Intensity Normalization

For each spectral band, *i*, henceforth called "wavelength", a standard acquisition process is followed. A white, highly reflective target is placed in front of the object. A "white" image, *W*, is acquired. The white target is removed and, keeping all settings unchanged, the acquisition of spectral image, *Q*, follows. Still keeping settings unchanged, light entrance is blocked in front of the camera and a "black" image, *B*, is captured, corresponding to the dark current of the camera.

Intensity normalization is performed independently for each spectral image and for each pixel *x* as:

$$I_i(x) = \frac{Q_i(x) - B_i(x)}{W_i(x) - B_i(x)}$$

Zacharopoulos A., Hatzigiannakis K., Karamaoynas P., Papadakis V.M., Andrianakis M., Melessanaki K., Zabulis X. A method for the registration of spectral images of paintings and its evaluation. *J. Cult. Herit.* 2018;29:10–18. doi: 10.1016/j.culher.2017.07.004.
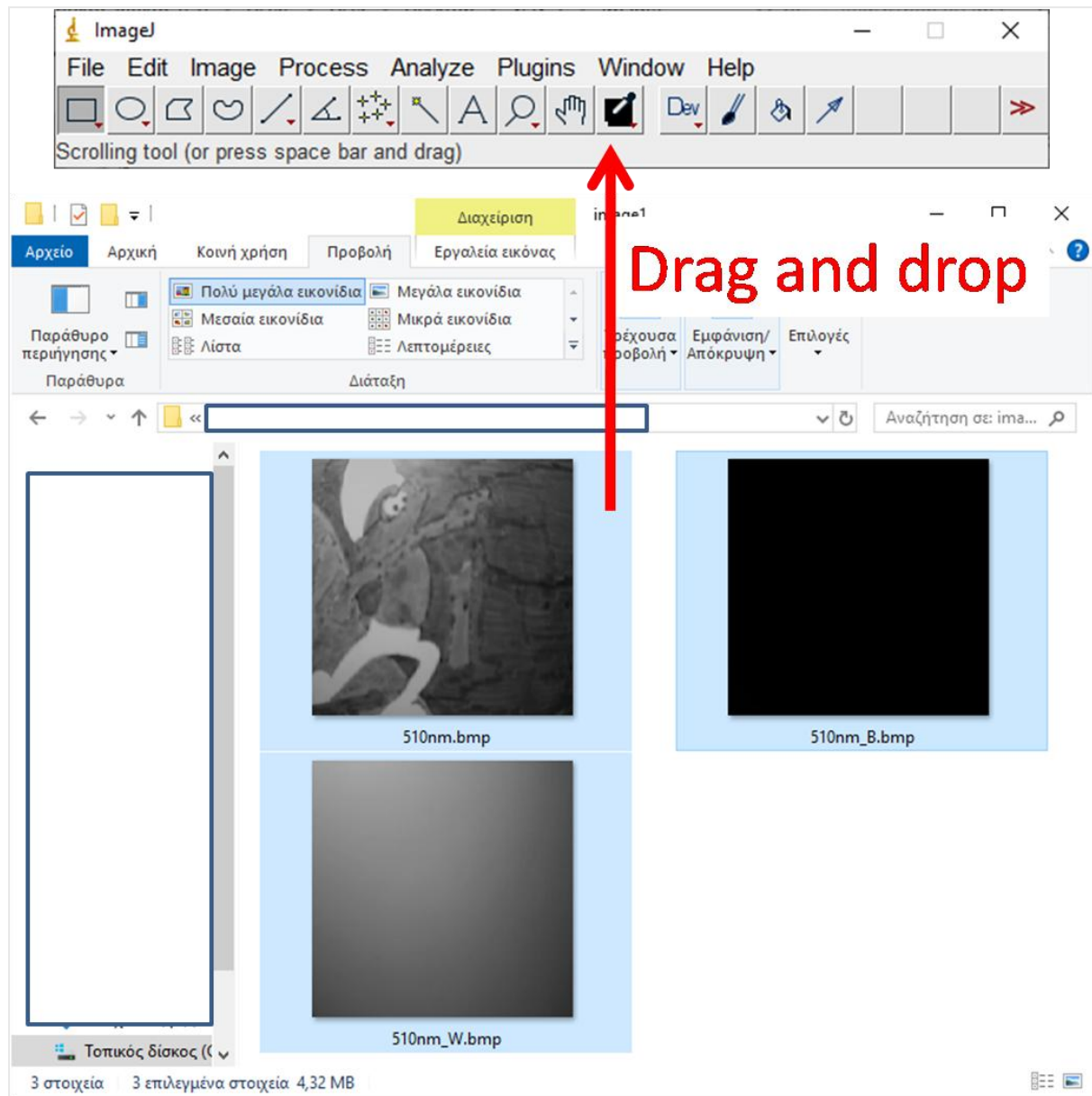
ImageJ

