## Setting up the system: step by step

The first thing to do would be to turn on the light booth to give the light source time to stabilize, but this booth should already be turned on (Generally light sources should be run 1-2 hours before the measurements to stabilize the spectra but for our purposes 30 minutes is enough). Next, we should place the camera on the tripod and connect it to the computer. These first two steps will be done by supervisor before you arrive. All of the steps after this point are done by you.

Since the camera has already been set on the tripod, but we have no idea what the camera is imaging so we begin by opening the program called **Nuance 3.0.0** on the laptop to get a live view of the camera.

- When this program is opened it always complains about resolution, which is not relevant for our measurement so just press ok to confirm.
- If the program complains about the license key missing it means that the laptop was not connected to the internet for some reason. Restarting the laptop should fix this issue.

Now the program should look as in Fig. 1 below:

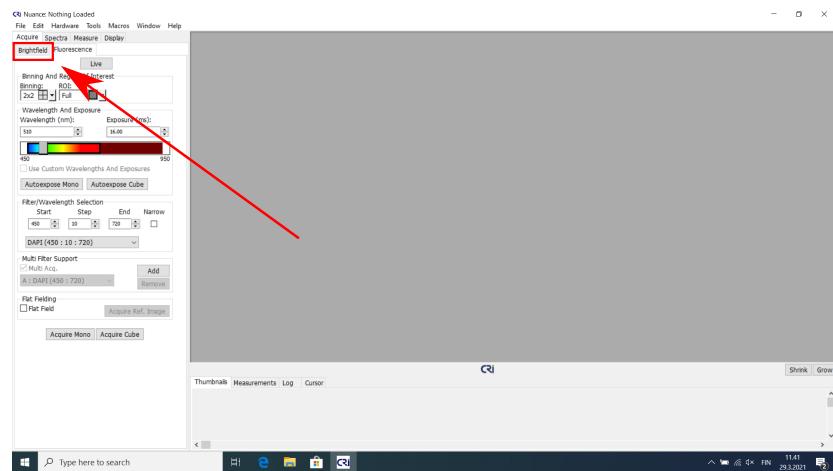


Figure 1: Program after startup. The red arrow indicates the location of the brightfield measurement tab we will be using.

Here we need to choose the brightfield tab, as indicated by the red arrow. We could also perform fluorescence measurements with this program but our setup is not meant for it. The brightfield

measurement tab is what we want and it should look as shown in Fig. 2 below. Here is an overview of the settings we will be modifying, also numbered on the Fig. 2:

1. This button activates or freezes the live view window.
2. This window shows the live view of the camera as a black and white image since we are imaging one wavelength at a time (510 nm in Fig. 2). Note that changing exposure time changes the time it takes for the image to update! For 1500 ms this would take at least 1.5 seconds.
3. This part controls the wavelength and exposure time of the live view, these can be changed freely and checked. If you change exposure time you need to freeze the live view, otherwise the program will freeze. Camera's wavelength range is from 450 nm to 950 nm, with an interval of 10 nm. We could also just use 450 nm to 720 nm to only image the visible light but we will utilize the whole range.
4. Here we set the wavelength range we want to measure and with how many steps. The narrow setting should not be ticked when doing measurements, it decreases the amount of light reaching the camera.
5. This should always be unticked.

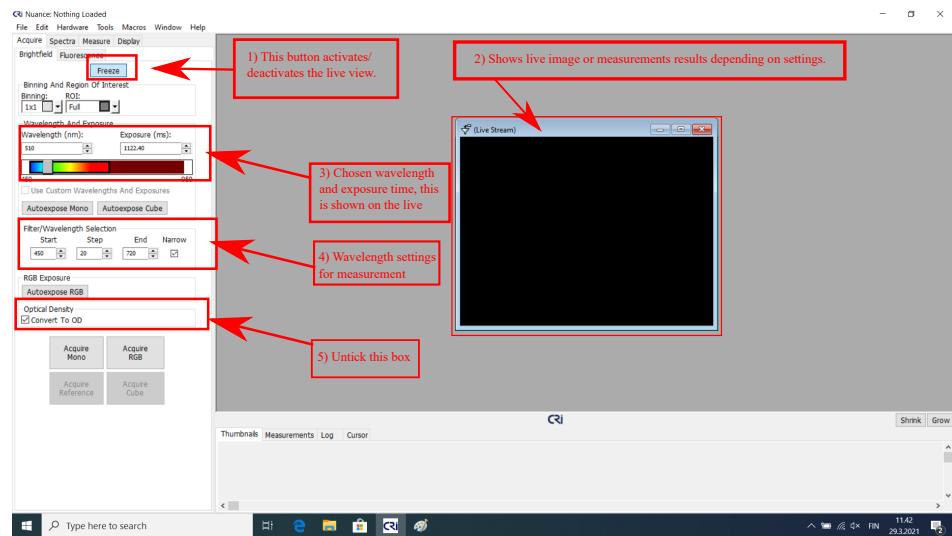


Figure 2: Program in the brightfield tab.

