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Excerpt
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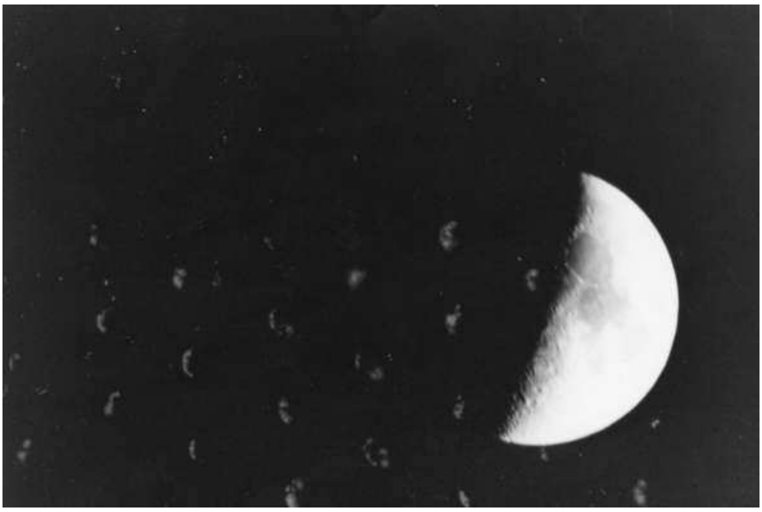
Introducing lunar imaging

1.1 Seven ways to shoot the Moon

Amateur lunar photography can efficiently record vast areas or close-ups of the Moon with various instruments: basic and apochromatic refractors, different types of reflectors, video cameras, compact, bridge, and DSLR (digital single-lens reflex) cameras, camcorders, and webcams, as well as astronomical cameras, even smartphones. As the Moon is bright and not too difficult to aim at, it can be a perfect first step to beginning astrophotography. As an example, Figure 1.1 shows the author's very first lunar image, taken with a high-performance 200-mm (8-in) telescope, a good, classic film camera, and a fine photofilm.

After having gained some experience, it became obvious that any instrument and camera should be able to capture decent images of the Moon (Figure 1.2). The golden rule is to exploit the ways in which they perform best. All instruments have a more or less limited field of possibilities; some are excellent for specific subjects. The trick is to match the instrument with the right filter, the right camera, and the appropriate method to successfully shoot the Moon.

Figure 1.1 The author's very first lunar image, taken with a 200-mm (8-in) telescope and a film camera. It shows almost all possible flaws: bad framing, multiple reflections, overexposure, motion blurring, incorrect focusing . . .



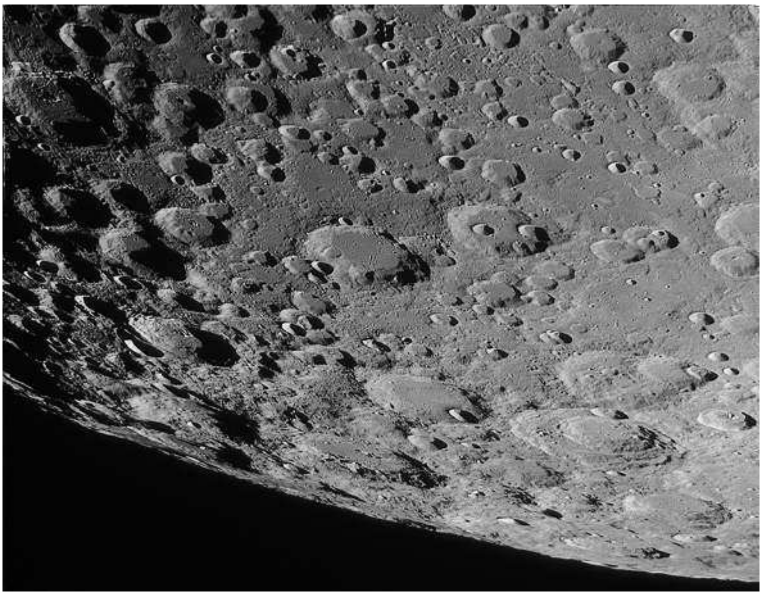


Figure 1.2 Some years later, the author obtained decent close-ups of the Moon with some cheaper – although a little larger – equipment. The image is centered on 33° E, 68° S.