The procedure of image manipulation is done with the free and open source software *ImageJ*.
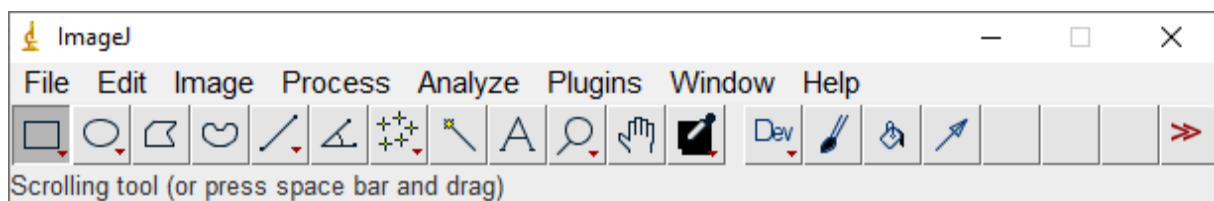
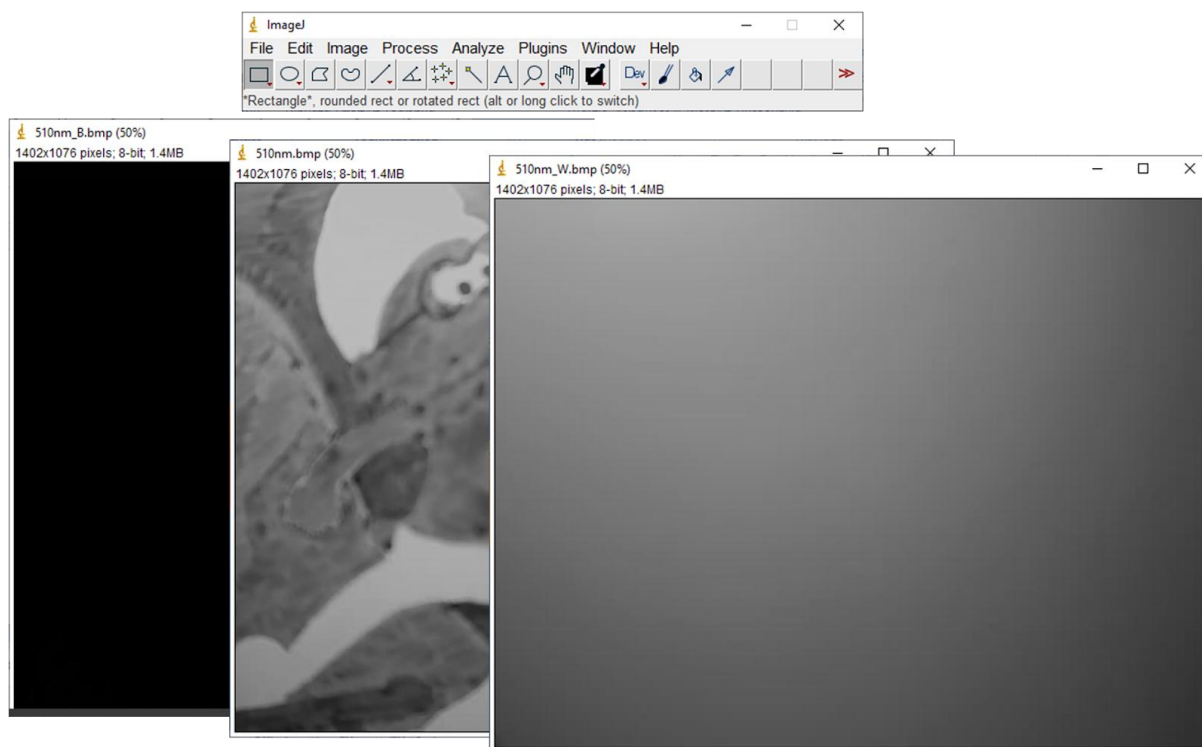You can download *ImageJ* from here: https://imagej.net/ij/index.html

