The Rio de Janeiro State University - UERJ
Laboratory of Photogrammetry and Remote Sensing
The E-Foto project

Exterior orientation by spatial resection

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Revision: Jorge Luís Nunes e Silva Brito

Introduction

The exterior Orientation is the process through which a set of control points measured on the ground and in an image are used to calculate the exterior orientation parameters of an aerial image. While the Bundle Block Adjustment gives the exterior orientation of all photogrammetric images of a block, the spatial resection algorithm allows the calculation of these parameters for each image separately. The exterior orientation calculates the camera optical center coordinates (E0, N0, H0) and its attitude angles (ω, φ and κ) in the image acquisition instant. These parameters are referred to the ground coordinate system. This tutorial shows how to proceed to get the exterior orientation of an image using the Spatial Resection algorithm. The Spatial Resection must be executed separately for each photogrammetric image in your project.

After starting the E-Foto Free Software, you will see its starting screen (Figure 1). On main menu there are the options **Project**, **Execute** and **Help**. The execution of a exterior orientation assumes that the following steps were already done:

1. A photogrammetric project was already created and supplied with its imput data, accordingly, and;
2. The interior orientation of the image was already executed.

In case you are not aware with Project Creation and Interior Orientation execution processes, a revision of their respective tutorials would be very useful before continuing. Next, let's see an example of Exterior Orientation by Spatial Resection method using E-Foto. Start selecting menu option Project as shown on Image 1.

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Figure 1 – The e-foto's main screen

Starting The Exterior Orientation

Firstly a previously created and saved photogrammetric project should be opened. For doing that we must choose **Last Project**, if our desired project was the last one opened, or **Load File** and a list of saved projects will appear. If the desired project is not on the list, it is possible to browsing it.

After selecting a project you can see if the interior orientation is complete for all images. As the image of interest has the Interior Orientation already done we can proceed to the Exterior Orientation (E.O.) Select item **Execute** and then **Spatial Resection**. A small window will allow you to choose the image to begin the measurement. It is necessary to select the desired image and to click **Ok** as shown in Figure 2.

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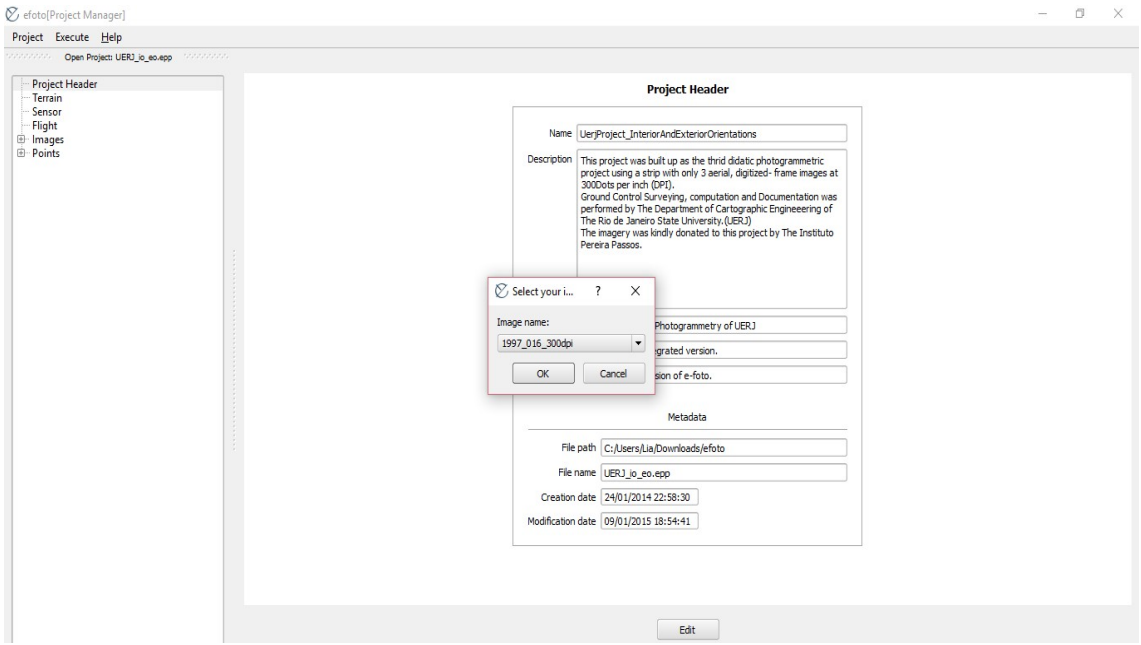