At this points we can place an object to the actual 45-degree black stand inside the light booth and set the camera so that we get the full target on the live view. Below are the steps required:

1. Set the object you want to image on the 45-degree black platform.
2. Adjust the tripod so that the whole object can be seen on the live view (on the laptop screen). **Do not adjust the legs!** Use only the dials right next to the camera.
  - First set the camera in 45-degree angle, this number can be seen from the left side of the tripod.
  - Set the tilt, height, and direction of the camera.
  - You can also move the platform inside the light booth.
3. When the whole image is shown on the screen you need to focus the camera from the objective to get the sharpest possible image.
4. If the image is oversaturated (the pixels are red in live view) see instructions below to see how the image is auto-exposed for the live view.

If there are red dots or large areas of red as in Fig. 3, you need to press autoexposure mono to set the correct the exposure time for the live view. Otherwise the image will be saturated and information for the red areas are lost.

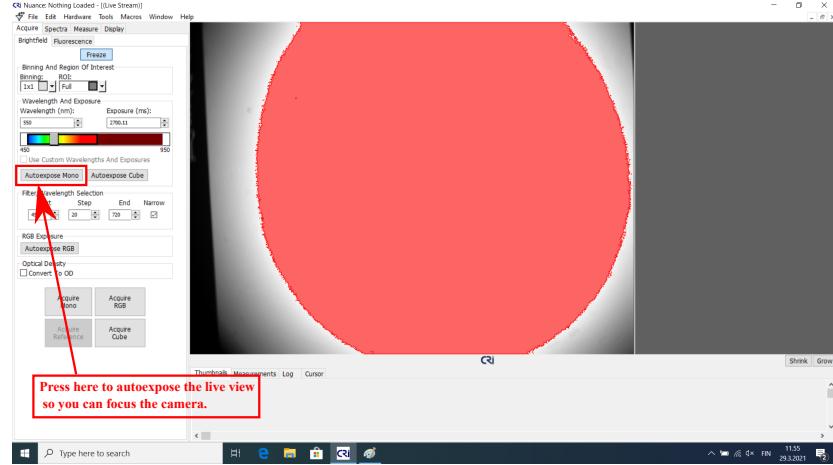


Figure 3: An example of oversaturated area (red) while imaging white reference. Press autoexposure mono to correct this in live view.

## The samples we will use

For this laboratory work we will be using the objects shown in Fig. 4. We could basically image anything that fits inside the light booth but we will stick to these samples. These objects are placed inside the light booth on a 45-degree black stand to get a uniform light to reflect towards the camera.

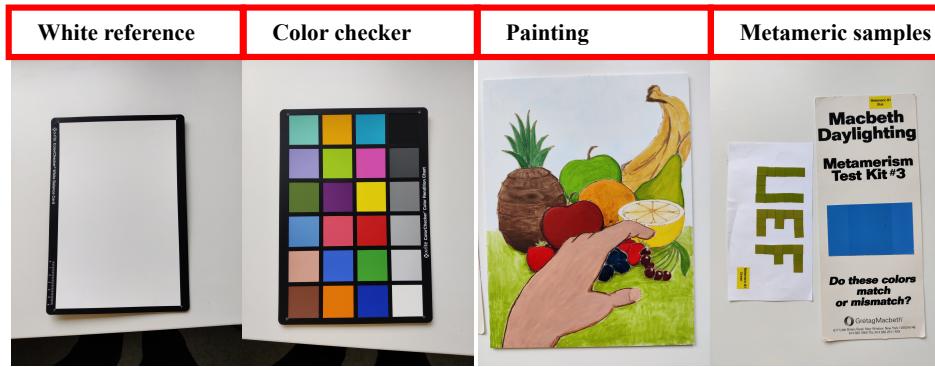


Figure 4: Items we will be studying.

## Taking measurements

Now that the camera has been set up we will place the white reference (see Fig. 4 for the item list) and set the exposure times for all wavelengths. This reference is used to define the spectra for all of the points seen on the camera. You can just put the white reference on top of the object you used to focus the image, since the reference is thin.