Step 1

For each wavelength (filter) drag and drop the three image files to *ImageJ* (white, picture, black).
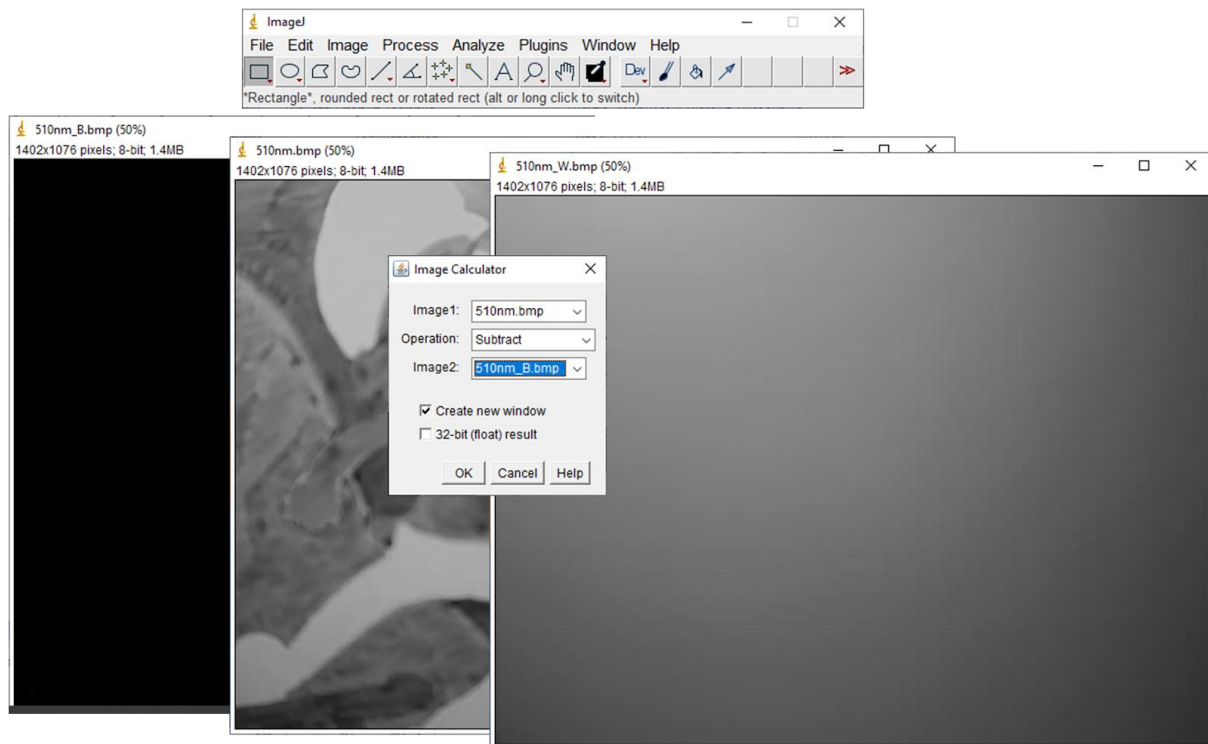
Now you will have something like that.

Step 2

In order to remove the noise (black image) from our painting, go to:
Process → Image Calculator
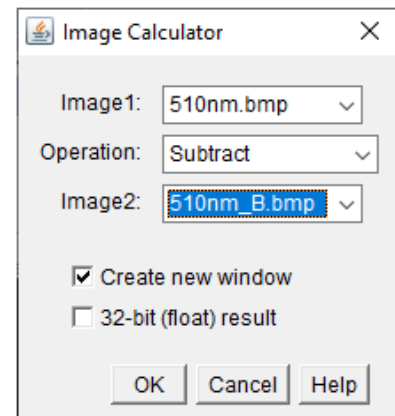
A small window will pop up.

