

how it works

TO KEEP A CAMCORDER OR BINOCULAR IMAGE FROM BOUNCING, DESIGNERS CAN CALL UPON SOME SOPHISTICATED AND CLEVER TECHNIQUES, EACH WITH ITS OWN SET OF FEATURES AND TRADE-OFFS.

Image stabilization shows diversity of engineering approaches

By Bill Schweber, Executive Editor

AS CAMERAS AND CAMCORDERS got smaller and lighter throughout the 1990s, and higher power imaging systems, such as binoculars and camcorders with magnifications of 10× and greater, became more popular and affordable, users increasingly found that the images

they saw suffered from annoying shake and jitter (Reference 1). Fortunately, a variety of image-stabilization technologies can compensate for and largely overcome this problem. These technologies, which employ a range of electro-mechanical and electronic techniques, offer trade-offs in weight, performance, cost, and degree of compensation. Canon Inc (www.canondv.com) developed or commercialized many of the techniques for use in its own products and for license to others.

The answer to the image-shake problem may seem simple to an electronics or software engineer. You take the digitized image from the CCD, apply some clever algorithms to determine what is undesired image jitter and shake compared with legitimate image motion, and then compensate by digitally shifting pixel data. Although this approach is viable, it has some drawbacks. For example, it requires considerable image-processing capability. No matter how well-crafted these algorithms are, they may be unable to distinguish in all cases between images that genuinely need stabilization due to camera motion from images that show motion of the



Figure 1

Variable-angle prism technique uses two prism elements; as these elements rotate in response to sensed motion, they can offset the light path and thus correct at the front of the optical path for image shift.

subject or the camera, such as a car moving. Also, you cannot use these algorithms in all-optical, non-electronic systems, such as binoculars.

Image stabilization for all-optical systems, such as movie cameras, was the impetus for the first practical system, the Steadicam, which uses spring-loaded extensions as part of a complex assembly and harness that the camera operator wears. Despite its awkwardness and cost, Steadicam may be acceptable for professional filmmaking. However, it is unsuitable for consumers and mass markets.

To combat these drawbacks, Canon developed the all-optical variable-angle prism system (Figure 1).

Mounted ahead of the main imaging lens, this system comprises two elements of a prism connected by a bellows with a clear oil between the elements. Two linear voice-coil actuators, similar to those in disk drives for head positioning, rotate these elements independently. A motion sensor based on an oscillating gyroscope senses any angular velocity of the camera or binoculars and varies a current, which in turn drives the actuators. As the prisms rotate, they shift the angle of the light path and thus correct for the image motion that results from motion of the system.

The virtue of this system is that it can correct light-path changes over large angles of motion. Also, because it is an optical assembly, it doesn't affect the final image quality or resolution, as long as the prismatic elements are high-quality, properly designed, and sized for the rest of the system. It is both literally and figuratively transparent to the rest of the system's optical path. The closed-loop control system that links the sensors to the actuators uses a combination of analog and digital circuitry for its control algorithms; some of the algorithms can predict motion, as well as react to sensed motion. A typical variable-angle prism system consumes 250-mW maximum power.

However, not every product can afford the increase in weight and power that this technique requires, although it works effectively in binoculars, high-end camcorders, and movie cameras. An alternative approach is to place a relatively small correcting lens in the middle of the optical path, floating this lens in the x-y directions with a pair of coils and small magnets (Figure 2).

By controlling the currents to the coils based on sensor signals, the image stabilization adjusts this lens' position and so implements optical compensation of the camera's movement but within the optical path. This lens-shift method is less costly and lighter than the up-front variable-angle-prism method and so is more suitable for smaller camcorders or 35-mm cameras. However, the motion range over which it can compensate is less than that of the prism method.

MORE ELECTRONICS TO THE RESCUE?

The optical-based compensation systems can provide excellent performance, but they add cost and weight to the design. If the product has an electronic imager, such as a CCD, you can use all or mostly electronic image stabilization and achieve stabilization that ranges from fair to good, depending on how you implement it.

The better approach begins with an oversized CCD; the subject image that the objective lens focuses onto the CCD is smaller than the CCD itself (Figure 3). Thus, the image floats on the CCD plane as the camera jitters and is not truncated or clipped as it shifts due to camera shake. The

system digitizes the entire CCD imaging area, with the subject image and any guardband border area and sends it to the signal-processing circuitry.