Figure 2 – The selection of an image for performming the spatial resection algorithm

Please observe the figures 3a and 3b. You will notice the available ground control points for images 016, 017 and 018 in an overlapped view (Figure 3a) and a single view for image 016. It is necessary to stress that a minimum of four control points to make possible the E.O. calculation. You can use Google Earth to identify the location of your ground control points. For doing so, use the geographic coordinates φ and λ or E, N (UTM). This will be very useful when you are working with imagery and control points in an area that you are not familiar with.

Figure 3a – Images' 016, 017 and 018 ground control points overlapping overview

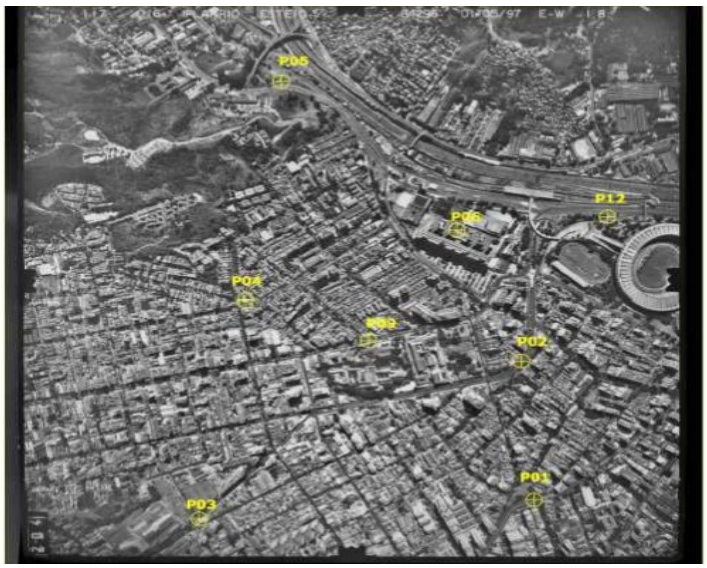

Figure 3b – Ground control points distribution available for image 016

Now we need to identify the ground control points on the image. For doing so, we suggest you to download the report of the detailed description of ground control points. This is an pdf file named **"GCP_description.pdf"**

available in the E-Foto's homepage. Figure 4 shows a table (Point Coordinates) containing points saved previously, when a photogrammetric project was created. For locating the first ground control point to be measured on your image, zoom into point 1 region with the **zoom** tool as shown in figure 5.

Points

Point Id	Type	E	N	H
P01	control	681100.209	7464305.984	12.002
P02	control	681079.091	7464791.902	10.103
P03	control	680114.618	7464269.661	14.941
P04	control	680262.749	7465023.964	16.250
P05	control	680377.816	7465806.099	20.306
P06	control	680888.011	7465251.245	68.268
P08	control	681875.866	7465066.854	5.980
P09	control	680626.292	7464876.497	12.075
P10	control	682031.497	7465841.798	21.146
P11	control	682134.395	7464127.842	8.656
P12	control	681361.203	7465299.251	7.796
P13	control	682208.231	7465250.939	5.913
P14	control	682912.044	7464795.162	4.595