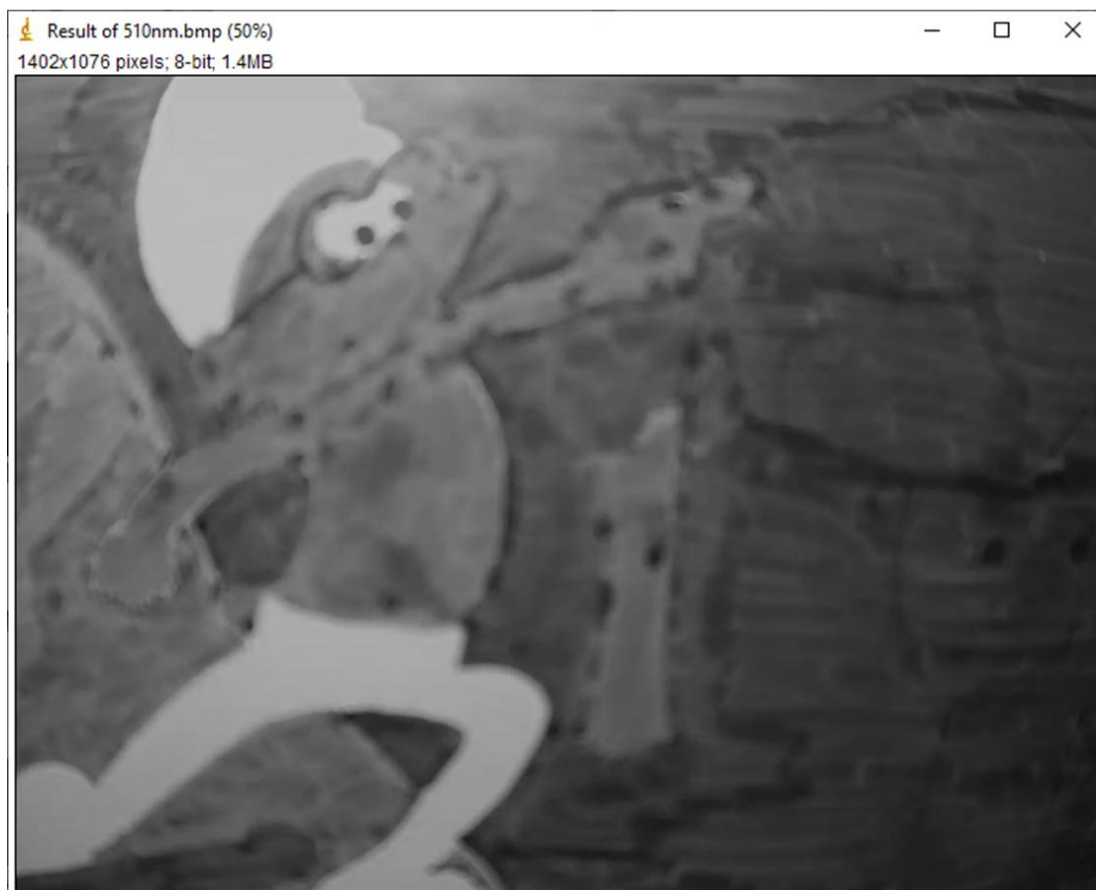## Step 3

Image1: The image of the painting.

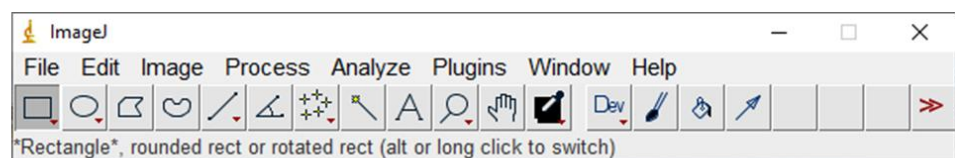*Image2*: The black image.

