



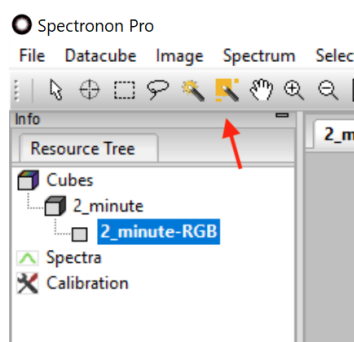
Building Training Sets and Using Regression

This tutorial will show multiple ways of building training sets for use with classification and analysis plugins in Spectronon. These training sets will then be used to perform a regression analysis, a process for estimating or predicting an outcome from a dataset. In contrast to a classification algorithm, which assigns pixels or object to a category, a regression can predict a continuously variable quantity. The data used in this tutorial are scans of cookies baking in an oven, which were periodically removed from the oven and scanned with a Pika NIR at various times. The regression will be used to predict the amount of time the dough had spent in the oven. Baking time is interesting because it serves as a useful proxy for the moisture content of the cookies, a quantity of frequent interest in food preparation.

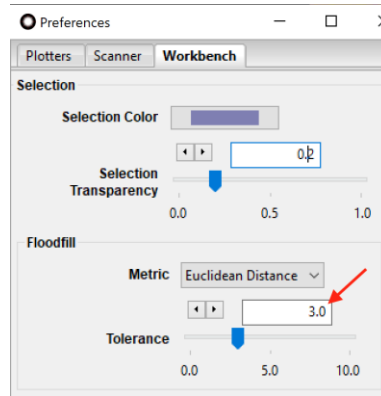
Using Spectral Selection Tools.

This section details the use of the *Spectral Selection* tools  to create a region of interest (ROI) of spectrally similar areas of a datacube. These tools can be more efficient than the Rectangular or Free Form selection tools  for large area ROIs.

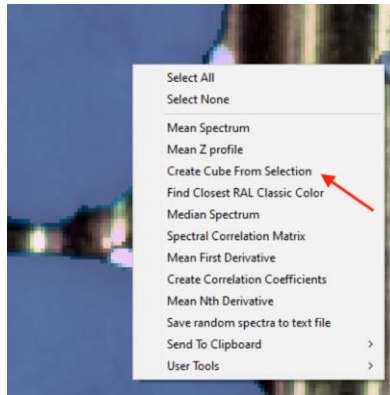
1. Open Spectronon, then select *File->Open Datacube*. Navigate to the folder of datacubes provided with this tutorial, and select *2_minute.bil*.
2. When the datacube opens, select the second spectral selection tool from the tool bar, shown below. This tool will select spectrally similar pixels across an entire image. The selection tool to the left operates in a similar manner, but selects spatially contiguous pixels instead of across the entire image.



3. Click on an area inside of one of the cookies. The sensitivity of this tool can be adjusted in *File->Preferences->Workbench->Floodfill->Tolerance*. Increasing the tolerance will select more pixels. The tolerance can be defined in either Euclidian distance, or spectral angle units. Euclidean distance units are more sensitive to overall brightness of the image than spectral angle units. For this dataset, a tolerance of 3.0 in Euclidian distance units or 0.3 radians in spectral angle units provides good results.



- Another useful trick for using the magic wand tools is to hold the *Ctrl* button on your keyboard down as you click unselected pixels. This will add to new regions to the existing selection instead of completely replacing it. Use this technique to select the majority of the cookies. When satisfied, right click in a selected portion and select *Create Cube From Selection*.

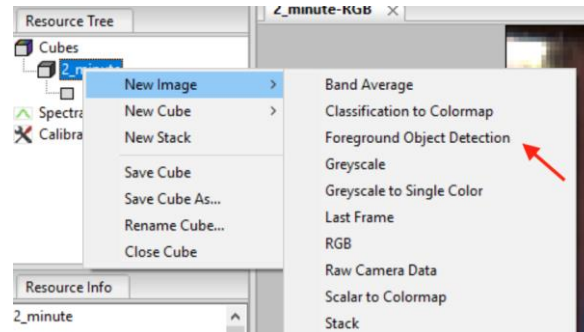


- Repeat these steps for the datacubes *4_min* and *6_min*. These will be used as training cubes during the Regression section.