Figure 4 – Ground control point coordinates table

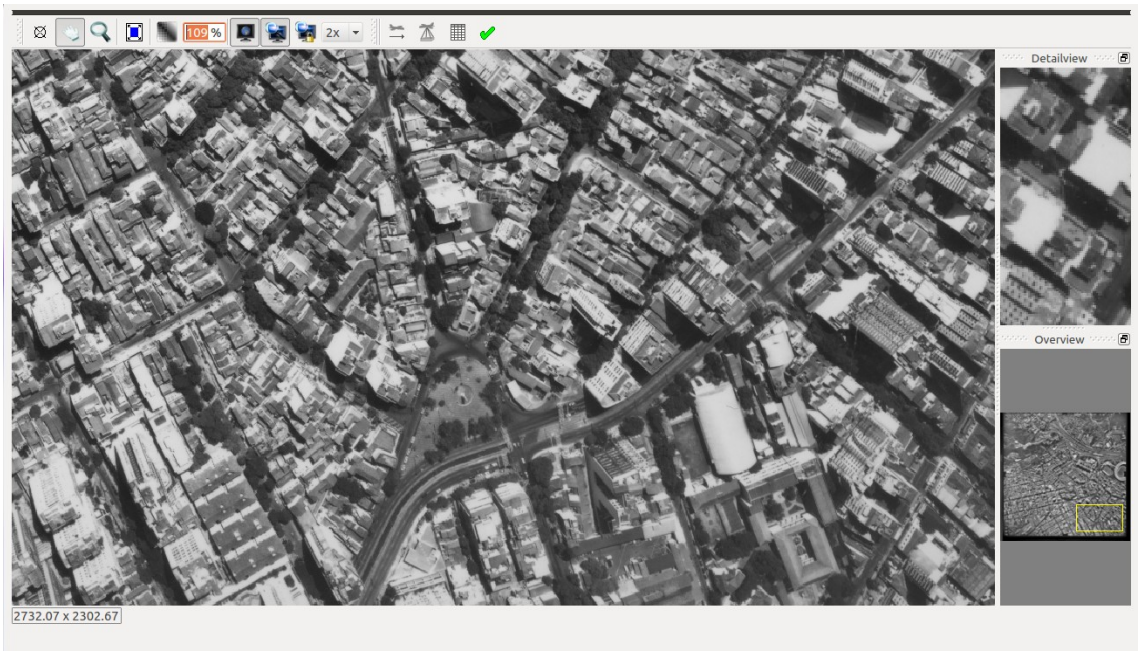

Figure 5 – Zoom in to measure the fisrt ground control point

The user should **zoom in** until clearly see the exact location of the first chosen point, in this example, point 1. When done, click button Set Point to measure it, as shown in Figure 6.

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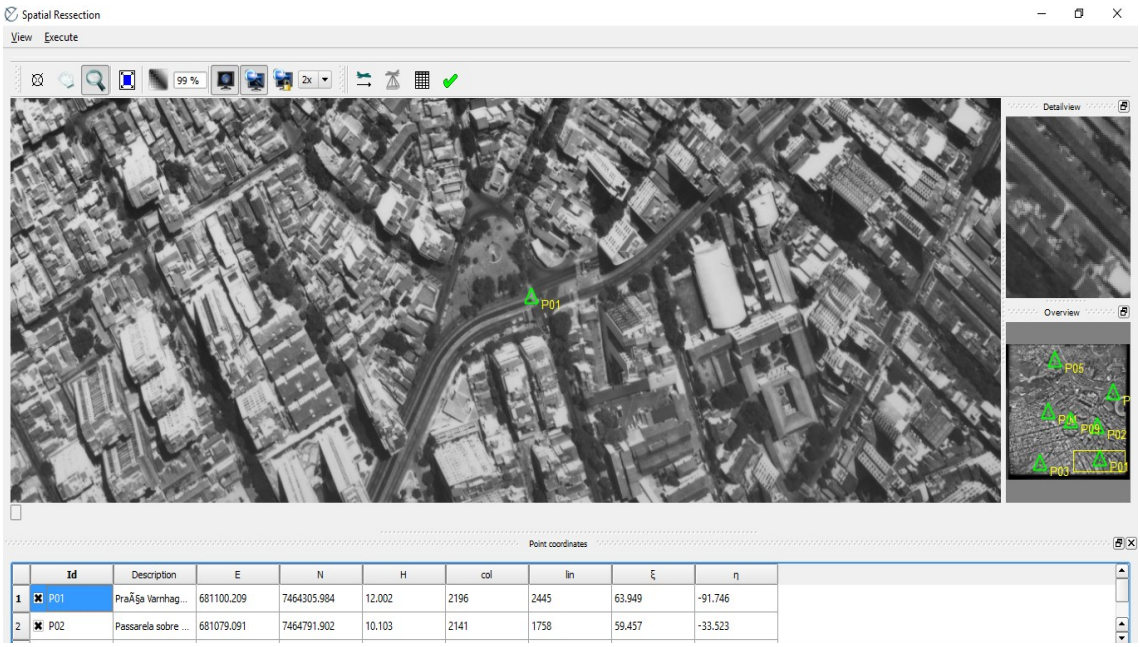

Figure 6 – The ground control point measured in the image

Note: Observe that in the table of Point Coordinates the first line contains the results of measuremments of the GCP. If the measurement needs to be redone, only return to previous line with cursor and click on the image again in the correct position. The point will be measured again and the table updated.