Experienced amateurs occasionally reach a 400-m resolution on the Moon, or even slightly better. No professional Earth-based telescope, with conventional film (or plates), was able to reach such a resolution. But modern telescopes fitted with digital cameras no longer image the Moon. This is because, for several decades now, professional planetology has relied mostly on interplanetary probes (alongside some of the greatest Earth-based telescopes with adaptive optics and orbital observatories studying today's targets such as Jupiter's moons). But amateur equipment and original techniques have evolved during the same period.

There are numerous ways to shoot the Moon. The observation site matters, and so does the aperture of the telescope, but *imagination* is the most important factor that gives rise to pleasing images. In this book, we will have in-depth, practical views of these techniques, how to fix some optical and mechanical flaws, and how to fit the optics to the camera (whatever kind it is, as summarized in Figures 1.3 and 1.4), and then we will learn how to process the images to unveil bright, tiny craterlets as well as charcoal-dark, ancient lava-fountain deposits. We shall admire the incredible variety of lunar landscapes, to learn about the history of the Solar System or, more simply, to scrutinize the closest extraterrestrial world.

We will see that a number of mechanical adapters can help to marry various optics, imaging devices, and mechanical parts.

- Smartphone (behind a small telescope, finderscope, spotting scope . . .).
- Camcorder (alone or behind a small telescope).
- Compact or hybrid still camera (alone or behind a telescope).

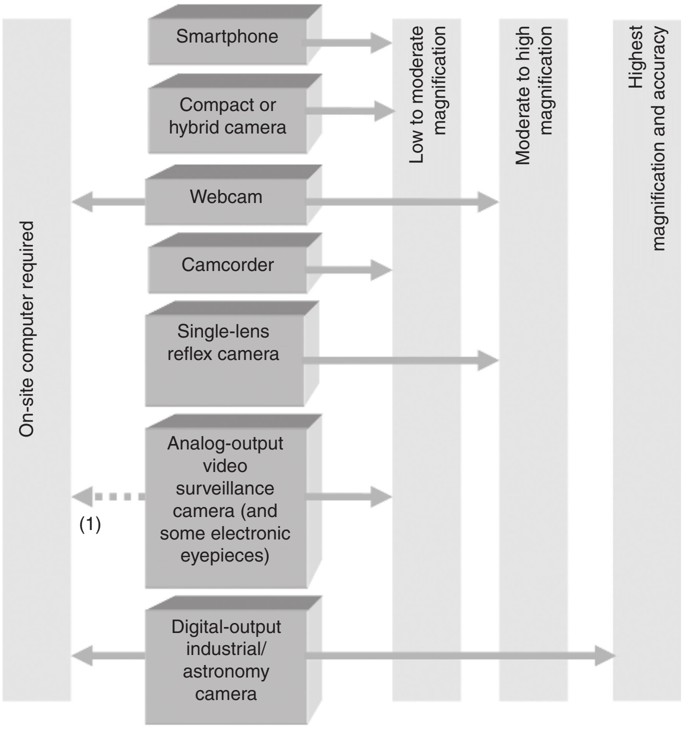


Figure 1.3 Common and specialized imaging devices and their possible scopes, whatever the optical equipment is. (1) Requires a video “grabber” (Section 2.13).

- Webcam (with a photolens or directly attached to a telescope with high magnification).
- Analog-output video camera with an analog-input monitor or a computer with a video grabber (directly attached to a telescope).
- Single-lens reflex camera (on its own or directly attached to a telescope).
- Digital-output industrial/astronomical camera (with a photolens or directly attached to a telescope).

This is now the second step of the debate. Which optics and combinations can be imagined, or are feasible, and when do they perform at their best? Any imaging device requires a lens. It can be included, removable or not. Many combinations are possible; e.g. a smartphone is self-sufficient but performs better with a telescope.

1.1.1 Beginners’ equipment

We can start by holding a smartphone behind a small refractor (see Figures 1.5 and 1.6): the smartphone is simply put behind the eyepiece, instead of our eye. Star parties provide ideal opportunities to shoot the Moon for the first time.

