StarMicrometer

Bill Smith 2020

Introduction

StarMicrometer (SM) is a Java application program (or *app*) for astronomers who use digital cameras with a live-view capability to take astro-photographs with equatorially mounted telescopes. The SM app allows the user to take measurements of the separation between stars in a live image, just as they would using a physical micrometer at the eyepiece of the telescope. The app has a built-in calibration procedure which quantifies measurements for any particular optical set up.

The SM app is supplied in the form of Java jar file (StarMicrometer.jar) which should be immediately executable on any computer that supports Java 1.7 (or later versions), such as computers using MS Windows or Linux operating systems. An essential requirement of the operating system is that it supports the concept of *transparent* windows.

Installation

After the SM app has been downloaded, locate the StarMicrometer.jar file and place it in a known directory of your preference. This completes the installation insofar as you now have all you need to run the SM app - provided your system is properly configured and up-to-date.

In the first instance you should check you have the correct Java version on your computer. For example, from a command window you can type the command

java -version

If you have Java installed this responds with a statement about which version of Java you have, make sure it is version 1.7 or higher. If you don't have a suitable (or any) version of Java you will need to download and install it. A simple internet search for Java for your particular operating system will provide the required version and explain how to install it. This is a simple procedure on most Linux or Windows computers.

Next you can run the SM app itself by typing in a command window located in the app host directory the following

java -jar StarMicrometer.jar

This should then open up the SM panel on your desktop (see Figure 1). Details on how to use it are given below.

If you access the SM app through the desktop file manager rather than through the command window, it is worth first just double clicking on the SM jar file to see if it starts up the app. Both Linux and Windows can do this if they are suitably configured. A possible issue here is that the jar file is not marked as executable, so make sure of it by right-clicking on the file and accessing (and amending) its permission settings.

A more sophisticated way of activating the SM app is to set up a desktop starter (also called a launcher) so the app can be started by clicking on a desktop icon. Different operating systems have different ways of creating such a starter tool. A full description is impractical here, but launchers are generally easy to set up after a little reading of the system documentation. (The subsequent convenience makes it worth the effort!)

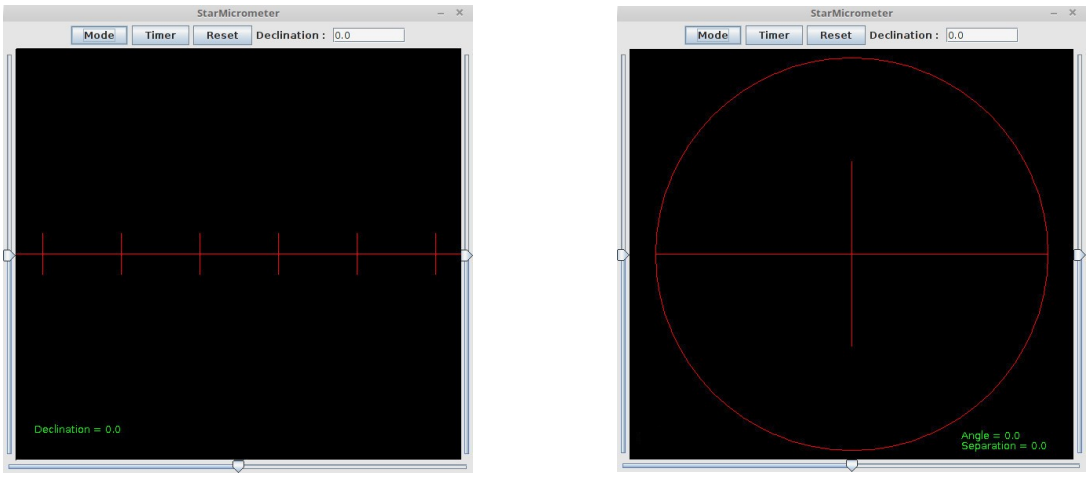
The biggest issue you may face when starting the app is a message which says:

Transparency is not available on this device.