Operation: *Subtract*

Click: *OK*

The result of this manipulation will be shown in a new window with a new image name.
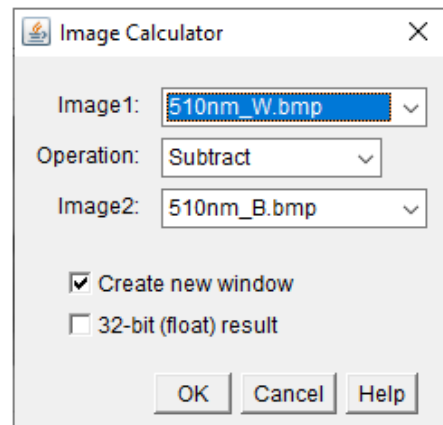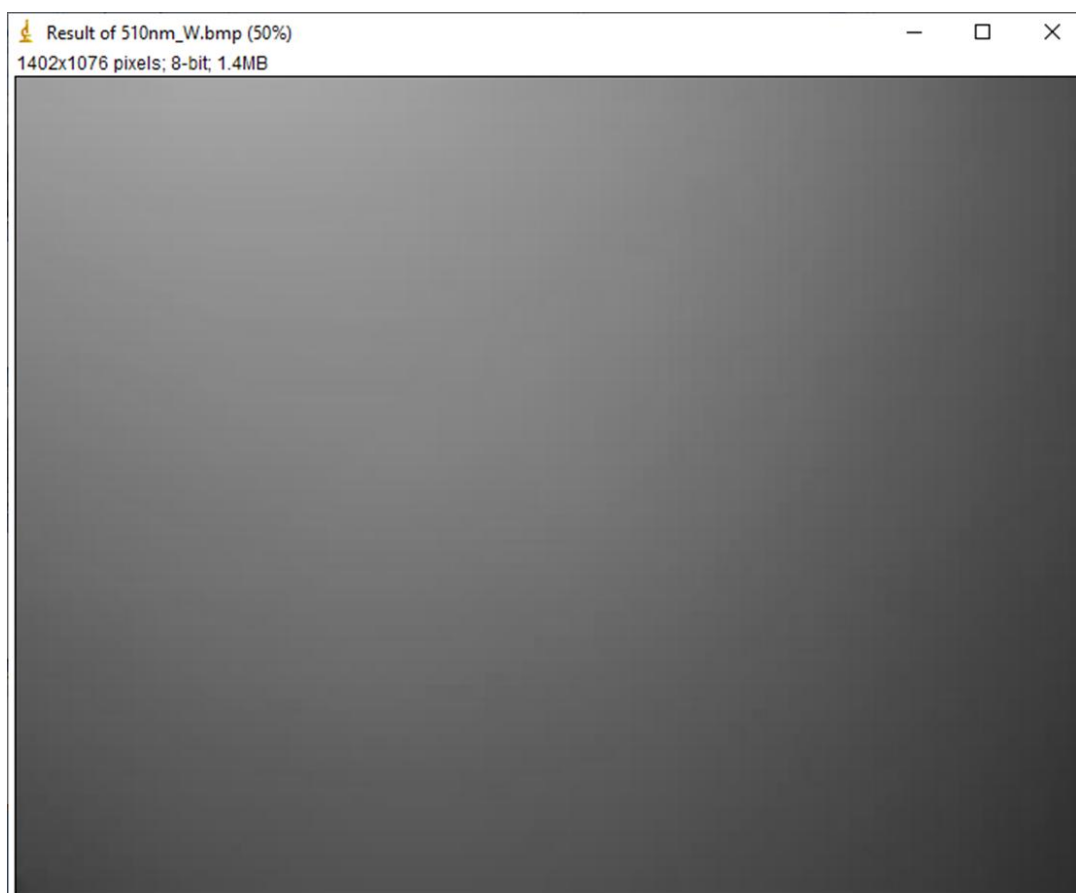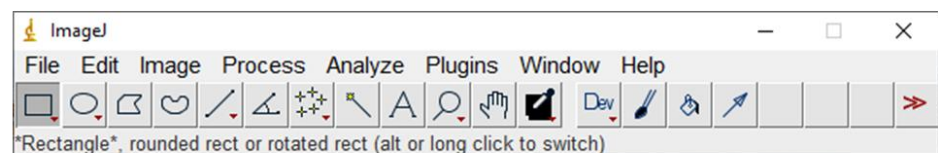
Step 4

In order to remove the noise from the white image, select again:
Process → Image Calculator

In the small window, select the white image as *image1*.

The result of this manipulation will be shown in a new window with a new image name.
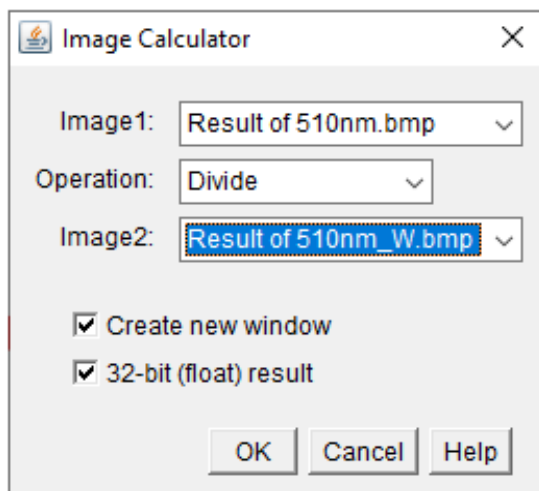
Step 5

To get the normalized image, select again:

Process → Image Calculator

In the small window, select the result of the manipulation of the painting as *image1*, and the result of the manipulation of the white image as *image2*.