Now we can take the actual measurements for all items shown in Fig. 4 below. This is done by pressing the **acquire cube**, shown also in Fig. 5 Note that you only need to run the autoexposure for the white reference, after that we can just image all objects sequentially (unless the software is restarted). **We also need to image the white reference after autoexposure for our analysis.**

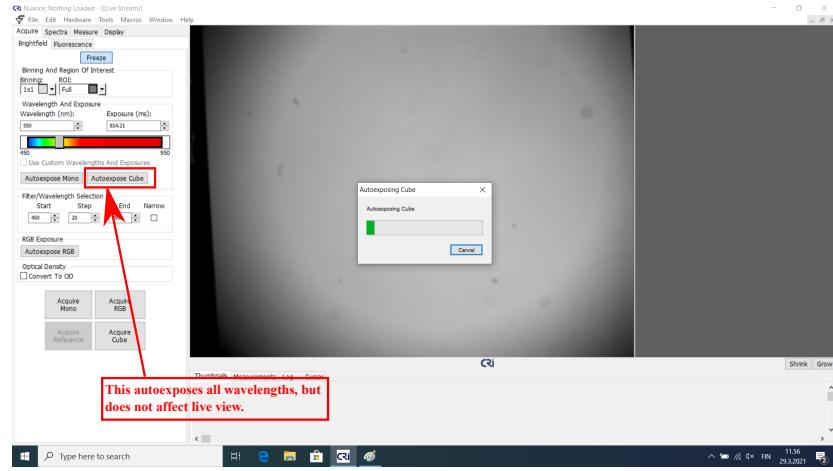


Figure 5: Running autoexposure for the whole wavelength range, imaged object is the white reference. Why is this image not uniformly white?

## Saving and viewing the data:

For saving the data we will be using .tif images; this is a common image format and it is easy to import this into Matlab or Python. To save the data for a single measurement choose file and from there save cube, shown in Fig. 6(a). Now a new window for saving opens, and we need to choose tiff cubes as a file format, shown in Fig. 6(b). Now we will have a single .tif image for each imaged wavelength with name corresponding to whatever you chose as the name abbreviated with the wavelength ( e.g. Image\_Cube\_710.tif would be the filename in Fig. 6(b) for wavelength of 710 nm). If we use the whole range of 450-950 nm with 10 nm interval, we will have 26 different .tif images. These .tif images do not conform to the standard windows uses to view .tif images. You can use IrfanView graphic viewer or import the image to Matlab/Python and plot it from there. I suggest doing the latter since you anyway need to analyze the images.

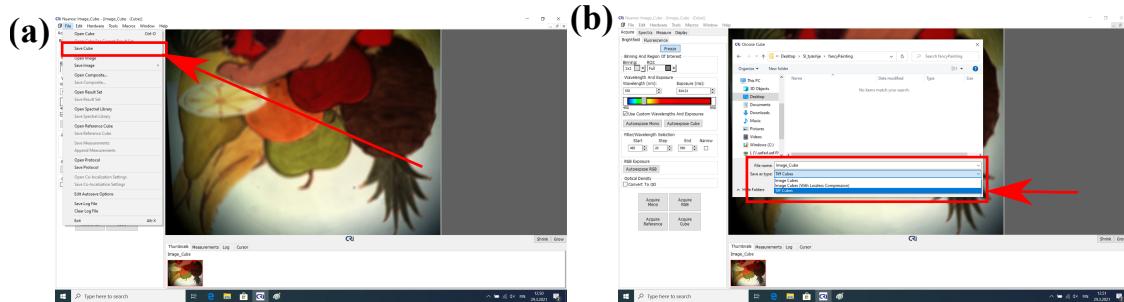


Figure 6: How to save image cube; here I have taken an image of the painting.

You can also view the spectra from the software itself by taking the tab spectra, shown in Fig. 7. In this mode you just hover the cursor over the image and the software shows the spectra at that point. We only use this to check the images if required, you should manually use the data inside Matlab/Python for your analysis.



Figure 7: How to view the measured spectra from the software.

## Checklist of samples:

For reference here is a list of all samples you need to image separately:

- White reference
- Color checker
- Metameric sample 1 (yellowish UEF logo)
- Metameric sample 2 (blue, Macbeth Daylighting Metamerism Test Kit 3)
- Painting

## What to include in the report/analysis

Report should be approximately 2-5 pages long. You need to answer these points:

- Find out what is a spectral camera, spectral image, reflectance, and how a traditional RGB image is formed.
- Show one reflectance image for a single wavelength.
- Create RGB images of the imaged objects. You can use three wavelengths for the color channels, there is no requirement to use standard color models.
- Calculate reflectance spectra for every image pixel. Choose five points from images object, mark these points in the RGB pictures, and plot corresponding reflectances as function of wavelength. This has to be done for all samples listed in Fig. 4 (a total of 5 images, each with 5 chosen points).
- How do the metameric samples differ in spectra and why?
- Why is the image of the white reference not uniformly white?