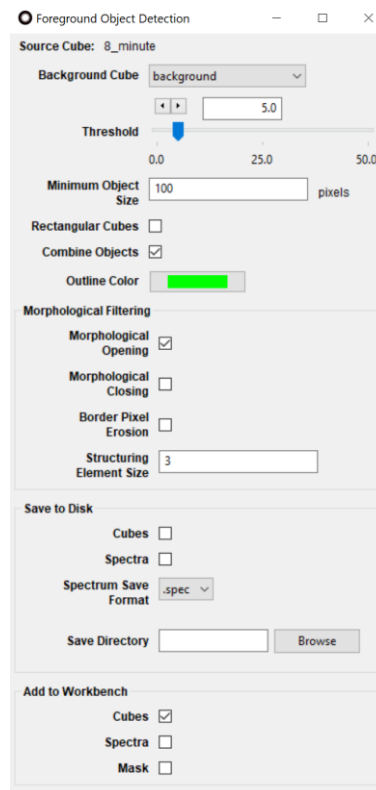
Using Foreground Object Detection

The *Foreground Object Detection* plugin is an Image plugin that can also be used to automate the ROI creation process. This tool separates objects of interest from a background. A background is a user defined datacube containing pixels of everything but the objects of interest.

- Open the *8_min.bil* datacube. To create a background cube, use the *Rectangular Marquee* or *Lasso* tool to select an area that represents everything except the cookie, in this case the metal tray, holes, and shadows. Right click on the selected area and select *Create Cube From Selection*. Name this cube *background*.
- Right click on the *8_min* datacube in the Resource Tree, then select *New Image->Foreground Object Detection*.



3. In the resulting dialog, select the background datacube created above. Uncheck the *Rectangular Cubes* option and check the *Combine Objects* option. This will create a single datacube from the results. Press OK. You will see a preview of the results, and the options for the plugin will now be available in the *Tools* section of Spectronon, in the lower right corner.

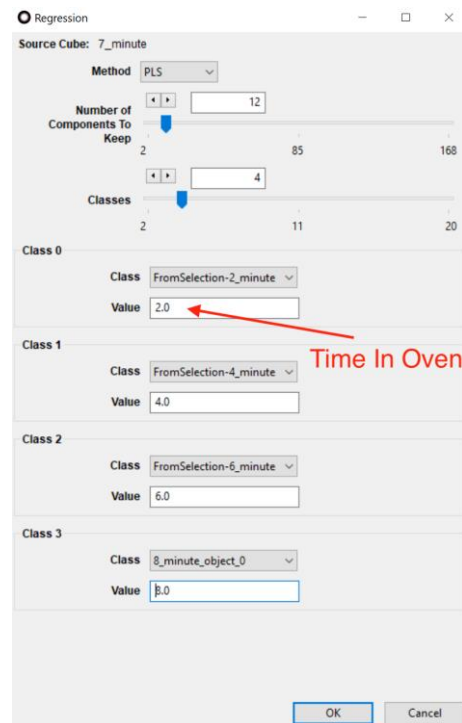


4. Adjust the *Threshold* until you are satisfied with the results (you will have to press the *Update* button at the top of the *Tools* pane if *Auto Update* is not checked). When satisfied, uncheck the *Spectra* and *Mask* boxes in the *Add To Workbench* field, then press the *Run Now* button to add the resulting datacube to the Resource Tree. This will be the last training cube used in the next section.

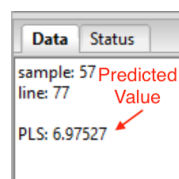
Regression Analysis

We will now use the training cubes created in the above steps to predict the amount of time the cookie dough in a *holdout* data set (data not used in training) was in the oven.

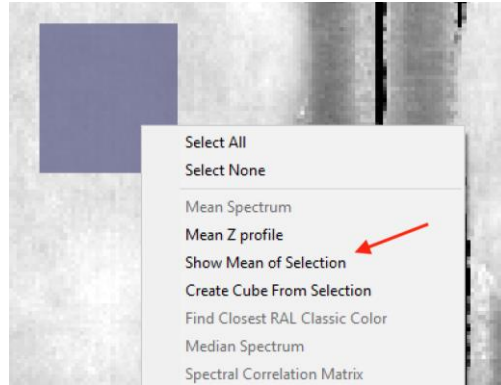
1. Open the datacube named *7_min.bil*.
2. Right click on this datacube in the Resource Tree, *select New Cube -> Analyze -> Regression*. We will use the PLS method, which is Partial Least Squares¹. You can try other methods later, but be aware that Support Vector Regressions² (SVR) are very slow unless the number of features has been greatly reduced by PCA or other feature selection methods.
3. Choose 12 *Components to Keep*, and change the number of *Classes* to 4, one for each training cube.
4. For each Class 0-3, select one of the training cubes created above, then enter the number of minutes the cookie in the datacube was in the oven for in the *Value* field.



5. Press OK. The resulting datacube will be a single band containing the predicted time. Use the *Inspector* tool (crosshairs) to inspect the value of various pixels. The value of the pixel under the crosshair can be seen in the *Data* window of Spectronon, in the lower left hand corner.



