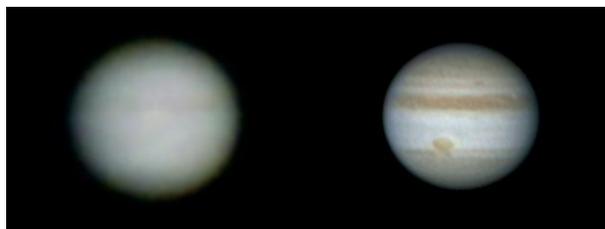


Webcam Imaging with Small Telescopes

With webcams and freeware like *Registax* readily available, many owners of small telescopes have been trying to image celestial objects. The Moon, the Sun, bright planets like Jupiter or Saturn and double stars are the favourite targets. Most of the times, the enthusiastic beginning astrophotographer is deeply disappointed.

Images of lunar craters lack detail, Jupiter is a mere bright blob showing nothing more than perhaps one or two belts at best and Mars' polar caps are hardly discernible. The reason for these low-resolution results surely isn't bad image processing software. For example, *Registax* is a highly sophisticated piece of software that operates nearly automatically. Neither can the optics be



Typical small-telescope image of Jupiter as it can be found everywhere on the web

This is how an image of Jupiter made with a 3.5" telescope can look like

blamed. Most amateur telescopes in the 4-inch class are fitted with high-quality optics that allow diffraction-limited imaging. So why does it seem to be so hard to obtain high-quality webcam images with small telescopes? The answer is simple: Most casual imagers pay way too little attention to the imaging process itself.

Tune your imaging process: When it comes to astronomical imaging, a simple rule applies - what the source lacks cannot be processed into the result. With webcam imaging, the source is the video file you capture with your telescope/webcam setup in the field. The consequence is: There is every reason to make sure that this webcam video file has the highest possible quality. The following hints may give you a clue how to reach the turning point in your solar system imaging.

Wait for good seeing: There is a myth that webcams overcome bad seeing conditions. This is only partially true. Although it is correct that even under bad seeing conditions your video file will include some good frames, you'd better go for a large amount of good frames. This is only possible when seeing conditions are excellent. Even under good seeing conditions, an object elevation above horizon of at least 30 degrees is necessary to get a satisfying result. Only on some very special nights with exceptional seeing conditions this value may be a little lower. In any case, always image the object at the highest possible elevation above the horizon. If this means to wait, then wait. Also remember, after midnight the seeing often calms down. In most nights the second half of the night is the best period for imaging planets or lunar detail. If you have to capture your video in the evening or morning (e.g. when imaging Venus or Mercury), shoot within one hour of sunset or sunrise.



Lunar crater Clavius shot in April 2009 during perfect seeing conditions with an ETX-90 working @ f/28, f=2500mm, ToUCam Pro, IR-UV cut filter

