Chapter 1
Introduction to Webcam Astrophotography

1.1 Some Background

The idea that charge-coupled devices, or CCDs, have completely revolutionized the field of professional and amateur astrophotography over the past several decades is no longer up for debate. It is a fact. Starting in the late 1980s, commercially available CCD cameras began making significant inroads into an area of astronomy that had been dominated by film photography for over a century. Early CCD cameras possessed relatively small imaging sensors that translated into small, pixilated fields of view. This keyhole perspective on the universe, coupled with high cost and new and complex operating procedures that required the use of a computer, made the transition to digital imaging an expensive and challenging option.

By the 1990s, computers were a common item in most homes and could be adapted to amateur astronomy as quickly as a new eyepiece design. The price of electronic gadgets also declined and the price of entry-level astronomical CCD cameras soon became competitive with mainstream film cameras. As the 21st century arrived, digital astrophotography with CCD cameras had taken an equal footing with the older technique of using conventional film cameras to image the universe. At the same time, however, the advent of CCD imaging polarized the astrophotography community into "purists," who remained loyal to film, and "tinkerers," who saw new possibilities with digital imaging.

But the true challenge to the dominance of film astrophotography came from another direction. Consumer digital snapshot cameras have been around since the mid-1990s, but early versions were clearly inferior to film cameras for anything except lunar and planetary imaging. Then, fittingly, it seemed, with the arrival of the new millennium, Canon introduced the SLR-style EOS 30D, followed soon by the 60D, and astrophotographers around the world took note. When the long exposure-

Fig. 1.1 *This mosaic of 49 webcam images showing the January 24, 2005 full Moon is actually the inspiration that led the author to write this book. The mosaic (details on mosaic assembly are in Appendix D) was taken with a Phillips ToUcam Pro II 840K on a Celestron-8 telescope at f/10 and assembled using freeware software programs and simple webcam imaging techniques. The completed image shows greater detail than the author has been able to achieve in over 40 years of lunar imaging with conventional film and digital cameras. Photo by Robert Reeves.*

capable 6-megapixel EOS 10D and 300D cameras were released in 2003, digital imaging entered mainstream astrophotography.

Although it is fashionable to say that digital astrophotography became mainstream in the early 21st century, the basic truth is that another form of digital astrophotography had already quietly become popular with a large number of astro-imagers. Before consumer digital cameras evolved to the point of surpassing film cameras in popularity for sky-shooting, webcams had been enthusiastically applied to imaging the Moon and planets. At the same time, a number of pioneering individuals discovered that with some modifications, certain webcam models were capable of taking long expo-

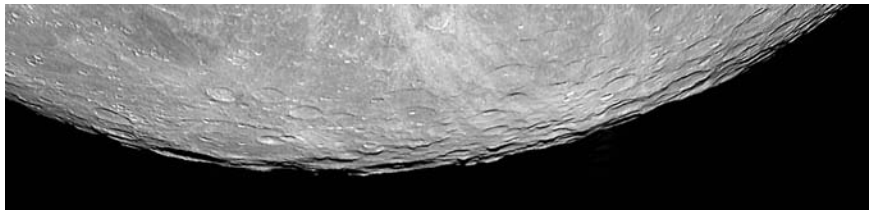

Fig. 1.2 *The cropped and enlarged southern edge of this January 24, 2005 lunar mosaic shows the amazing detail that can be captured using webcam imaging techniques. In this view benefiting from an unusually high southern lunar libration angle, the viewer is actually peering over the peaks of lunar mountains and crater rims. Photo by Robert Reeves.*

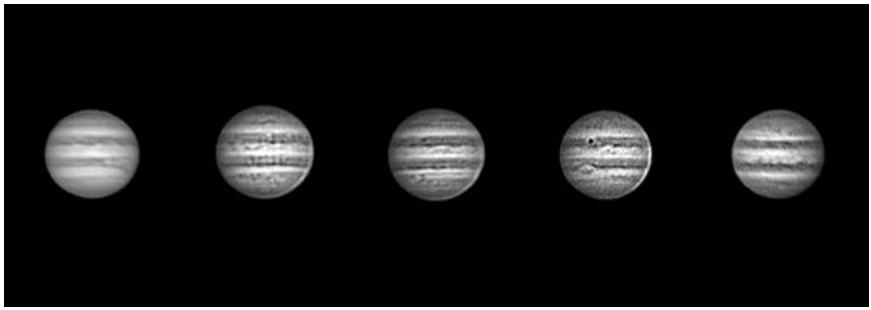

Fig. 1.3 *Jupiter should never be considered a "one-shot" target. The planet is a dynamic subject that presents a constantly changing appearance as cloud structures evolve and change in the planet's atmosphere. These images were taken over a period of months using a ToUcam 840 and a Celestron-8 telescope operating at f/10. Photos by Robert Reeves.*

sures of deep-sky objects. The results achieved with these simple little cameras were amazing. At the time, most people regarded webcams as a means of getting started in digital astrophotography without having to spend a lot of money, but they soon proved themselves to be not only simple to operate, but capable of achieving high-resolution images of the Moon and planets. Amateurs using nothing more than an 8-inch telescope and a webcam produced very NASA-like, high-resolution, research-grade images of solar system objects from their backyard!