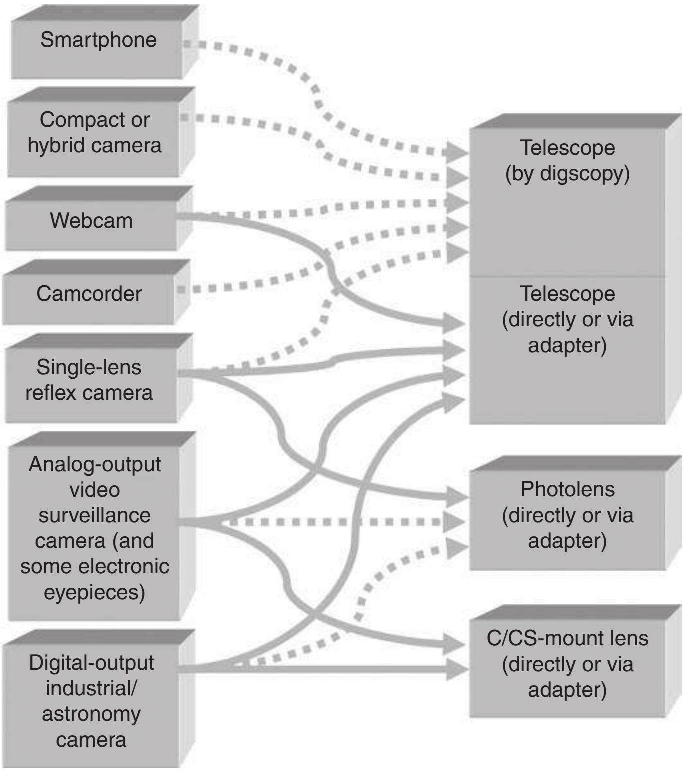


Figure 1.4 Combining imaging devices and optics. Dashed arrows indicate "plan B" or rare combinations.

A \$30 webcam attached with the help of heavy-duty, opaque adhesive tape to a simple \$90 refractor (Figure 1.7) shows surprising images of large craters, mountains, and maria. This is a reasonable expense to obtain our first lunar close-ups with a moderate magnification.

Many lunar subjects do not require a telescope: a lunar halo, a lunar eclipse, the basics of celestial mechanics illustrated by apparent movement variations of the Moon, a bright planet next to the Moon, the reflection of the Earth's sunlit side lighting up the dark side of the Moon, landscapes in moonlight, lunar phases . . . Most of these subjects are accessible to a common, \$160 compact camera with a 60-mm zoom[1] or more (16× or 20× optical zoom). A more powerful bridge camera equipped with a 200-mm zoom (50×) provides wider possibilities in setting (especially manual focusing) and more detailed, smoother images. Lunar subjects need the use of a tripod, or you can place the camera on a low wall or at the edge of a

[1] We always mention the real optical characteristics, that is, the effective focal length of the photolens. Vendors often mention the equivalent 24 × 36 focal length, e.g. 250 mm in place of 60 mm. This is because sensors of compact cameras are smaller than those in DSLRs, leading to this equivalence.

Figure 1.5 Shooting with a smartphone held by hand behind a small refractor equipped with an 8-mm eyepiece. The mount was undriven (like a simple, sturdy photo tripod). Image by Catherine Port.

Figure 1.6 The image is processed to gently enhance contrast and sharpness. The Moon is upside-down as viewed from the northern hemisphere through numerous astronomical instruments. This was the only rescued image out of twelve blurry, fuzzy, cropped, and overexposed still images.

table, orientating the camera by placing it on a piece of folded fabric. The installation has to be reasonably firmly secured by keeping the strap around one's wrist; heavy-duty adhesive tape is also useful in many cases.

1.1.2 Intermediate equipment

This means a "standard," portable telescope: a 90–200-mm (3.5–8-in)-diameter reflector (an example is shown in Figures 1.8 and 1.9), an 80–110-mm (3–4-in) ED/apochromatic refractor, or a 100–150-mm (4–6-in) achromatic refractor. Such equipment performs well for earthshines, conjunctions, and lunar eclipses with a rather large field of view and a moderate to high magnification. An experienced astrophotographer may have to spend $550 to $2500 for the whole setup, not

Figure 1.7 The housing of the webcam is partially removed to unscrew its lens (the plastic housing is fragile and opening it voids the guarantee). Then the webcam, with its bare sensor, is attached to a small refractor with no eyepiece with the help of heavy-duty, opaque adhesive tape. The refractor is placed on a stable video tripod, allowing you to acquire decent still images, although the tripod cannot compensate for the diurnal motion.

including the computer. The ease of use and the total weight and bulk matter as much as the price, and the best instrument is the one we can use with pleasure.

Shooting lunar close-ups requires the following:

- a debut “planetary” camera ($70–110) or a better-performing, monochrome planetary camera (starting from $230);
- or a DSLR ($400, not including the lens);
- or a webcam (for cheapskate astrophotographers, $25);
- a laptop or desktop able to perform mid- to high-speed image capture ($450), even if it doesn’t do so well at heavy image processing, especially stacking (the latter may be batch-executed, while we are sleeping);
- a fine, 127–200-mm reflecting telescope (starting from $425);
- and its motorized mount (starting from $470) with its tripod, to cancel the apparent motion of the Moon and to facilitate the orientation of the telescope because the camera has a very narrow field of view.

