Shoot the Sun, Moon, and planets

Surprisingly simple cameras will let you capture the solar system. **by Michael A. Covington**

In recent years, high-resolution photography of objects within our solar system has gone through a revolution. Imagers no longer use film and try thousands of times to get one lucky shot. Instead, they shoot streams of video and use software to select, align, and stack the sharpest frames, taking advantage of moments of steady air the way a visual observer does. The resulting amateur images are often as good as those taken from professional observatories.

The camera

The traditional video camera used for astroimaging is a low-end webcam with the lens removed and a telescope adapter fitted in its place. Nowadays, you can buy similar cameras ready-made for astronomy, such as the Meade Lunar Planetary Imager, Orion's StarShoot Solar System Color Imager, and many others. Just like webcams, these cameras do not need cooling or elaborate controls. Their power comes through the USB cable that connects them to the computer.

Amateur astronomers can also choose higher-grade planetary cameras from the Imaging Source, Lumenera, and other vendors. Such units have better sensors, more rugged construction, and more sophisticated control software.

All these cameras fit in a telescope's focuser and record about the same field of view as a 6mm eyepiece. A 640x480 sensor is big enough because planets — even Jupiter — appear small. You might want a slightly larger sensor in your camera if you plan to use it with a 12-inch or larger telescope, but you won't need the multiple-megapixel units that are desirable for deep-sky work.

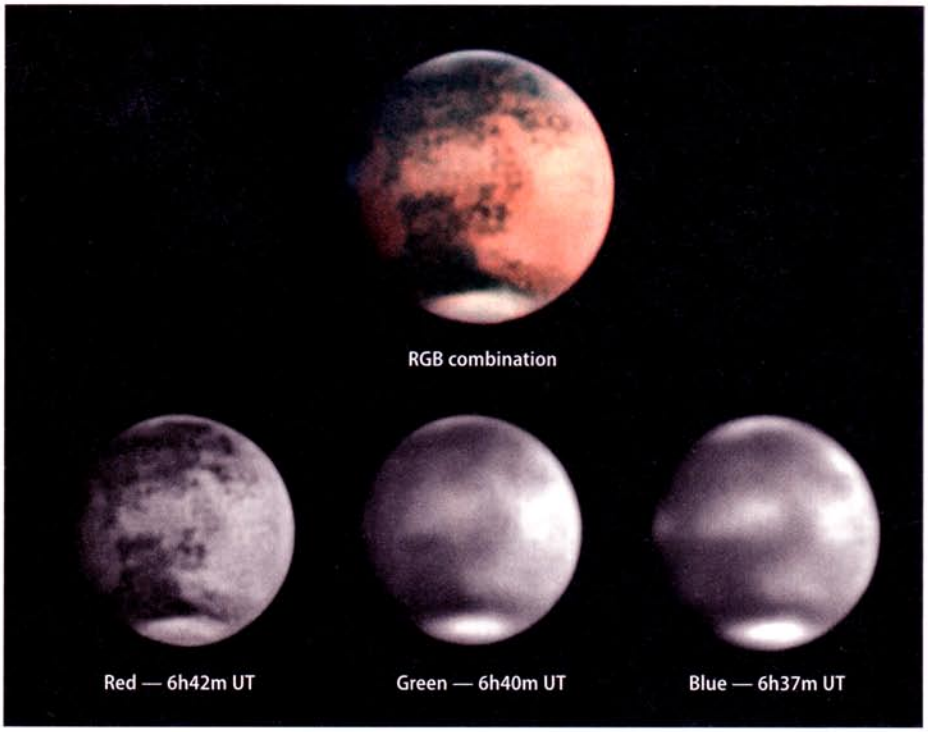
Most of these cameras produce color images the same way a webcam does — using a matrix of pixels sensitive to red, green, and blue light. For higher quality, you can use a monochrome camera and take each picture three times, through red, green, and blue filters.