Repeat the process for the second point and remember to use the description of the locations of the GCP. To return image to its original size, click button **Set View**. Select second chosen point's region, on this example, point 3, and **zoom** in on it. Use button **Set Point** to measure point 3, as shown in Figure 7.

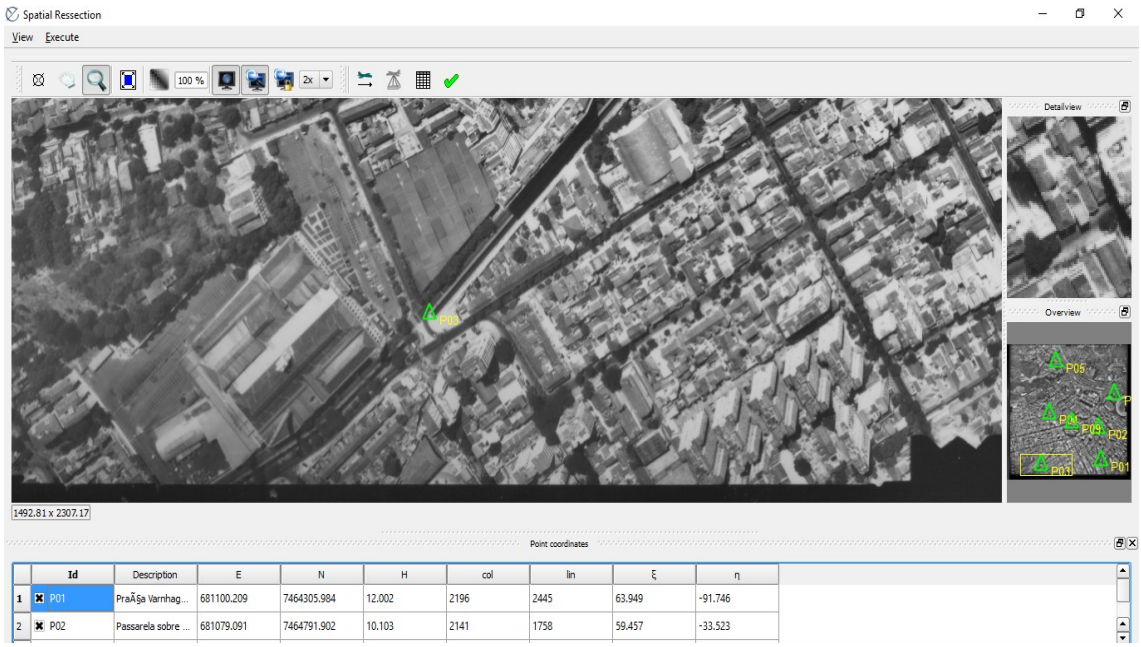

Figure 7 – The measurement of a ground control point in an image

It is necessary to repeat the process for next (third) chosen point, in this example point 5. Again, remember to use the point's report file to ease the point location on image. To return image to its original size, click button **Set View.** Find third point region and zoom in on it. Use Button **Set Point** to measure point 5.

Repeat the measurement process for the fourth point, in this example, point 12. Using the point's description report is recommended to help on locating the point on image. To return image to its original size, click button **Set View**. Find point's region and zoom in on it. Use button **Set Point** to measure point 12.

If you have measured more than four ground control points, you can choose in table **Point Coordinates** the four you want to use to execute E.O., by clicking the corresponding field, that will be marked with an "x". To proceed with

External Orientation calculation, on main menu choose the option **Execute** and then **Exterior Orientation** or press **Ctrl+O** as shown in figure 8. A window will appear asking about the quantity of iterations, as shown in figure 9. After selecting **Ok**, a new window is shown, asking about parameters precision for the parameters as shown in figures 10 and 11. Again, selecting **Ok** the calculation's result is shown with values corresponding to the Xa vector (E.O. parameters matrix and its variance-covariance matrix (MVC(Xa))), as in Figure 12, La Matrix (adjusted observations matrix) and V (vector of residuals) as shown in figure 13.