As operation, choose *"Divide"* and select the option *"32-bit (float) result"*.
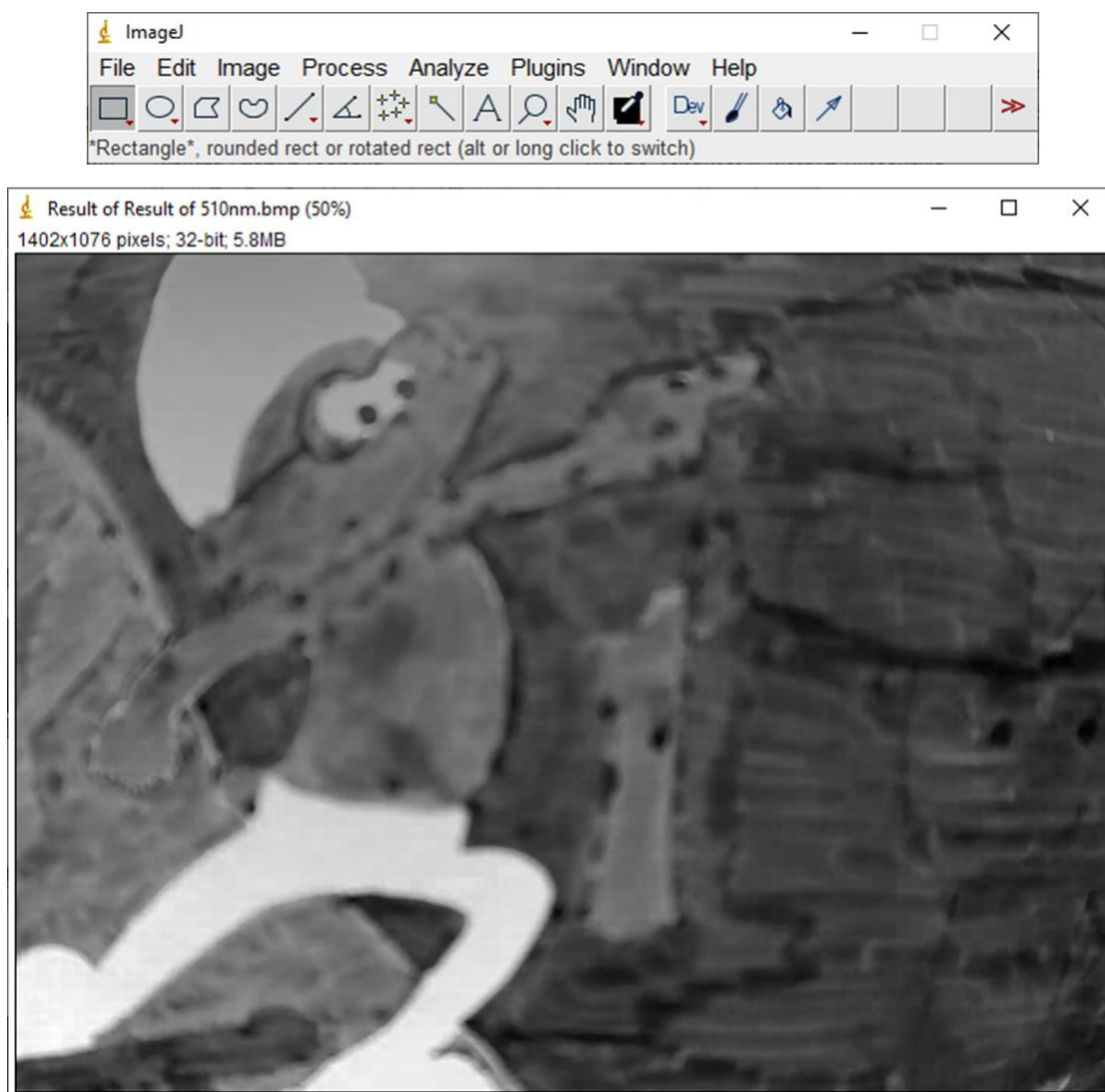
Step 6

The normalized image will pop up. You can save this image by selecting:
File → Save as → BMP

A good practice is to save all normalized images in a specific folder. You can do these steps for each wavelength (filter) to get all normalized images.

You find further information on the project page by the authors.

The project "Shedding "light" on a Picasso!" by Kalliopi Giannakoudaki and Georgios Chatzisavvas introduces students to multispectral imaging. Go to the Science on Stage teaching material.