The Imaging Source offers three lines of cameras: monochrome (DMK), color (DFK), and color without an infrared-blocking filter (DBK). The last of these requires a separate infrared-blocking filter to give realistic color images, but you have the alternative of using a visible-light-blocking, infrared-passing filter (deep-red) to take pictures that record infrared (IR) radiation. Some imagers prefer an IR filter because the "seeing" (a measure of the atmosphere's steadiness above your camera) is often better in infrared than in visible light.

The pixel size of video astrocameras is a good match to the diffraction-limited resolution of a telescope at focal ratios between f/20 and f/30. That means you'll need at least a 2x Barlow lens with an f/8 or f/10 telescope. With my f/10 Schmidt-Cassegrain, I normally use a 3x Barlow to give f/30. When imaging Saturn, which is not as bright as Jupiter or Mars near opposition, I use a 2x Barlow and work at f/20. That combination produces a brighter but smaller image.

Conditions

The main challenge of planetary observing is atmospheric unsteadiness. Experi-



These images of Mars, taken December 30, 2009, from Coral Gables, Florida, included the description: "Bright terminator cloud south of Meridiani; Clouds over Chryse and Tharsis, S. Limb; 'Lifesaver Effect' in NPC; Possible dust streak along western NPC edge." Such images prove that amateur astronomers using video cameras can record lots of planetary detail. Donald Parker

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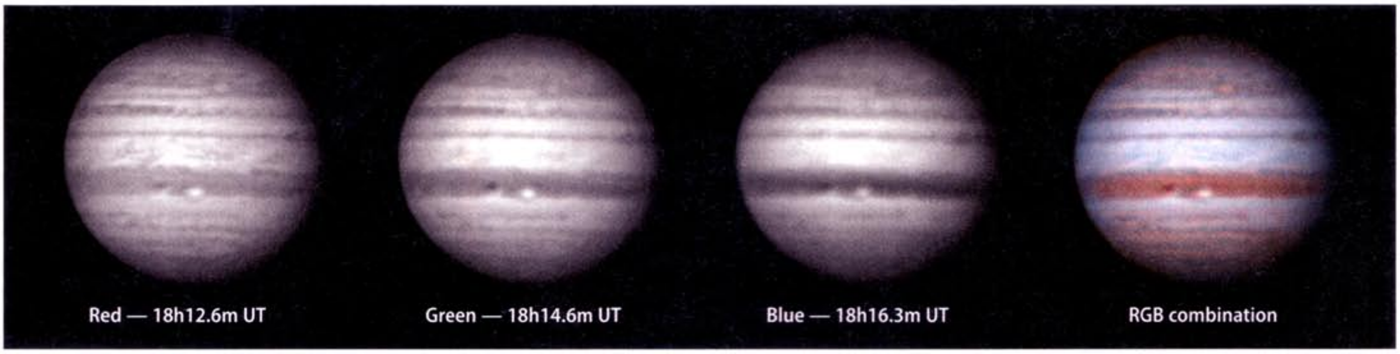


To make the color image of Jupiter, the photographer captured the giant planet through red, green, and blue filters, and then combined them into the single image on the right using software. He shot these through an 8-inch Meade LX200 Schmidt-Cassegrain telescope at f/32 and a Lumenera SKYnyx 2-0M CCD camera January 15, 2011, at the times shown, from Tournefeuille, France. Marc Delcroix

enced visual observers keep staring at a planet, making the most of brief moments of clarity. The trained observer's brain also can reconstruct, at least partly, the sharp image that he or she would see if the air were calmer.

Image-processing software also can do both of these things. By selecting and stacking the best video frames, it simulates good seeing. And with other techniques, it can sharpen the image.

Even so, it's best for the air to be as steady as possible. A slight haze can be good, extremes of hot and cold are bad, and a clear sky is often an unsteady one. Your telescope must be in thermal equilibrium with the air, so leave it outdoors in the shade for a couple of hours before doing critical planetary work.