The mount is sold separately or with the optical tube. A German-type equatorial mount is better suited to astrophotography for all subjects, and it can be useful even without a telescope, for instance to shoot lunar eclipses with a camera and a telelens.

Figure 1.8 A widely used, intermediate-level telescope. With a compact design, a light weight, a motorized mount, and stable, good optics, it delivers very sharp images given the aperture.

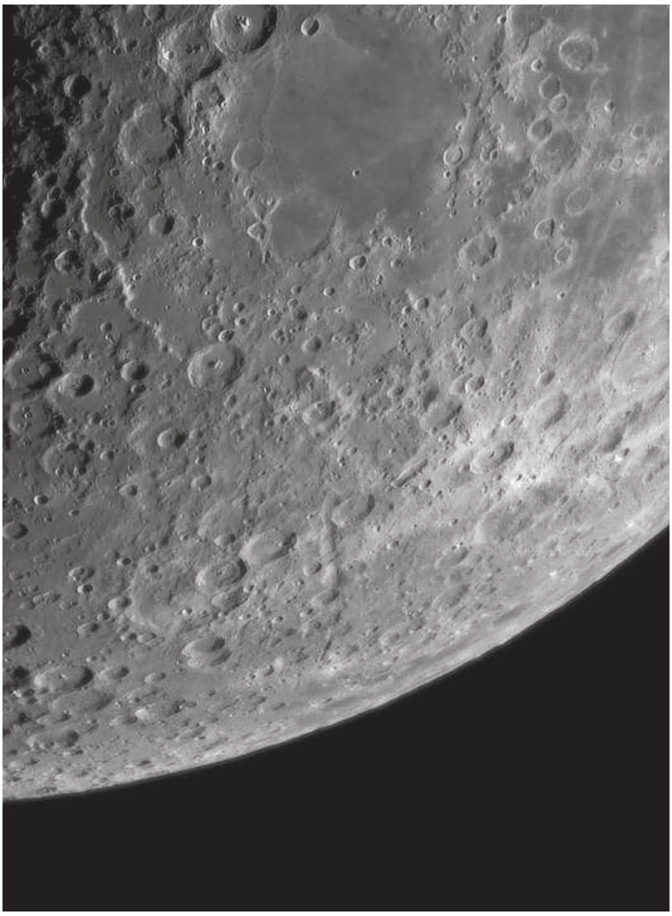


Figure 1.9 This image is from a processed movie taken with a planetary camera directly inserted into the eyepiece holder of the compact, 90-mm motorized telescope shown in Figure 1.8. Given the long focal length of this kind of reflector, known as a Maksutov–Cassegrain reflector, along with the tiny photosites of the camera, the direct adaptation offers appreciable magnification and pretty good sharpness. Despite its undeniable optical quality, the magnification of the telescope is limited by its diameter (41° E, 30° S).

Bigger telescopes perform better, but they are more expensive, cumbersome, and heavy. In addition to this, they are more sensitive to turbulence and wind; their mirrors need to be controlled often (taking some tens of seconds) and possibly aligned (taking a few minutes, with experience). They have typically 180–250-mm apertures, and they weigh 30–50 kg (they can be broken down into components weighing 2–15 kg).

A telescope is not mandatory; numerous subjects need the following:

- a DSLR with a good 300-mm photolens ($1700) or a good compact or hybrid camera ($300+);
- a sturdy photo/video tripod ($220);
- or, for taking images or movies of lunar eclipses, a mount with one motorized axis and a counterweight, for loads of up to 2 kg ($300) or up to 8 kg ($550 with no GOTO[2]).

1.1.3 Advanced equipment

An experienced astrophotographer may purchase more expensive equipment:

- a high-end planetary camera (typically $450–2800);
- a 15–30 kg, 280–350-mm (11–14-in) catadioptric OTA (optical tube assembly) ($2500–8000),
- or a 250–400-mm (10–16-in) Newtonian telescope ($800–6000)
- and its motorized, sturdy mount ($1800–4700 for lunar imaging[3]),
- or, alternatively, a 50–80-kg, 400–600-mm (16–24-in) collapsible and motorized Dobsonian telescope ($3800–10 000);
- various accessories (filters, correctors . . . $350–1700) with an optional car battery;
- a reasonably good laptop or desktop (about $800) for high-speed image acquisition and processing;
- and it helps to own a backyard in a dry, high-altitude desert with a permanently steady atmosphere.

