Topic no. 63

Camera Lens Mechanism

The lens system

Engraved on the front of every lens are two important numbers:

- *The lens' focal length*—or in the case of zoom lenses, its range of focal lengths. This gives you a clue to the variations in shot sizes the lens will provide.
- *The lens' largest aperture* or *f-stop* (e.g., *f*/2)— the smaller this *f*-stop number, the larger the lens' maximum aperture, so the better its performance under dim lighting (*low- light*) conditions.

There are two fundamental types of lenses on video cameras:

- Prime lens (primary lens), which has a specific (unchangeable) focal length. Prime lenses have become specialty items, primarily used by film- makers, digital filmmakers, and in special use situations such as security or scientific research.
- Zoom lens, which has a variable focal length. Zoom lenses are by far the most popular lens on cameras because of their ability to move easily from wide-angle to telephoto focal lengths.

Focal length and lens angle

The term focal *length* is simply an optical measurement—the distance between the optical center of the lens and the image sensor (CCD or CMOS) when you are focused at a great distance such as infinity. It is generally measured in millimeters (mm).

A lens designed to have a *long focal length* (*long focus*) behaves as a *narrow angle* or *telephoto* system. The subject appears much closer than normal, but you can only see a smaller part of the scene. Depth and distance can look unnaturally compressed in the shot.

When the lens has a *short focal length* (*short focus*) this *wide-angle* sys- tem takes in correspondingly more of the scene. But now subjects will look much farther away; depth and distance appear exaggerated. The exact coverage of any lens depends on its focal length relative to the size of a camera CCD's image size

The prime lens

The *prime lens,* which stands for primary lens, is a fixed-focal- length lens (Figures 6.8 and 6.9). Only the iris (diaphragm) within the lens barrel is adjustable. Changing its aperture (*f*-stop) varies the lens' image brightness, which controls the picture's exposure. The focus ring varies the entire lens system's distance from the receiving chip.

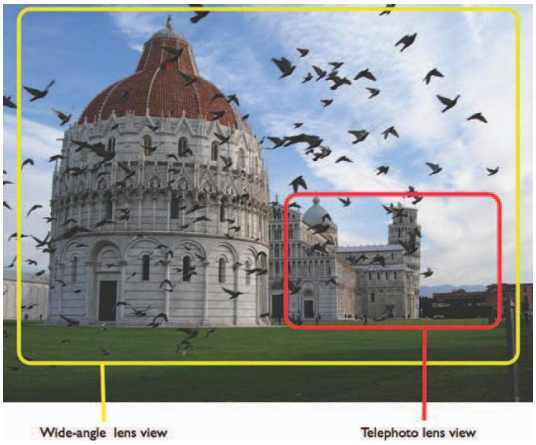

FIGURE 6.7

The various shots that can be obtained by different lenses. The wide-angle and telephoto shots can be taken while standing in one place and exchanging lenses.

FIGURE 6.8

A prime lens has few features, focus and aperture. (Photo courtesy of Zeiss and BandPro.)

If a video camera with a single prime lens is being used and a closer or more distant shot of the subject is needed, the camera operator has to move the cam- era nearer or farther from the subject. The alternative is to have a selection of prime lenses of various focal lengths to choose from.

The zoom lens

A zoom lens is a variable focal length lens. It allows the camera operator to zoom in and zoom out on a subject without moving the camera forward or backward. The zoom lens enables the camera operator to select any coverage within its range. Most video and television cameras come with optical zoom lenses. An optical zoom uses a lens to magnify

the image and send it to the chip. The optical zoom retains the original quality of the camera's chips (Figure 6.10).

An increasing number of consumer video cameras are fitted with a lens system that combines both an *optical zoom* and a *digital zoom*. A camera might, for instance, have a 20 optical zoom and 100 digital zoom. Depending on the quality of its design, the optical zoom system should give a consistently high- quality image throughout its zoom range; the focus and picture clarity should remain optimal at all settings. In a *digital system*, the impression of zooming in is achieved by progressively reading out a smaller and smaller area of the same digitally constructed picture. Consequently, viewers are likely to see the quality of the image progressively deteriorating as they zoom in because fewer of the original picture's pixels are being spread across the television screen.

Lens design involves many technical compromises, particularly in small systems. The problems with providing high performance from a lightweight, robust unit at a reasonable cost have been challenging for manufacturers. So the optical quality of budget systems is generally below that of an equivalent prime lens.

When the camera operator wants to get a "closer" shot of the subject or is try- ing to avoid something at the edge of the picture coming into shot, it is obviously a lot easier to zoom in than to move the camera, particularly when using a tripod. In fact, many people simply stand wherever it is convenient and zoom in or out to vary the size of the shot.

However, the focal length of the lens does not just determine the image size. It also affects the following factors:

- *How much of the scene is sharp*. The longer the telephoto used, the less amount of depth of field (the distance between the nearest and farthest objects in focus).
- *How prominent the background is in closer shots*. The background is magnified at the same time as the foreground subject. Instead of zooming, if the camera were moved closer to the subject, the background size would be different from the zoom shot (see Figure 6.11).
- *How hard it is to focus*. The longer the telephoto, the smaller the depth of field.
- *Camera shakes*. The longer the telephoto, the more the operator's shake is magnified. The wider the shot, the less amount of shake.
- *The accuracy of shapes* (geometry). Lenses can easily distort shapes. For example, when a very wide-angle lens is tilted up at a tall building, the building will distort, looking as though it is going to fall.

As you can see, the zoom lens needs to be used with care, although amateurs do ignore such distortions and varying perspective. The zooming action, too, can be overused, producing distracting and amateurish effects.

FIGURE

The background changes in size are due to the lens used. Note that the first photo was shot with a telephoto lens and the last shot was taken with a wide-angle lens. The camera had to be moved closer to the subject for each shot as a wider lens was attached so that the subject would stay the same approximate size. (Photo by K. Brown.)

Zoom lens control

Zoom lens remote controls are an important tool for camera operators. Standing close to the camera to manipulate the controls on the lens is uncomfortable if required for a long period of time. Remote controls allow the cam- era operator to operate the zoom lens while standing at the back of the camera (Figure 6.12).