The immediate surroundings of the telescope also matter. Observing over a cliff is best, over grass is all right, and over hot pavement is unacceptable. Because my permanent pier sits at the end of a driveway, I placed a plastic picnic table just south of it. This blocks the hot air rising from the pavement and improves the view considerably.

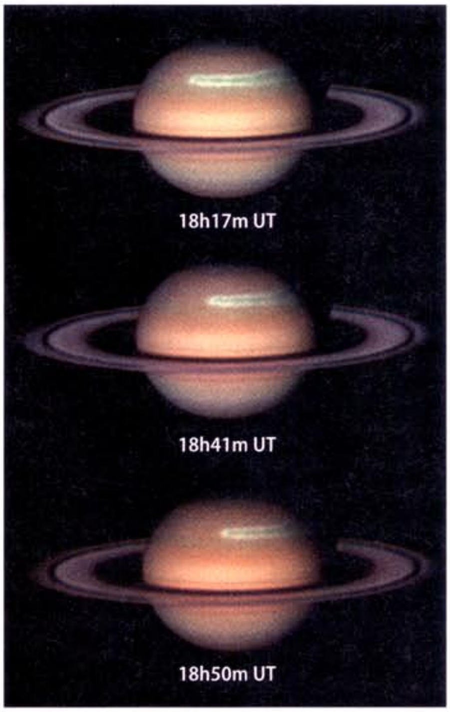
I also find that a Kendrick dew heater running at low power helps maintain a steady view in a refractor, even when there is no dew. The reason is that the front lens of the telescope actually gets colder than the surrounding air because of its low thermal conductivity. It therefore radiates heat faster than it can regain it by conduction. Warming the lens slightly to match the air temperature helps keep the image steadier.

This is the fifth and final part of Michael Covington's imaging series.

Exposures and time limits

To get a properly exposed image, you must have the correct integration time, a setting equivalent to shutter speed except that there is no shutter. You can find this by experimentation. As a starting point, assume your video camera's "speed" is comparable to ISO 400, but expect wide variation. Set the camera's gain and contrast to the middle of its range unless you're imaging a faint planet, for which you'd set it in the upper end of its range.

I often have better luck with slightly longer exposures (like 1/10 second) rather than shorter ones, but this depends on atmospheric conditions. Some software includes an auto-exposure feature that works well with planets. If yours doesn't, set the exposure manually rather than letting the computer take wild guesses. When in doubt, underexpose somewhat because you can restore dim areas by stacking images, but overexposed areas are irrecoverable.



This Saturn series shows what astronomers call the Northern Electrostatic Disturbance, a huge storm in the ringed planet's northern hemisphere. The imager used an 11-inch Celestron Schmidt-Cassegrain telescope and a Point Grey Flea3 FireWire CCD camera February 6, 2011, from Cebu, Philippines. Christopher Go

You must also choose the number of frames per second your camera shoots. Typically it's 15 or 30. Make sure the frames aren't shorter than the exposures. If you select 30 frames per second and each frame is 1/20 of a second, most of them will record more than once, and the duplication does no good.

You also get to choose the video format, called the codec. The best choice is to record uncompressed or minimally compressed video rather than using heavy compression. For specifics, consult the documentation for your camera and software. Note that Microsoft AVI is not a video format; it's just a type of "container file" that can contain video encoded many different ways.

The planet's rotational speed limits how much video you can use in your image. A reasonable limit is the time it takes for the planet's rotation to smear central details by half an arcsecond as seen from Earth. The formula for this is: time (in minutes) = the planet's rotational period (in hours) x $(60/\pi)$ x apparent diameter of planet (in arcseconds).

That works out to about 2.5 minutes for Jupiter, 5 minutes for Saturn, and 15 minutes for Mars. You can see why multifilter work is popular with Mars but somewhat unfeasible with Jupiter. In practice, you can do a bit better than