Fortunately, this is an unlikely problem on Windows computers but it can happen with some versions of Linux. Unfortunately it means the SM app cannot be used properly on your computer because Java cannot open transparent windows. Nevertheless, if you click the OK button on the warning panel, the app will usually start anyway and you can at least check out how it is intended to work. Hopefully you can find another computer that allows you to to use it properly.

How the App Looks On-Screen

When the app first starts its panel looks as in Figure 1(a). This is the panel in



(a) (b)

Figure 1

calibration mode, showing a horizontal line with six vertical tick marks, the purpose of which is described below in the section headed 'Calibration'.

At the bottom and sides of the panel are found sliders which are used to adjust different properties of the panel. The vertical slider on the left adjusts the transparency of the panel. The right and bottom sliders of the panel are described in the following paragraph. In calibration mode, neither of these sliders is operable.

A click on the **Mode** button at the top left of the panel switches the app to *micrometer* mode shown in Figure 1 (b), which is used to measure star separations on-screen. This mode features a circular reticle with vertical and horizontal crossed lines. The arrangement of these can be changed using the bottom and right hand sliders, which become active in micrometer mode. The sliders adjust the micrometer angle and separation. The manner in which these are used is described in the section below, headed 'Using the Micrometer'.

The **Mode** button is one of three buttons at the top of the panel. The others are **Timer** and **Reset**. The functions of these will be described in the appropriate places below. Also at the top of the panel is a text box, by means of which the user can enter the declination of the star selected for the calibration of the app (see next section.) The text box is redundant in micrometer mode.

Calibration

Calibration mode is immediately active when the SM app is started up. The user can however toggle between the calibration and micrometer modes by clicking on the **Mode** button.

Calibration is necessary when using StarMicrometer to establish the relation between micrometer measurements and the actual separations between the stars in the sky. This takes the form of an internal conversion factor that is computed from the calibration data and can then be used throughout the observing session, provided there is no change of equipment or alteration of the software settings from the original set up. It is important to note that any attempt to change the size of the astronomical image window *after* the SM app has been calibrated will invalidate the calibration. In such cases it is essential to re-calibrate! It is good practice for the user decide how big the live astro-image needs to be on the computer monitor *before* starting up the SM app, and then keeping the image size fixed thereafter.

It is possible to use StarMicrometer without calibration. In which case the separations between stars are calculated in arbitrary units. It is then up to the user to determine the conversion factor to convert the measured distances into more suitable units such as arcseconds by hand calculation. The conversion factor is obtained by measuring the separations between stars for which the actual separation in arcseconds is known. The numerical ratio of the true separation to the value obtained using the micrometer is the required conversion factor. However the for performing a calibration procedure is relatively simple so it is worth doing to avoid unnecessary work.

To begin calibration, start up the SM app and adjust the transparency of the panel using the left hand slider. The intention is to be able to see through the panel to whatever is behind it on the desktop. (It is all right to change this setting from time to time to get it right for you.) If your system permits it, set the SM panel to be permanently on top. This prevents you having to do this repetitively yourself.

Next decide which prominent star you wish to use for the calibration. Preferably (but not essentially), choose one near the celestial equator. This will make calibration quicker. Find out what the declination of the star is in *decimal degrees* (e.g. using a convenient planetarium app such as Stellarium) and enter this number into the text box at the top of the SM panel. Press the **<enter>** key on your keyboard and make sure the number you entered appears in text at the bottom left of the SM app.

Now centre the telescope on the chosen star. Replace the eyepiece with the astro camera, re-focus, and start up the camera control software. When the live image appears on-screen, identify and centre the target star then drag the SM panel over the star image so that the star is somewhere on the horizontal line of the calibration screen.

Switch off the telescope RA drive and watch the motion of the star across the screen. If it deviates from the horizontal line, turn the camera at the telescope until the star moves constantly on the line. Note the direction in which the star moves along the horizontal line. This will define the East to West direction in the live image.