This is not entirely true. Experience shows that affordable 250–300-mm (10–12-in) telescopes (Figure 1.10) offer a good mean diameter to achieve high-resolution imaging. Although they have a limited resolution, they are less sensitive to wind and turbulence than are telescopes with larger diameters: some tens of nights of good atmospheric conditions per year can be exploited. Telescopes of diameter 350 mm and larger deliver their best lunar images about five nights per year from common locations (in the suburbs, in the countryside, or at the seaside).

This may seem surprising, but high-end, high-cost, apochromatic refractors are not often mentioned in this book. This is because, despite their image quality indeed being magnificent, the average diameter seldom exceeds 120 mm (180-mm and even bigger apochromatic lenses exist . . . at an astronomical cost), resulting in a relatively moderate resolving power; so they cannot compete with low-cost, large-aperture telescopes when the atmosphere is calm. The author exploited a 150-mm

[2] A computerized mount, able to automatically aim at (“go to”) a celestial object after an initialization step. A motorized mount does not require a GOTO facility to track the Moon. This functionality may be disengaged for the sake of simplicity.

[3] Planetary and lunar imaging do not require a very stable mount for long exposures, nor do they require precise sidereal tracking, autoguiding, or GOTO.

Figure 1.10 A 200–300-mm (8–12-in) Newtonian telescope or a 250–280-mm (10–11-in) Schmidt–Cassegrain telescope resolves 600-m details. This is a portable but cumbersome and heavy instrument, typically weighing about 30–50 kg (66–110 lb).

(6-in), F/D = 8, triplet apochromatic refractor, but a low-cost (fourteen times cheaper), conveniently prepared, 250-mm (10-in) Newtonian telescope proved to be more adapted to lunar imaging when the atmosphere is steady.

Copernicus through a one-meter, DIY Dobsonian

Frédéric Géa (France) imaged the Copernicus crater (Figure 1.11) with the unusual Dobsonian he had built (Figure 1.12):

“For a long time, I thought that the Moon existed only to prevent me from deep-sky observing. In March 2013, with the hereafter motorized 1000-mm (40″) Dobsonian and a DMK31 camera with a near-infrared, 742-nm filter and a 3× Barlow lens, despite a demanding focusing because of the F/D = 3 prime focus, the image of Copernicus seemed steady and I captured some movies. On the next day, the friend I asked to process the stacked images (I was a beginner in image processing) told me, with a strange voice, that they had a *certain potential*.”

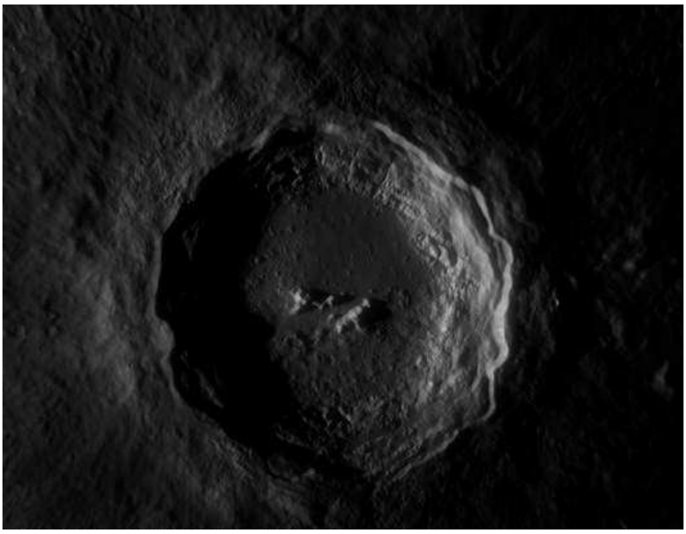


Figure 1.11 "Observing the Moon with a one-meter telescope is fascinating, especially with a binoviewer, albeit dazzling. When the atmosphere is calm, the show is splendid, with a feeling of relief. Depending on the turbulence, tiny craterlets appear or vanish. The extraordinary subtlety of shades of this powdery soil, like a gray talc, is surprising, and sometimes I'm almost expecting to discover the tracks of imaginary creatures." (Frédéric Géa).

Figure 1.12 Frédéric (on the right).

Frédéric's blog: www.stellarzac.com/eng/.