Today, digital astrophotography has come full circle. With the adaptation of webcams to celestial imaging, we are now back to the point of using imaging devices that provide a small keyhole perspective of the universe and require the use of a computer at the telescope. But in contrast to the expensive early astronomical CCD cameras, these devices are cheap and widely available at electronics and computer outlets. Exposure times can range from $\frac{1}{10,000}$- to $\frac{1}{25}$-second, and in some cases as long as $\frac{1}{5}$-second—more than sufficient to image the brighter planets and the Moon. The resulting images can be easily processed using specialized freeware pro-

Fig. 1.4 *The astronomical webcam "family tree" is shown above. At the right is the original spherical Connectix black-and-white Quickcam that started the long-exposure webcam astrophotography revolution. The Philips ToUcam Pro II that matured webcam astrophotography is next followed by the new generation Philips SPC900NC. At the left is the Atik ATK-2HS, a commercially-modified air-cooled long exposure-capable version of the ToUcam that has allowed the novice to achieve CCD-quality electronic astrophotography. Photo by Robert Reeves.*

grams designed for webcam astrophotography and software tools widely available for standard digital photography. While their 640 x 480 pixel format is small compared to modern 8-megapixel and higher digital still cameras, when properly processed, webcam output is very high quality. This makes a webcam a great starting point for someone who wants to enter the field of astrophotography.

1.2 A New Imaging Era

Over the past several decades, a majority of consumer electronic goods have branched off a single technological breakthrough—the ability to convert analog data into digital binary data. This breakthrough has allowed the development of still and video digital cameras that have redefined the ways that we handle and process video and audio information. CDs, DVDs, HDTV, and image-processing programs like Photoshop® are some of the ways we digitally manipulate images. The webcam is a direct offshoot of these breakthroughs in electronic photography.

The name "digital" refers to the binary representation of data as bits and bytes. A bit is the smallest unit of information that a computer can store and process. It represents an electrical state of either "off" or "on"

with a value of either zero or one. The zero and one are used to create binary numbers, usually with eight bits associated together to form what is called a byte, representing a number between 0 and 255.

The digital photography term "pixel" is a contraction of PICture ELement. It is the smallest point of a bitmapped image that can be assigned color and intensity. Explaining further, a bitmap is the digital representation of a picture where all the pixels are arranged in a grid and assigned a specific color and intensity.

When they first became available to consumers, digital video cameras were costly. As they became popular and production increased, the price dropped, sometimes considerably. Webcams evolved from this technology as a low-cost digital video camera for computer video conferencing. Though small enough to hide in the palm of your hand, webcams are technologically complex devices, essentially little computers filled with imaging, memory, and processing chips as well as the optical components needed to create the image. The camera software has to handle megabytes of data every second. Additionally, the camera has to be able to network with computers in order to download the video images for display and processing.

If you want to start a good scrap between fellow astrophotographers, just ask which is best for astronomical imaging: film, digital, CCD, or webcams. In spite of the pontification of each medium's proponents, the basic answer is, "all of the above." No single medium can do all things in celestial imaging; each has its strengths and weaknesses. Film can still outperform digital media in some areas while digital-based imaging will outperform film in others. Indeed, if you want to silence the critics and supporters of each medium in the field of lunar and planetary imaging, just show them the amazing work being done on these subjects with simple video webcams. The icing on the cake is the fact that planetary images from the latest "Googlepixel" camera processed in "Pricemax" software can be outresolved by a simple webcam costing less than a good eyepiece while using free software!

The transition to all forms of digital imaging quickly overtook the astronomy community. The chemical photographic darkroom is a thing of the past. Following the publication of my first book, *Wide-Field Astrophotography*, I was invited to give many astrophotography presentations. A question I would ask the audience is how many process their images on a computer and how many still use a darkroom. In all the presentations I was privileged to give, I found a grand total of three practitioners of the darkroom arts.

While film is still cost-effective compared to the price of advanced astronomical CCD cameras, webcams are so inexpensive their use in

Fig. 1.5 *Glenn Schaeffer from Houston, Texas, uses a typical webcam planetary imaging setup. He couples a Philips ToUcam Pro II 840K to his 20-inch Obsession Dobsonian mounted on an Osypowski dual-axis equatorial platform to image the Moon and planets from his backyard. Photo by Glenn Schaeffer.*

astronomy cannot be ignored. Even those who never previously owned a film camera are attracted to the ease and instant results achieved with a webcam. Moreover, webcam imaging allows us to do some things that were not possible with film. The constant feedback from being able to view results instantly allows us to correct mistakes on the fly.

1.3 Minimum Requirements for Imaging

Now that we have seen that webcams are more than simple video conferencing devices and can be used for astronomy imaging, what is the minimum equipment you need to begin applying a webcam to lunar and planetary digital photography? Experience has shown that with good seeing and focus, and good telescope optics, a webcam astrophotographer will be able to record lunar and planetary detail that exceeds the Dawes Limit, the usual benchmark for visual capability through a given telescope. Indeed, it is not unusual to see far more detail on Jupiter with processed webcam images than can be seen visually through the same telescope under equal viewing conditions.

Fig. 1.6 *It is easier to view images when the camera's display shows north at the top. When installing the camera, orient it so the display is properly aligned to begin with. With an ATK-2HS on a Celestron-8, aligning the camera cable with the telescope focus knob aligns north at the top of the field. Photo by Robert Reeves.*

The required basics to achieve good images of solar system objects are surprisingly simple, but as with anything in astronomy, there is room to grow and expand capabilities as one's interest develops.

The requisites are:

- Any telescope with a removable 1¼-inch eyepiece.
- A good quality webcam with a CCD sensor instead of CMOS and a device to adapt it to the telescope focuser.
- A telescope mount capable of tracking a celestial target.
- A Barlow lens for additional magnification (but this is not an immediate requirement).
- A computer, preferably a laptop for easier portability.

With the exception of the adapter to allow mounting a webcam at the focus of the telescope, most amateur astronomers already possess the minimum equipment to begin webcam imaging. Now that webcam astrophotography has entered mainstream astronomy, an entire industry has evolved to supply the needed imaging adapters through the popular sources that supply our standard astronomy needs.