Trends In High-Definition Imaging For Military Applications

While high-definition video offers some significant advantages over legacy analog and standard-definition systems, making the switch is not without its challenges.

by Paul Dempster

High-definition (HD) imaging has widely affected many industries over the past several years, from broadcast, biotechnology, microscopy, NDT (nondestructive testing), and inspection, to life sciences, materials research, process control, and more. The benefits provided by HD technology, including expanded field of view (FOV), higher resolution, improved color definition, and full motion video (FMV), offer solutions that may positively impact intelligence, surveillance, and reconnaissance (ISR) functions.

Though there are advantages to HD video implementation for applications in military and defense, it is critical that the challenges of HD are understood and met in order to transition from legacy analog and standard definition (SD) video systems to high-definition imaging. The larger HD format and corresponding increase in data will impact infrastructure, transmission, display, and storage requirements when compared to SD systems.

HD video refers to any video system of higher resolution than standard-definition video, and most commonly involves display resolutions of 1,280 x 720 pixels (720p) or 1,920 x 1,080 pixels (1080i/1080p) (see *Figure 1*). Consumer video formats and digital broadcast are increasingly moving towards implementation of various HD formats, primarily 720p with displays commonly supporting 1080p. Because of the larger format, HD video produces a fourfold increase in data per video frame, providing significant increases in video resolution, an expanded field-of-view, and substantial improvements in color definition and contrast. Digital HD video signals allow additional image processing for improved analysis and different forms of distribution and storage.

Format	Format matrix pixels (WxH)	Pixels per image[1]	Scanning type	Data rate (Gbps)	Frame rate (Hz)
720p	1,280x720	921,600	Progressive	1.485	23.976; 24; 25; 29.97; 30; 50; 59.94; 60; 72
1080i	1,920x1,080	2,073,600	Interlaced	2.970	25 (50 fields/s); 29.97 (59.94 fields/s); 30 (60 fields/s)
1080p	1,920x1,080	2,073,600	Progressive	2.970	23.976; 24; 25; 29.97; 30; 50; 59.94; 60

Figure 1: Chart indicating typical high-definition video formats.

Sensor Technology

High-definition video cameras can have CCD (charge-coupled device) or CMOS (complementary metal oxide semiconductor) based sensor technology and utilize single-sensor or three-chip designs. CCDs have traditionally provided the best imaging, and three-chip CCD cameras offered the highest sensitivity and superior color fidelity. Three-chip technology cameras have the advantage that each primary video color — red, blue, and green (RGB channels) — has a dedicated sensor, which allows fine tuning to precisely color match the video output, based on lighting conditions and application. Three-chip cameras are widely used in video endoscopy, clinical pathology, and other critical medical imaging applications.

CMOS-based cameras have been improving in their characteristics, and today their performance closely matches CCD quality. CMOS technology is widely used in consumer devices, such as video camcorders, cell phones, and lower-end, non-professional devices. As the capabilities of CMOS sensor technology improves, it increasingly is being integrated into professional video systems. CMOS technology is also available in single-chip and three-chip camera designs.

Applications

HD video offers tremendous advantages for military, special operations, and first responder training courses that utilize instructional videos. Developing content for educational and training videos with HD resolution provides substantially greater detail and offers a more compelling visual image that makes the learning process more immersive, realistic, and engaging, and ultimately increases retention. The HD format is compatible with the latest low-cost consumer displays, eliminating the letter-box or stretching/distortion when displaying SD video formats on HD displays.

Due to the exceptional clarity and true color reproduction that HD video offers, HD video systems are now widely used in surgical microscopy, clinical pathology, tumor review boards, and video endoscopy. By adding appropriate video servers to provide the compression encoders and transmission interfaces (available via third-party vendors and/or integrators), HD video cameras could also be used for remote surveillance, conferencing, and/or military training videos with live, real-time performance.

There is a wide selection of advanced HD imaging systems for industrial, defense, microscopy, and broadcast applications, including remote-head, miniature HD cameras on the market today. These compact HD cameras are small enough to be easily integrated into manned and

unmanned aircraft systems (UAS) and various ground vehicles. HD cameras provide substantially greater detail and resolution than SD technology and they are now available with ruggedized MIL-SPEC housings for integration into a wide range of military vehicles.

Compression And Storage

One of the greatest challenges in implementing HD full-motion video (FMV) solutions for military use is management of the enormous volumes of data generated that impacts both transmission and storage. Consider that one minute of uncompressed 1080p60 FMV is approximately 124 MB of data, and USB 2.0 supports a maximum transfer rate of 480 Gbps, which is adequate to support only about five frames per second transfer of uncompressed HD video data. The only solution for managing this data is through image compression. Fortunately, there are a number of commercial off-the-shelf (COTS) technologies that provide real-time video streaming compression to allow more manageable wired and wireless transmission schemes and to provide more cost-effective storage.

The Motion Imagery Standards Board (MISB) was established to help define and recommend appropriate standards for motion imagery (MI), interoperability, and its associated metadata for use within the DoD, the intelligence community, and the United States Imagery and Geospatial System. Specific compression types recommended for FMV systems include MPEG-2, MPEG-4 Part 10 (H.264/AVC), or JPEG 2000 image compression. Video teleconference (VTC), video telemedicine, and video support services applications do not fall within the purview of the MISB and are not subject to its requirements.

To maximize the value of the HD FMV, it is desirable to incorporate additional metadata-supporting analysis and to maximize the situational intelligence that the video segments provide. COTS technologies support compression, format conversion (based on available transmission bandwidth), and the addition of key-length-value (KLV), which is essential to retrieval, tracking, and management of the video files. These integrated systems, combining FMV and appropriate compression encoding protocol for KLV metadata, provide the mission-critical image data essential to today's intelligence, surveillance, and reconnaissance needs, as well as supporting more traditional video applications. ■

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