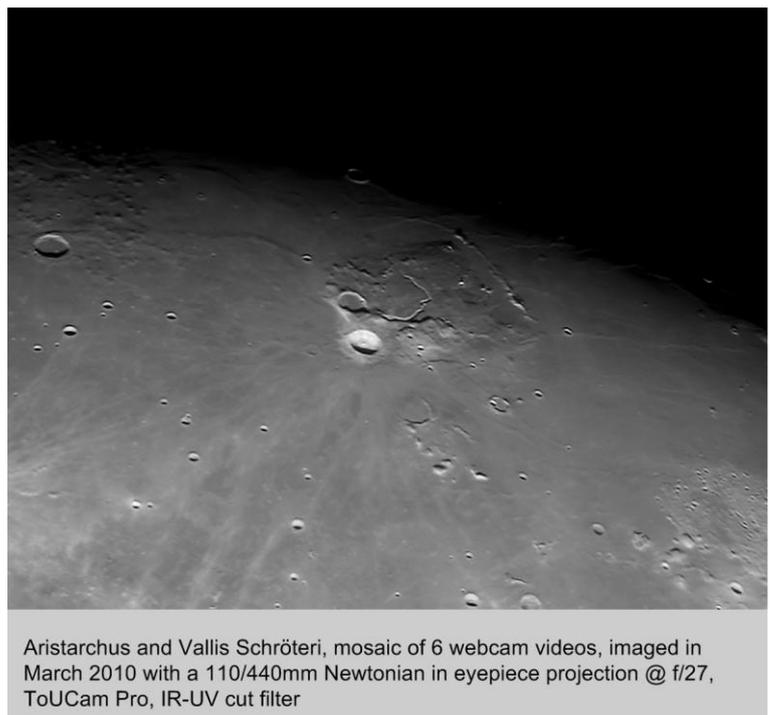
Let your telescope cool down: Small telescopes are not as much plagued by tube seeing as larger scopes are. Nevertheless, also small scopes have to cool down to ambient temperature to perform satisfactorily. The simple rule is, bring your instrument outdoors in time, especially if you are using a Newtonian design. Even for telescopes in the 4-inch class a cool-down time of at least one hour is strongly recommended.

Focus carefully: One of the most critical factors for capturing high-resolution webcam videos is to image at the correct focus. The authors have seen amateurs focusing by simply sliding the webcam in and out of the focuser drawtube. This is surely not the way to focus for a high-resolution planetary image. Some simple math shows that at f/25 a webcam chip with a pixel size of around $5\mu\text{m}$ must be placed within 0.1mm of the telescope's focal plane. Consequently, a lot of effort must be taken to find the best focus. We recommend taking several minutes for this task, focusing, de-focusing and focusing again, until the best possible image is steadily visible on the computer's monitor. Very small bright features like a Jovian moon or a lunar crater peak can be useful for this important step. Remember that your stacked result strongly depends on how crisp the individual frames of your webcam video are.



Use an IR/UV cut filter: Your webcam is sensitive to wavelengths in the ultraviolet and infrared part of the spectrum. These wavelengths tend to blur all channels (red, green and blue) of your webcam video. Therefore, an IR/UV cut filter should be used to block these wavelengths. IR/UV cut filters are available from most telescope dealers. If you bought your webcam from a telescope dealer, chances are that your webcam already came with a 1.25" IR/UV cut filter.

Collimate your scope: Even short-focus instruments like an f/4 Newtonian are capable of imaging the planets, however, they are quite sensitive to collimation errors. Many amateurs with short-focus instruments believe that their telescopes are not usable for planetary work. In most cases, the optics are quite fine, they are just out of collimation. The best way to find out whether your scope is in collimation is the star test. Refer to your instrument's manual or to web resources to find out how to star test and how to collimate your short-focus instrument.



Adjust your focal length: Optimum angular resolution can only be achieved when the smallest resolvable detail covers two by two of the webcam's pixels or more. With most small telescopes and webcams, this is the case when the focal ratio is around $f/20$. To estimate the needed focal length, simply multiply your telescope's aperture with 20.

Consider eyepiece projection: Most webcam imagers use Barlow lenses to extend the focal length to the desired value. With short-focus instruments a 2x or 3x Barlow may not be enough. In this case, eyepiece projection is a valid alternative. Especially if you already own a high-quality planetary eyepiece this method boosts your effective focal length at no extra cost. You only have to find a way to mount your webcam several centimetres behind the eyepiece. We wouldn't recommend duct tape, but for testing your configuration this will work.

Use a high-quality Barlow: Even if your telescope is no short-focus instrument, the standard focal length will not be enough to capture the smallest possible details. In this case, a high-quality Barlow lens will work best. Low-cost Barlow lenses suffer from chromatic aberration, which becomes visible as coloured fringes around bright objects. They also introduce ghost images and reduce contrast noticeably. For webcam imaging, always use the best Barlow available.