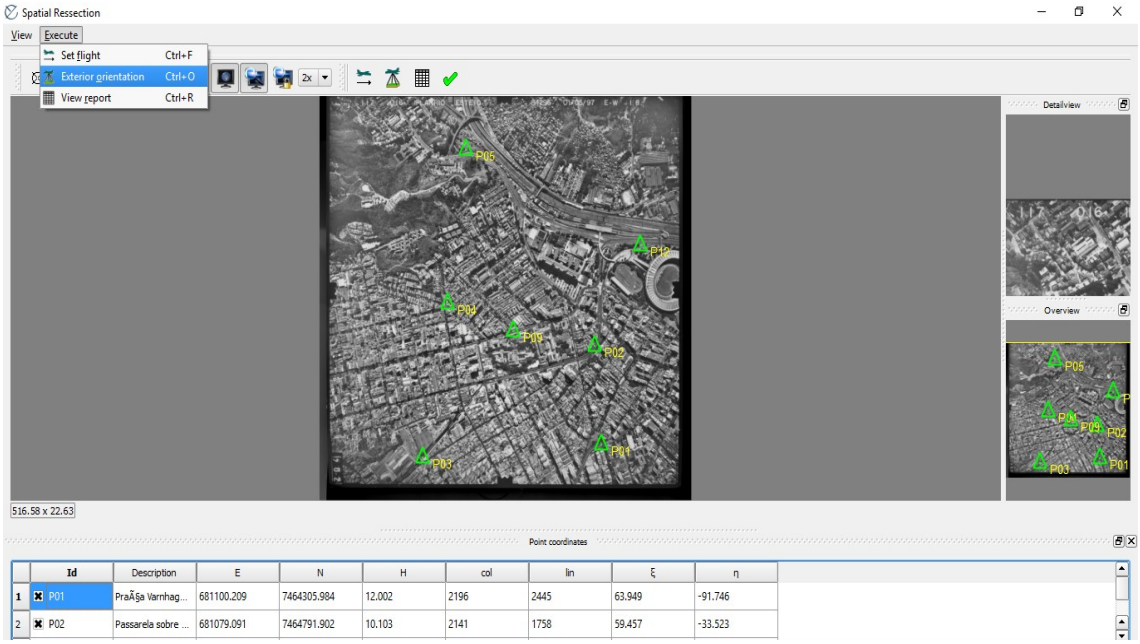

Figure 8 – The execution of the exterior orientation

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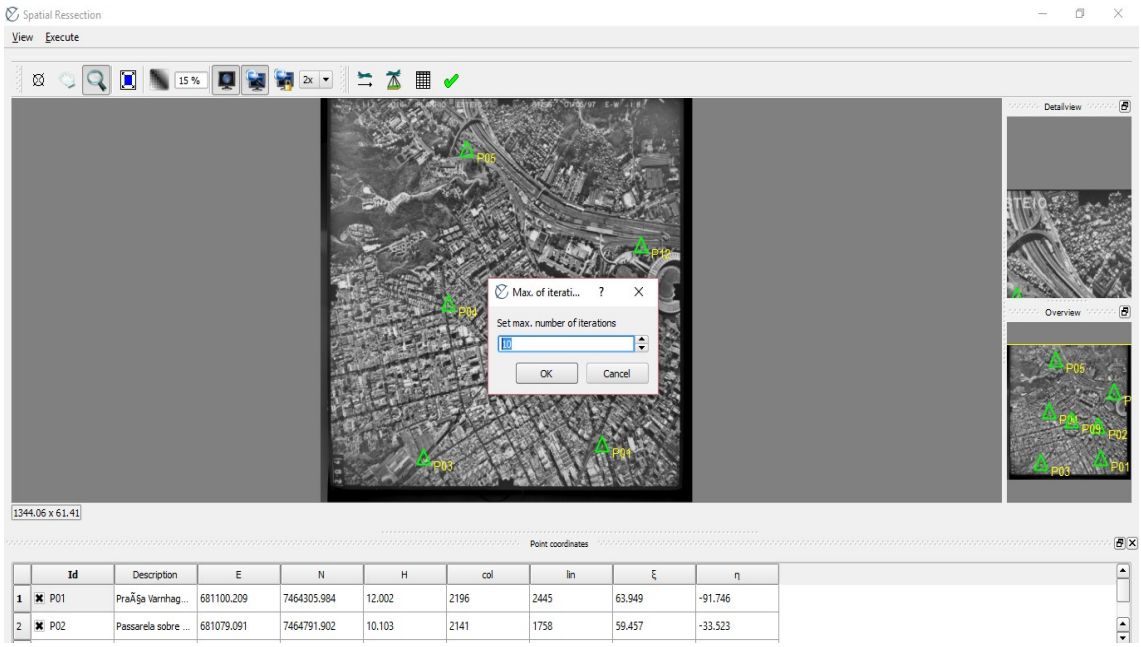

