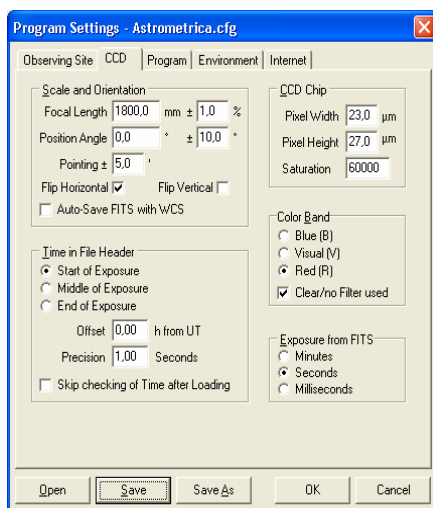


Finding the right settings for your Images

Before one can process his or her own images with Astrometrica, the correct settings for the software need to be found. New users sometimes have difficulties with finding these settings, so I will describe a way to find reasonably good values here in some detail. I will focus on the most relevant settings for processing the images successfully. For description of other parameters in the program settings, please refer to Astrometrica's help system.

Getting started

First, open the program settings and switch to the go to the 'CCD' tab. Enter the nominal focal length of the telescope, and set the Position Angle to zero, assuming that the images have north up. Set the variations for these two parameters as small as possible, but as large as required. As a rule of thumb, $\pm 1\%$ for the focal length and $\pm 5^\circ$ for the image orientation are sufficient in most cases.



*Astrometrica Program Settings,
CCD tab*

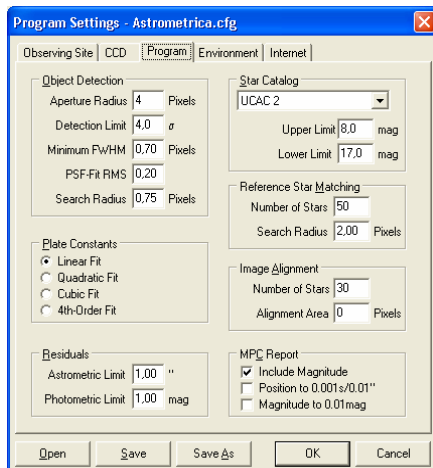
Then, set the pixel size of the CCD camera, and the saturation level. When using a CCD with a resolution of 16 bit, the saturation level usually is 65'535 ADUs. However, after subtraction a dark frame, saturated, the saturated pixels will have lower values, so you may want to set this to 60'000 first.

Set the other values, which tell the software in what color band you CCD camera works and how the timestamps in the image file header should be interpreted, according to the specifications of your CCD camera.

Now, load a CCD image. If you find it either to be upside-down or mirror-reversed, check the 'Flip Horizontal' or 'Flip Vertical' checkboxes, respectively, and load the image again. To check the image orientation, it might help if you load an image of a well known galaxy or of a similar object, so you can compare the image orientation with a star atlas or a computer planetarium.

Now, open the 'Program' tab of the program settings. In the section 'Object detection', you can specify the parameters that are used by the software to find stars, minor planets and comets in your images, and to reject spurious detections.

To get started, set the aperture radius to match the size of stars in your CCD image. I recommend setting the detection limit not too low at first, so you may want to try a value of five or six sigmas. Set the minimum FWHM to 0.7 pixels (so single bright pixels will be rejected) and the PSF-Fit RMS to 0.2. We will fine-tune these parameters later.



*Astrometrica Program Settings,
Program tab*

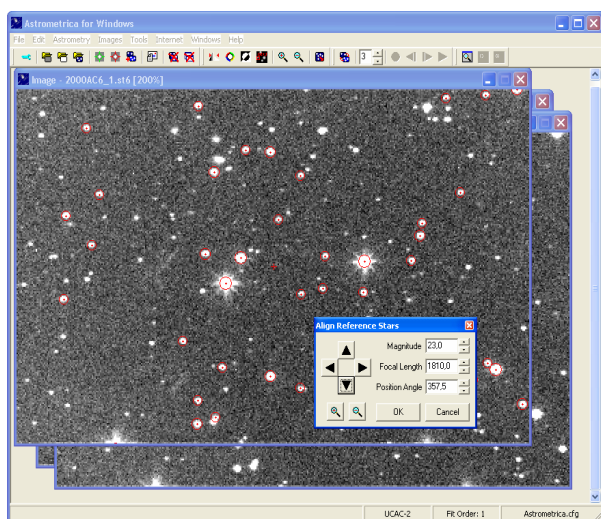
In the 'Star Catalog' section, set the upper magnitude limit so it matches the saturation limit in your images – stars that are saturated in the image and thus are not used in the astrometric solution should not be present in the data set for the reference stars. Set the lower limit according to the approximate limiting magnitude of your images. Or maybe you want to consider using a brighter magnitude cutoff, to avoid faint reference stars.

In the 'Reference Star Matching' section, you can set the parameters for the automatic reference star match. At this time, set the 'Number of Stars' to zero. This will tell the software not to attempt a automatic reference star match, but rather ask the user to match the stars read from the reference star catalog and the stars in the image manually, giving us the chance to check our settings.