Try special filters: As mentioned above, colour images gain contrast when exposed through an IR/UV cut filter. For special applications, other filters are worth a try. Our Sun, for example, is best imaged with a combination of a full aperture solar filter and a so-called solar continuum filter. Both are sold by Baader Planetarium in Germany. For Venus' atmosphere, a violet filter can be helpful. And the other planets respond well to an infrared pass filter, if the luminosity channel is to be recorded separately from the RGB channels.

Use flatfields: Especially when imaging solar or lunar detail, proper image calibration with a flatfield is necessary. Otherwise the inevitable dust specks on the webcam chip will show up prominently. With webcams it is quite easy to produce flatfields. Simply point your scope at something uniformly bright, like the early evening sky. Set your webcam to auto-exposure and capture a video of several hundred frames. Use this video file in programs such as *Registax* to generate a flatfield, which you later apply in your stacking process.



Jupiter with the Great Red Spot and two of its moons shot in April 2005 with an ETX-90 working @ $f/28$, $f=2500\text{mm}$, ToUCam Pro, IR-UV cut filter

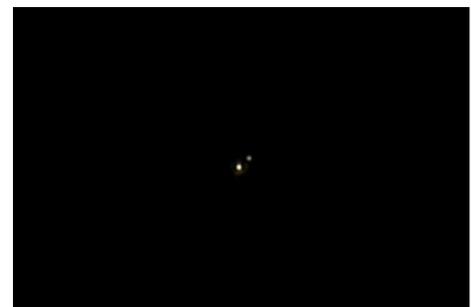


Sunspot and solar granulation in August 2005 with an ETX-90, ToUCam Pro, Baader solar continuum filter, image artificially coloured

Switch to polar mode: Today, computer-aided telescopes with GoTo functions are quite popular, even amongst beginners. If you own such a scope, you are probably using it in the standard alt-azimuth mode of operation. For webcam imaging, it is a better choice to switch your GoTo telescope to the equatorial (or polar) mode. In this mode, the telescope's mount needs to use only one axis for tracking. Therefore it will be much more reliable in following your imaging target. Refer to your telescope's manual on how to operate it in polar mode.

Polar align carefully: Whether you are using a GoTo or a conventional equatorial mount, always polar align carefully. If the hour axis of your telescope is too far off the celestial pole, object tracking won't perform satisfactorily and your target will drift out quite fast of the webcam's small field of view. This makes focusing and recording videos an almost impossible task.

Set the correct exposure value: When trying to record a well saturated source, many beginning webcam photographers have the tendency to overexpose their video files. Overexposure means that there are regions in the image that have brightness values of 255. Within such regions, no object information will be recorded. When processing a planetary image with such overexposed areas, the result always looks unnatural. To avoid overexposure, make test shots to find the correct exposure for your object.



Double star Gamma Leonis (separation 4.4")
imaged in March 2010 with a 110/440mm
Newtonian in eyepiece projection @ f/27

Collect enough frames: To obtain a good signal-to-noise ratio, a simple rule applies: The more frames, the better. For a high-quality planetary image, one or two hundred frames won't be enough. Videos with one or two *thousand* frames have a much better chance to contain the information you want to record. Thin low-contrast bands on Jupiter, tiny lunar rilles and subtle shadings on Mars are the kind of details the *Registax Wavelets* will bring out if you provide a video file with a sufficient number of frames.

Use the highest possible frame rate: When imaging a planet, the time span for recording your video is limited by the planet's rotation. For example, webcam videos of Jupiter made with a small telescope should not exceed three minutes. If you record longer, planetary rotation will smear the details in the resulting image. Therefore, it is necessary to use the highest possible frame rate. This way you will be able to record the largest number of frames possible within a given time period. 30 fps (frames per second) is a typical value that will be working fine with most computers. The frame rate can be set manually in the video driver of your webcam.

For more information on digital astrophotography, tests and tools visit the author's astronomical website project-nightflight.net