Restart the RA drive and slew the telescope so that the star lies on the extreme Eastern edge of the calibration panel and then stop the RA drive once again. The star image will now move along the horizontal line in the East – West direction. As it does so, it will pass over each of the vertical ticks in turn. Every time it passes over a tick, click on the **Timer** button at the top of the SM panel. (Note that every click displays the recorded time at the top left of the SM panel in units of seconds.) Six clicks will be necessary to gather all the required timing data. A seventh click on the **Timer** button starts the calculation of the conversion factor, using an optimal fit to the timing data you have generated. The result is stored internally. Do not close down the app or the calibration will be lost. It is all right to minimize the panel however.

At this point the calibration is complete and the SM app automatically switches to micrometer mode (Figure 1(b)). The calculated conversion factor appears at the top right of the SM panel for reference and is designated 'Scale'. You may wish to keep record of this to compare with values obtained on different occasions, with different reference stars. (They should all be the same if you use the same set up.)

Using the Micrometer

Calibration establishes a fixed relation between the SM app and the live image on the computer monitor, which means the telescope can now be swung to any point in the sky to make use of the micrometer. A typical screen view should resemble Figure 3, where the SM app is, ideally, positioned centrally over the live view. The transparency should be adjusted so that the stars and the reticle of the SM app are equally prominent.

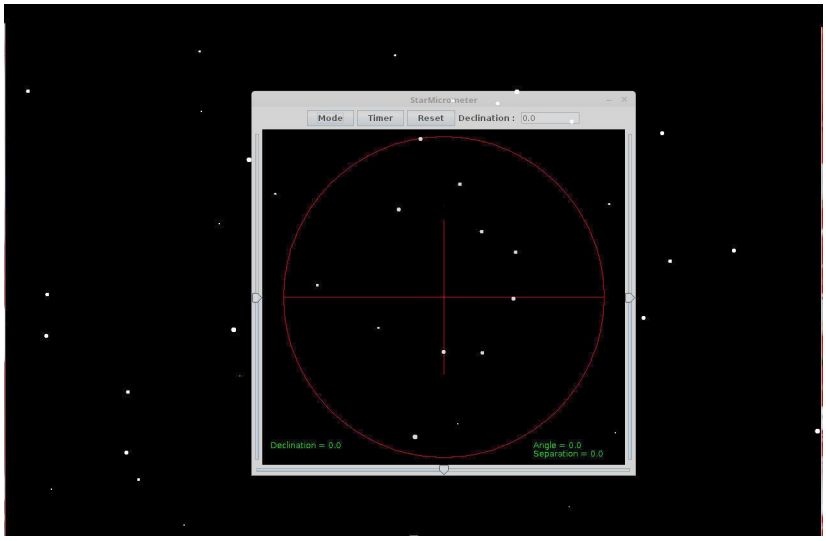


Figure 3

To determine the separation between two stars, first use the fine controls of the telescope to put one of the stars on the centre of the crossed lines in the SM reticle. Small movements of the SM panel itself on the screen to help achieve this are permissible, but excessive movements can cause problems, such as taking the panel control buttons and sliders off the screen.

With one star properly centred, the second star must be found within the large circle of the reticle. It is a limitation of the app that it cannot calculate the separations beyond this range, but if this occurs, see what can be done in the Additional Comments section below.

If the second star is within the circle, the reticle can now be rotated using the slider on the right hand of the SM panel. Drag and release the slider cursor repeatedly until both stars appear to lie on the rotated diameter. Note that fine adjustments of the slider can be made by making single clicks on the slider track, either side of the current position of the slider cursor.

When the two stars are on the diameter, then by using the bottom slider a new line perpendicular to the diameter can be dragged away from the centre of the diameter so that it lies upon second star, as in Figure 4. Once again, fine adjustments can be made if required. When this is finally done the separation (in arcseconds) between the stars appears on the bottom left of the SM panel, along with the angle (in degrees) that the pair of stars make with respect to the East – West line. Some caution is required in interpreting the latter quantity, since the optics of the telescope may not project the normal relation between the quadrants of the North-East-South-West plane. The user will have

to determine this according to the optical set-up and make the appropriate correction.