Figure 9 – The selection of the number of iterations of the calculation

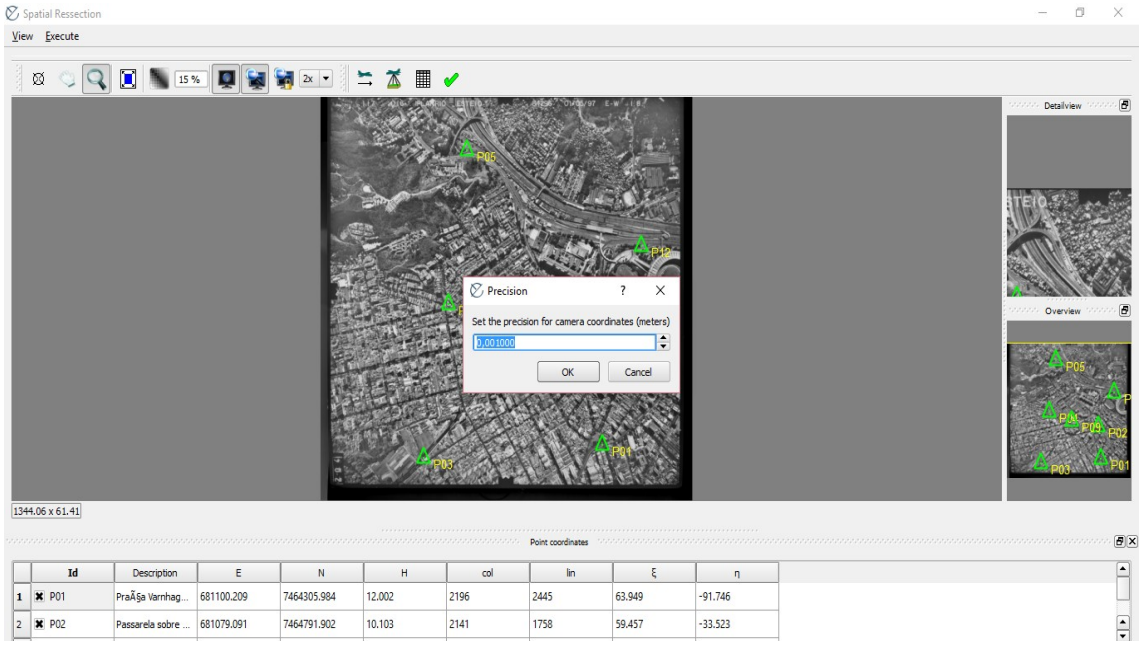

Figure 10 – The selection of the precision for camera coordinates

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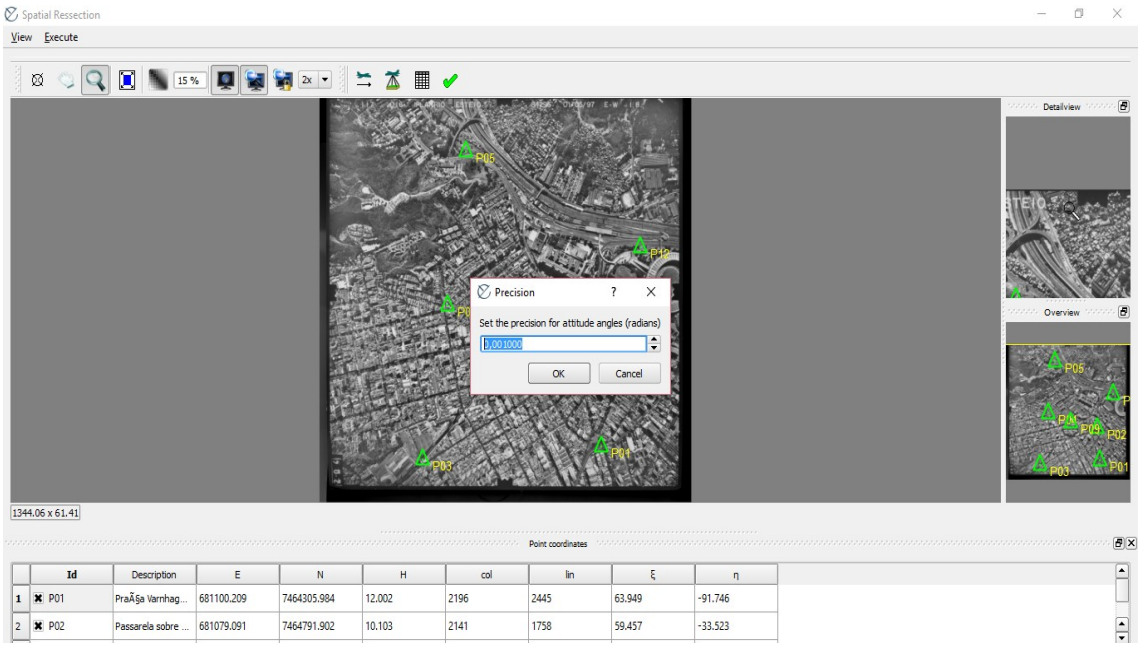

