

Non Linear Correction

*This support note will show how to use the **WSxM** program to correct the non-linear behaviour of your piezoelectric scanner. These adjustments should be done only once for each piezo.*

Obtaining polynomial coefficients of your piezoelectric scanner.

Piezoelectric material responds to an applied electric field by changing its shape. When this field is small, the response can be taken as linearly proportional. However, when large fields are applied, this is not true. This linear response does not apply, specifically, for large scan sizes.

To be able to cover the whole area, large electric fields must be applied to the piezo. This leads to a distortion on the measured data that must be corrected by a transformation of the data.

Obtaining images for adjustment

In order to obtain your piezo's specific set of polynomial coefficients you need to obtain two images. These images should have a regular pattern, so a grid is highly recommended. The size of the pattern should be about a 10% of the total range of the scanner. It is very important to obtain these images as good as you can. The quality of the correction will be worse when using bad images. The parameters to obtain the images are:

Non-linear correction: **DISABLED**

X-Scan direction: the same for the two images (for example, both scanned forward).

Y-Scan direction: the same for the two images.

Frequency: 1 Hz (or near).

Points: 512

X offset: 0.

Y offset: 0.




Angle: 0.

XY Gain: 50 (or 15, if you are using a Dulcinea electronics).

The first image should be obtained with the maximum allowed scan size, the second one with half that maximum scan. In order to get the piezo stabilized, when you change the scan parameters, you have to ignore at least the first two images that you can get and then save the third one. We recommend do not press **Up**, **Down** or **Middle** buttons while stabilizing.

Obtaining Center Maps.

Once the image has been recorded, you need to obtain a center map for each image. In order to do that, please follow the next steps:

1. Open the image.
2. Subtract a plane with the “Global plane” filter  or click on Process ⇒ Plane ⇒ Global.
3. Smooth the image using twice or three times the Smooth command .
4. Select the smoothed image. You can close all other images, discarding the changes.
5. In the toolbar, select the flooding command  or click on Process ⇒ Flooding. Depending on the grid that you are using, you should apply the flooding command over the holes or the hills of your image.
6. Check **View centers** and **Ignore borders**. You should get something similar to Figure 1.

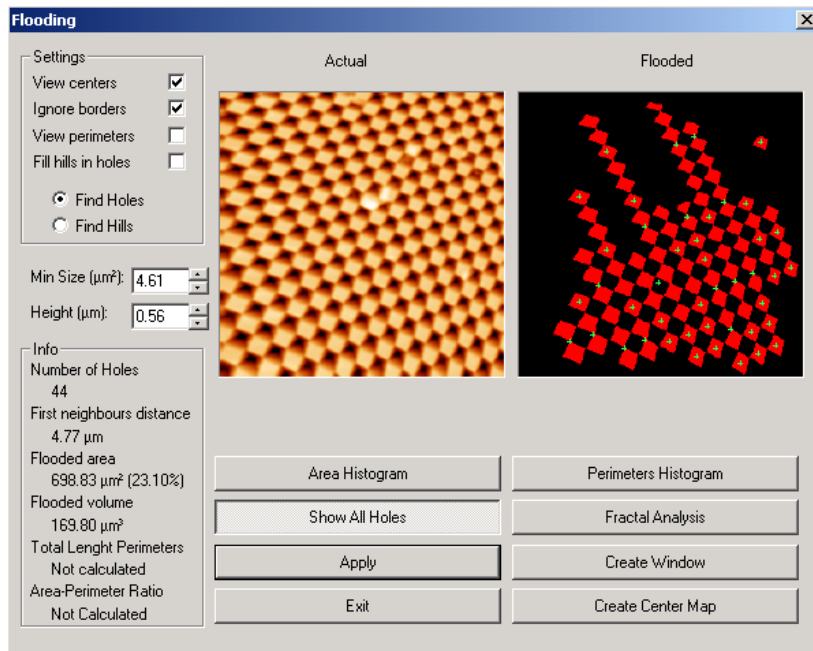


Figure 1

7. You may need to adjust the height and min size if needed, in order to obtain one green cross for each real hole in your grid. Look at Figure 2 to see the example.

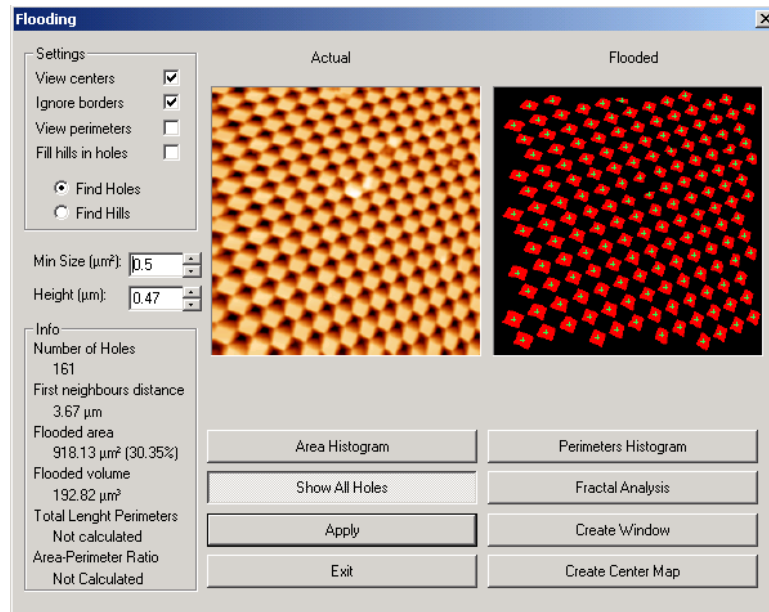



Figure 2

8. When done, click on create center map. A new window will open. Now you can close the dialog box and save the center map image.
9. Repeat the process with the second image.