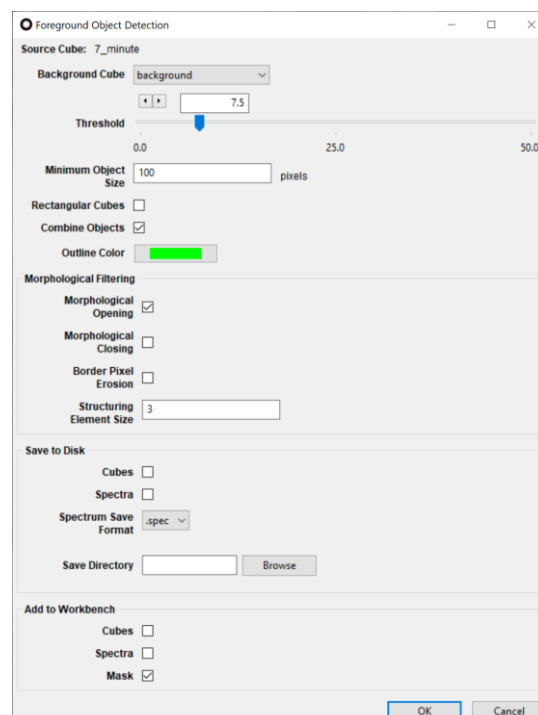
6. To see the mean value of a ROI, select the *Lasso* tool, and select an area within a cookie. Right click in this area and select *Show Mean of Selection*.



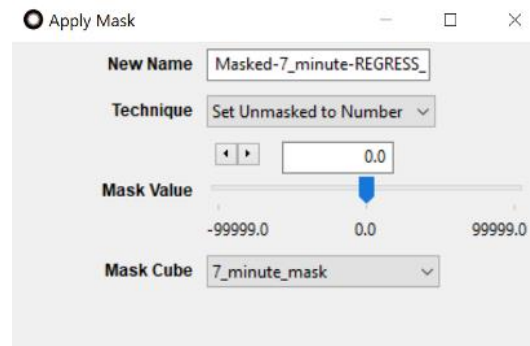
Using Masks

Masks can be used to crop unwanted pixels from a datacube or set them to an alternative value. This can be useful for extracting data or to make results visually clear for presentation.

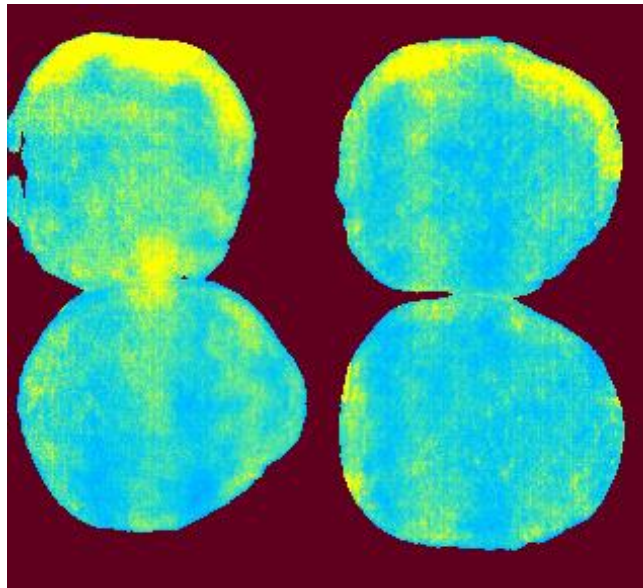
1. One way of building a mask is to threshold a datacube with the *Build Mask* plugin found in the *New Cube->Mask* plugins. This is typically performed on a *Spectral Angle Map* datacube, using the background and/or objects of interest as training spectra. In this example, however, we will use the *Foreground Object Detection* plugin to create a mask.
2. Right click on the *7_min* in the *Resource Tree*, and *Select New Image->Foreground Object Detection*. Use the same *Background Cube* as before, as well as *Threshold*. Uncheck the *Rectangular Cubes* option and check the *Combine Objects* box. In the *Add to Workbench* section, uncheck *Cubes* and *Spectra*, but check the *Mask* box. Press OK.



3. If the mask preview looks acceptable (background is black and cookies are white), press the *Run Now* button in the *Export Results* field to add the mask datacube to the *Resource Tree*.
4. Next, right click on the Regression datacube created previously, and select *New Cube->Mask->Apply Mask*.



5. Select the mask datacube and press OK. The background pixels should now be set to 0 and the cookie pixels unchanged.
6. Finally, to better visualize the results, right click on the datacube just created. *Select New Image->Scalar to Color Map*. The results should look similar to the image below.



References:

1. Partial Least Squares: https://en.wikipedia.org/wiki/Partial_least_squares_regression
2. Support Vector Regression: https://en.wikipedia.org/wiki/Support-vector_machine