At the same time, motion-sensing transducers tell the circuitry which way the camera is moving, so the signal-processing circuitry can digitally implement a compensating shift on the captured image data. Again, the system needs to use algorithms that try to adjust the compensation parameters to account for various real-world conditions and types of image motion.

For this electronic technique to work well, the CCD must be large enough to have sufficient image-area guardband around the nominal image area. A smaller, lower cost CCD provides the basis for a stabilized image but one that has less actual resolution than the CCD itself offers. Some low-end camcorders use this approach, trading effective image resolution for some electronic-stabilization capability.

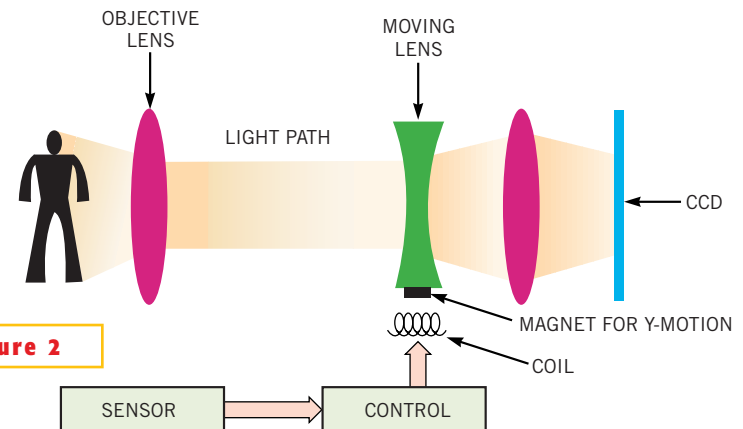


Figure 2

Placing a small corrective lens in the light path and moving it in the x and y directions can correct for shift at lower cost and weight than the variable angle prism method but over a smaller range.

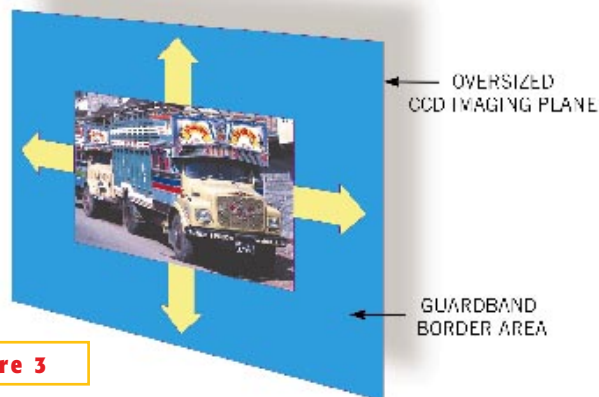


Figure 3

An oversized CCD that is larger than the subject's image area provides the basis for electronic stabilization by pixel manipulation and processing without losing any of the subject image itself.

At the lowest end of performance but also with the lowest cost, the imaging system can altogether dispense with the cost of external motion transducers. Instead, it can try to use firmware executing real-time image analysis to decide what type of undesired motion and shake are in the image and then shift the image data as needed to achieve the desired stabilization.

Even with well-designed algorithms, however, it's difficult for the signal-processing system to accurately differentiate between various types of legitimate image shift and motion versus unwanted jitter and shake-induced motion. This situation occurs because the signal-processing circuitry has to infer what is happening and convey that information to the camcorder without any direct information from actual transducers. For example, if a car drives quickly in front of a camera, the algorithm might assume that the camera, rather than the image, has moved and incorrectly compensate for this genuine motion of the subject. Some low-end camcorders use this all-electronic system; often these camcorders also cut costs by using a standard-sized CCD, which loses some edge zones of the image.

Image-stabilization systems can also combine these techniques. For example, Canon's top-of-the-line XL camcorder

blends both optical techniques, using a variable-angle prism, and electronic techniques, using a CCD imager and external sensors, to detect and correct for both fast and slow undesired motion of the camera. Camcorders on the Space Shuttle and International Space Station, which have some especially challenging stabilization issues, also use this system. □

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1. Furchgott, Roy "Camcorders allow a steady shot, even without a steady hand," *The New York Times*, June 8, 2000, pg E15.