Adjusting the center map to a regular net

1. Open the first centers map image if you closed it.
2. With this image selected, press the button  or select Process ⇒ Linearize... in the Menu. A new dialog box will be opened (Figure 3).

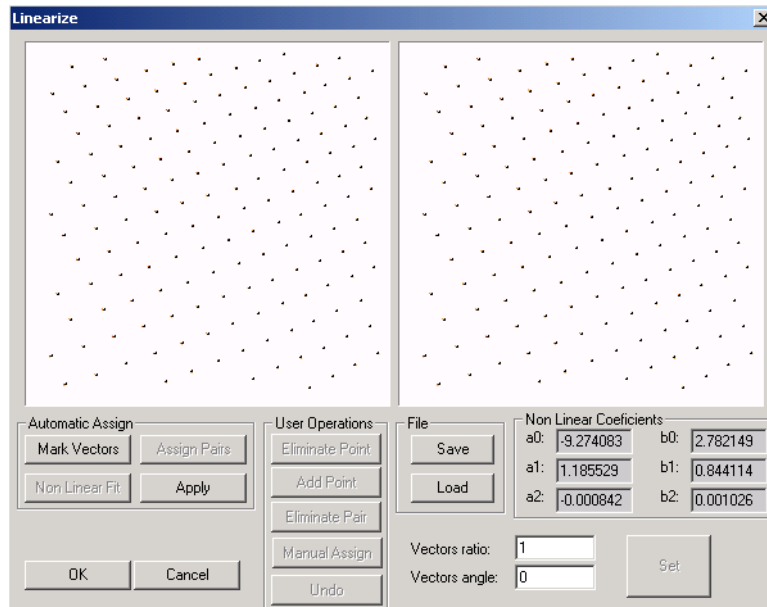


Figure 3

3. Press the **Mark Vectors** button and select three points as reference vectors. The first point will be the origin of both vectors. Select these three points near the center of your image, where the non-linear effects are lower and look for two good vectors. To check the quality of the vectors, compare the ratio and angle shown in the dialog box with the well known values. You can also select the first vector and adjust the second one using these edit boxes.

- Press onto **Assign Pairs** and the program will suggest a set of relations between real net points and ideal net points. Some of these assignments could be wrong, like shown in Figure 4. Take a look to find these wrong assignments and eliminate them using the **Eliminate pair** and clicking on the wrong point (not in the circle).

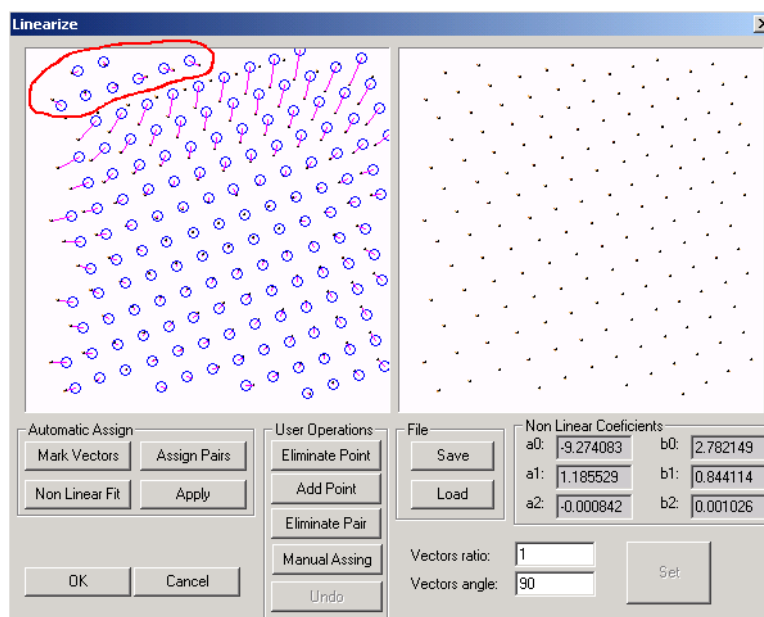


Figure 4

- If you want to add any other pairs or those that you removed, add them by pressing the Manual Assign and selecting the point and the corresponding circle.
- Click on **Non Linear fit** and you will have the non-linear coefficients for that image. You can verify the quality of the adjustment by pushing then **Apply** button. You will see the corrected net in the image on your right. Save the coefficients in a file by pressing Save and typing the name for the piezo. Each piezo name can allow up to three sets of coefficients, with different parameters.
- Repeat the process with the second centers map and save it with the same name. When asked for overwriting the piezo

with the second set of parameters, answer Yes. If you save it with a different name, you could not correct images with different scan sizes or the correction would be worse. Notice that if you want to create a different set of parameters with the same name, you have to save the parameters three times.

Scanning with non-linear correction

1. Select your set of coefficients in the **Head** dialog box before scanning, pressing the **Load** button in the field called **Piezo Name**.
2. Check non-linear correction in the “Scan options” dialog bar and scan your linearized images (Figure 5).

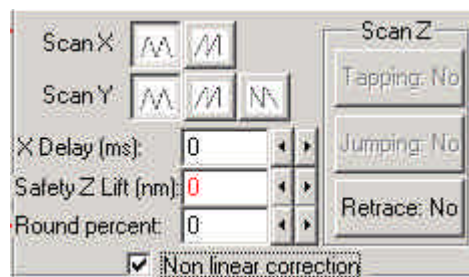


Figure 5