Figure 10 – The selection of the precision for the atitude angles

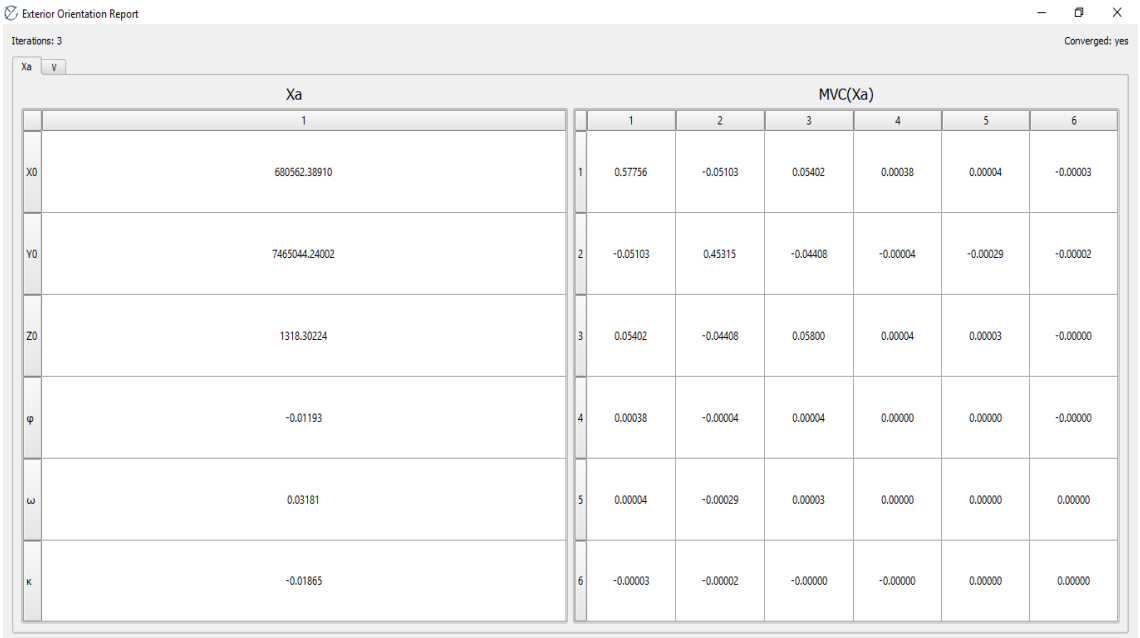

Figure 11 – The Xa matrix and its variance-covariance matrix

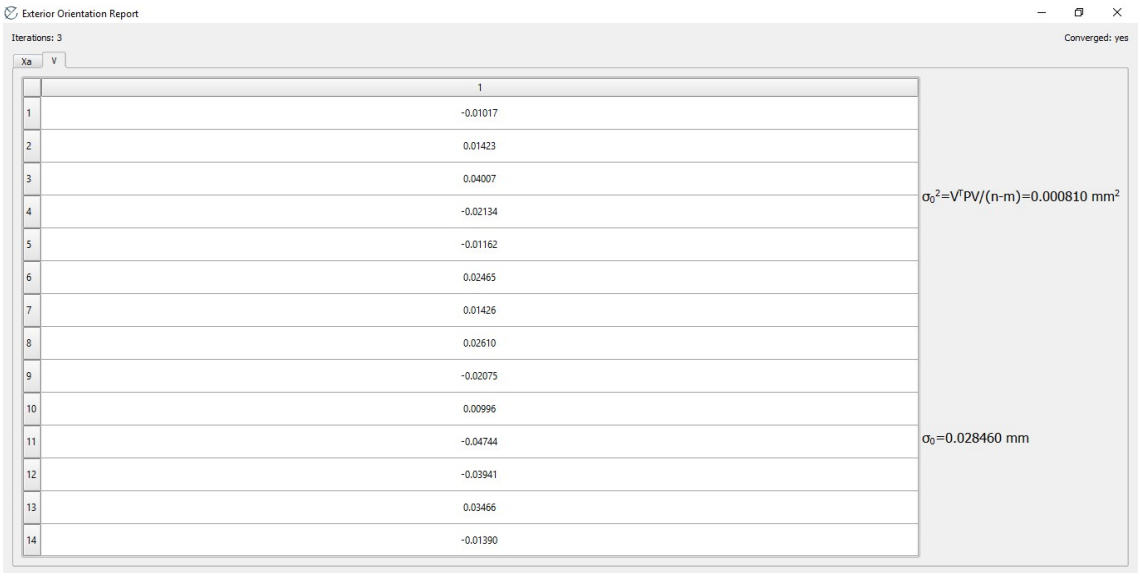

Figure 12 – The V vector

From now on, you should check the results and accept them, if you consider they are ok, by selecting **ACCEPT**. If you find necessary to remove any control point from calculation, go back to the table, reselect it and run E.O. calculation once again. When you get a satisfactory result, click button the **ACCEPT.** Close the main window and, on the main menu, in selecting **Project** then **Save File.**