In the 'Image Alignment' section, you can set the parameters that are used to align the individual images for blinking and for stacking. Usually, using 30 stars is enough for aligning the images. You may want to consider specify a zero for the alignment area, which tells the software to scan the complete images for alignment. If you have a slow computer, however, you might restrict the alignment area to, say, 512 pixels (square), and thus speed up the image alignment.

Processing the first set of Images

Now, we are ready to work with our first set of images. I recommend using a pair or triple of images, because by comparing the detections in more than one image, the software can separate real objects (which should appear on all images) from spurious detections (which are sometimes visible on a single image only). Also, I recommend using images that are not crowded with too many stars, as this will make it easier to manually match the stars from the catalog with the images.



Manual reference star match

Load the images, and process them using the 'Astrometry – Data Reduction' command. The software will first extract the stars from the image, and then ask you to match the stars read from the reference star catalog and the stars in the image manually: The stars from the reference star catalog appear as a red overlay on the image. Move the overlay, and change the focal length and position angle until it matches the star in the image as good as possible. Note the focal length and position angle, and if necessary, change the values in the program settings accordingly. Don't be surprised if the focal length you have set to match the stars differs from the nominal focal length of your telescope...

After accepting the reference star match, you should see the processed image, with the "good"

reference stars marked with green circles, the "bad" reference stars marked with yellow circles, and other stars marked with blue circles.

Now you can go back to the program settings, and change the focal length and image orientation, if needed. Also, set remove the 'zero' in the 'Number of Stars' for the 'Reference Star Match', and specify a value between, say, 30 and 50. Note that the automatic reference is a rather difficult computation, so increasing the number will also increase the time needed to process the images substantially.

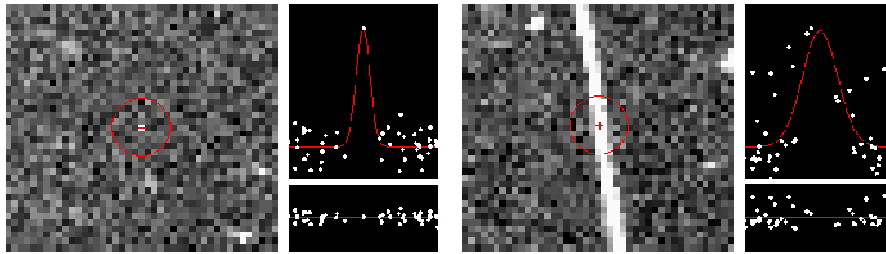
Now, start the Data Reduction process again. The software should now be able to match the reference stars automatically.

Fine tuning the object detection parameters

You can now try to fine-tune the object detection parameters, so the software will be able to detect faint objects and to reject spurious detections and image artifacts.

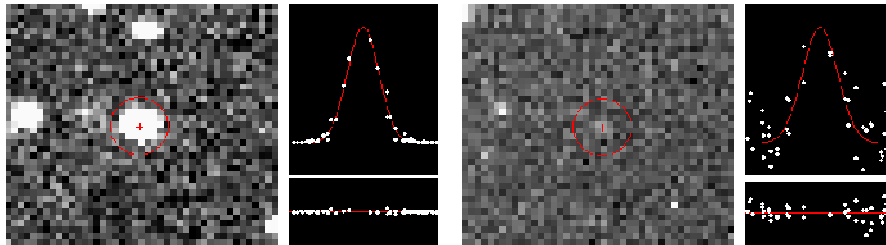
To do so, solve a "typical" set of images with the preliminary parameters you have found in the way that was described above. Go to the 'Image – Select Markings' menu and turn all markings (including unidentified detections) on. Now you closely inspect various sources in the images, and note their SNR, FWHM, and Fit RMS. By comparing these values for various detections (including both real objects and false detections), and also from objects that were not detected by the software, you can possibly improve the values specified for these parameters. Try to find values that separate real objects from spurious detections with the highest possible confidence level. Note that it will not be possible to detect all (even very faint) objects without getting false detections, and vice versa, so you have to find some compromise.

Also, you may want to check the saturation limit (in ADUs) and the approximate magnitude of saturated stars in your images and set the saturation limit and the upper magnitude limit for reference stars in the program settings accordingly.



Two false detections, found in the same image as the two stars shown above.

At left is a single bright pixel (hot pixel), for which a FWHM of 0.87pixels is found. At left is a satellite trail, for which the Fit-RMS is 0.24. The two false detections can be rejected without affecting real detections by setting the minimum FWHM between 1.0 and 1.5, and the Fit-RMS to about 0.22.



The quality of the PSF fit decreases for fainter sources. The Fit-RMS, which indicates the quality of the PSF fit, is 0.02 for the bright star shown at left, but 0.20 for the faint star at right. The FWHM found for these objects is 2.0 and 2.2 pixels, respectively.

If the automatic reference star match fails:

- Check the focal length and image orientation specified in the program settings. You may also want to decrease the variations allowed for these two parameters – set them as small as possible, but as large as needed.
- Check the saturation limit, and the upper magnitude limit for reference stars. The two settings should match, so that stars that appear saturated on the image are also excluded from the reference star data.
- Increase the number of stars used for the match. Generally speaking, larger images, and frames crowded with stars will need a higher number of stars used to find the match than smaller fields with less stars.

If the Image Alignment fails for blinking and/or stacking:

- Increase the Alignment Area, or specify a value of 0, which makes the software to use the complete image for alignment.
- Increase the Number of Stars used for the alignment.