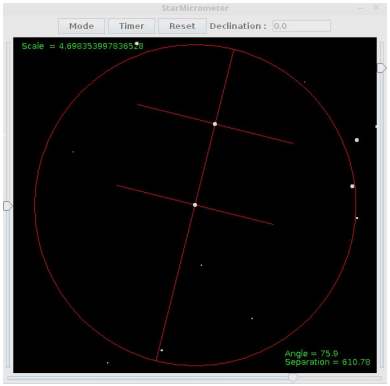


Figure 4

Once a pair of stars has been measured, clicking the **Reset** button will clear the micrometer ready for another determination.

Additional Comments

1. *Using a previously defined calibration.* If you always use the same equipment and use a live view screen that is always the same size, it should not be necessary to recalibrate the reticle every time you start a new session. If you make note of the scale factor (viewed at the top left of the app's screen) you can enter the number appearing as a parameter when starting up the app as follows:

   java -jar StarMicrometer -S *scale_parameter*

   where *scale_parameter* is the required calibration factor. Further to this, you would be wise to record the scale factors from several previous sessions and enter the average value as the parameter. The average will be a better statistical estimate of the true factor.

2. *Transparency is not supported.* In some Linux versions transparent windows/panels can be activated in the system preferences, so it is worth looking into this. (It appears not to be possible for Raspian Linux on the Raspberry Pi, alas.) For users of Linux Mint, placing the mouse cursor over the panel header and working the mouse wheel, alters the panel's opacity in the required way, so the transparency control in the app itself is unnecessary. (See comment 5 below for further information.)

3. *The pair of stars is outside the range of the micrometer.* This arises when, having placed one star at the centre of the reticle, the other star is outside the reticle circle. Two possible solutions follow, but note that both of the changes below will require a re-calibration of the SM app.

   a) Changing the optical coupling between the camera and the telescope. One obvious thing to try is to insert a *focal reducer* into the optical

train. This will reduce the magnification of the image and hopefully bring the target stars within range of the SM app. If you are already using eyepiece projection or afocal coupling between the camera and the telescope, you should consider using an eyepiece with a longer focal length, or even removing the eyepiece altogether. As a last resort, use another telescope!

b) Resize the reticle. This cannot be done once the SM app has been invoked you must restart the app using the command

java -jar StarMicrometer.jar -R *newsize*

where -R is a 'resize' flag and *newsize* is the new size in pixels. The default is 600, so choose some value larger than this. Note however, if you make it too big, you will not be able to move the reticle around much on the monitor, so beware.

4. *The optical field of view is non uniform.* It is self evident that the uniformity of the field of view provided by the telescope is an essential requirement for accurate results. However, non uniform fields of view are common with many telescopes designed for human eyes, which are forgiving of distortions that become apparent in a photograph. The practical cure for this is to put a *field flattener* into into the optical train. Often these devices offer *focal reduction* as well, which is useful for other reasons (see item 2 above).

5. The author's experience of Linux Mint is that window transparency is not accessible via Java. However, it is possible to control the transparency of the SM app in another way. Firstly, go to the System Settings and select the Windows settings. On the panel that opens go to the option titled '*Action on title bar with mouse scroll*' and choose '*Adjust opacity*'. Then close the panel and start up the SM app with the command:

   java -jar StarMicrometer -X

   where X is a flag indicating that you are using Mint. When you start up the app, you should find that placing the mouse cursor on the title bar and then turning the mouse scrolling wheel, will alter the app's transparency. (The app's slider for this purpose will be ineffective).

6. *Using multiple input parameters.* In the above comments is shown that the SM app will accept up to three different input flags: -S, -R (both with numbers following) and -X. These may be entered in any order (though both -S and -R must be followed by the required numbers) and both upper and lower case can be used.