Click on Images on the tree menu and, in the area beside, information on images with Interior and Exterior Orientations will appear. Those are identified with a check mark as in figure 13.

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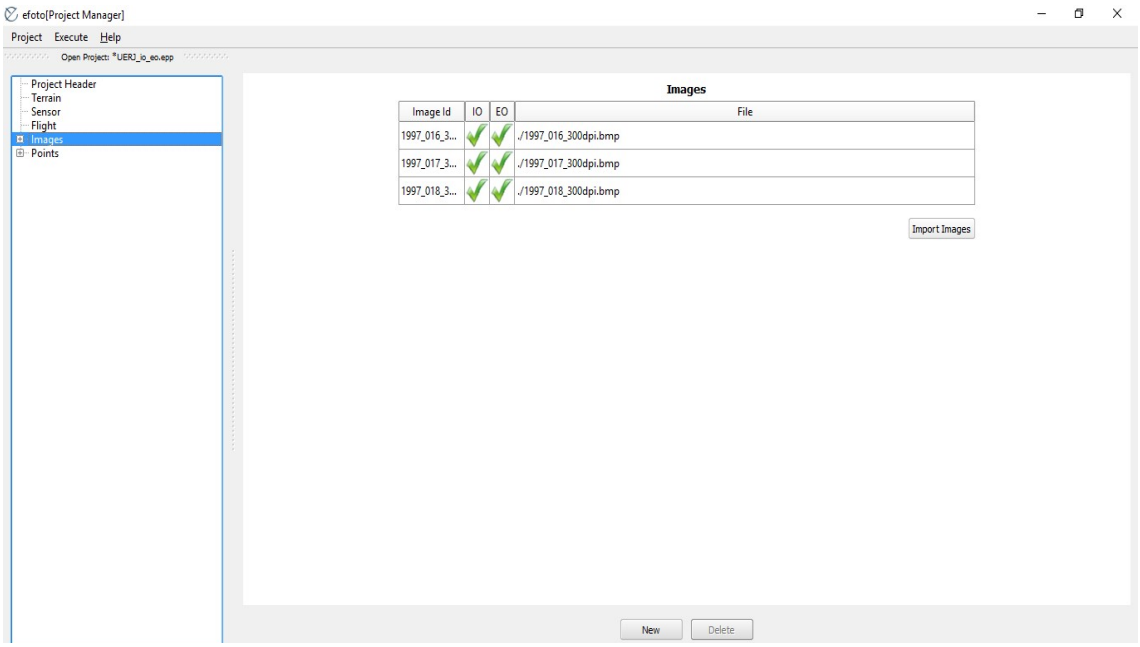

Figure 13 – The information about the images on the main menu

Now it is necessary to repeat the process for all images of your project.

Any contribution for correcting and improving this tutorial is very welcome. Please send your comments and/or sugestions to the e-foto team at http://www.efoto.eng.uerj.br/forum

<END OF TUTORIAL>