AXIS COMMUNICATIONS

DIGITAL IMAGES AND VIDEO
FOR SURVEILLANCE APPLICATIONS

Networked Video Surveillance and Compression Technology

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By Anders Laurin, Vice President, Networked Facility, Axis Communications

Worldwide use of computer networks grew dramatically during the 1990s. This growth was fuelled by the widespread acceptance of standards for the network (*Ethernet*), and for communication via the computer network (*TCP/IP*), that did not require licensing or usage fees. As a result, today there are a number of products and systems for video surveillance that utilize Ethernet and TCP/IP. Most of these employ a central PC with several network cameras and video servers connected directly to the network. As camera and network technology has improved, the amount of video recorded and transferred over networks has increased markedly. Because video contains very large amounts of data, storing this data and transferring it over a network has created the need manage it more efficiently. Video *compression* has emerged as the solution. Digitizing and storing video without compression is possible, but it's highly impractical and expensive. Compressing video involves reducing, or squeezing, the information that is invisible to the human eye.

How does digital video compression work?

Similar to network standards, a number of standards have also been developed for compression of digital images. Presently, there are a number of compression techniques, each aimed at a different application. There are two main compression methods: a complete image is transmitted every time; or, a reference image is transmitted and updated little by little until a major change requires a new reference image.

When considering an upgrade to a networked surveillance system with recording capabilities, there are a number of factors to consider in determining the most appropriate compression method:

- How high a frame rate is needed?
- Are different frame rates needed during certain events or at specific times?
- What image quality is needed?
- What image resolution is needed?
- What is the available bandwidth for network transmission?

Compression methods and how they compare

Common among all video compression techniques is the reduction of "invisible" details to achieve compression and reduce hard disk consumption and bandwidth demands. The video image details that are visible post-compression demonstrate the trade-offs involved between different methods of compression. Some of the more common image compression techniques in use today:

JPEG Joint Photographic Experts Group (ISO/IEC 10918), is the compression standard, to achieve high quality for still images, but is not used for video compression. JPEG's major advantage is that the software for decompression (and viewing) of images is included on any standard PC and web browser. JPEG is used for newspaper wire photo transmission, graphic arts, among many others.

Motion JPEG or **MJPEG** creates a digital video sequence from a series of JPEG images. JPEG/MJPEG are most appropriate when only single images are required to document a specific event like each time somebody passes through a door or for quality control monitoring of products. It is also a favourable format when bandwidth cannot be guaranteed. This is the most frequently used standard in the industry today.

MPEG (Moving Picture Experts Group) was established in 1988 to create a standard for delivery of video and audio. MPEG is used for monitoring applications where a stream of high-quality video and audio are needed, while limiting the amount of bandwidth used, relative to the quality level. Applications include surveillance requiring constant high frame rate, high quality, and the possibility to guarantee bandwidth. Examples are banks, airports, casinos and shopping malls.

There are several types of MPEG. While all are based on the same technology, each is tailored for a different application:

MPEG-1 (ISO/IEC 11172) Approved as a standard in 1993, it provides VHS quality on a CD-ROM or Video CD (VCD). MPEG-1 is basically a standard for storing and playing video on a single computer at low bit-rates (that is, requiring low transfer capacity, thus lower bandwidth).

MPEG-2 (ISO/IEC 13818) was approved in 1994 as a standard for high quality digital video (DVD), digital high-definition TV (HDTV), interactive storage media (ISM), digital broadcast video (DBV) and cable TV (CATV).

MPEG-4 (ISO/IEC 14496) approved in 1999 for use in mobile devices, such as small monitors for mobile phones requiring low bandwidth. It is also used for applications with extremely high quality demands and almost unlimited available bandwidth. One example is full-length feature movies, requiring very large, high-quality images. Because of the relatively recent approval of this technique, the industry has yet to develop much equipment and software for this compression standard. In addition, the issue of licensing is still not fully solved.

Some other well-known compression methods include:

H.261 was designed for videoconferencing and video-telephone applications over ISDN telephone lines. It uses a fairly old and simplified MPEG-1 technique, with a focus on bandwidth consumption over image quality. H.261 is not a standard, but a recommendation by the International Television Union (ITU).

H.263 the next generation H-method, is an extended MPEG-1 or simplified MPEG-2 technique. Its focus remains bandwidth usage rather than image quality.

JPEG 2000 is, the next generation still image compression standard. JPEG 2000's main advantage compared to JPEG is a better compression ratio for very high compression rates.
Motion JPEG 2000 (ISO/IEC 15444) As with JPEG, MJPEG 2000 can also be used to represent a video sequence as a series of still JPEG 2000 images. At high compression rates, the image quality is better preserved with MJPEG 2000 than using the earlier version.

The following table provides a comparison of some of the most common compression methods:

	MJPEG	**MPEG-1**	**MPEG-2**	**H.263**
Target bit rate	N/A*	About 1.5 Mbit/sec	2 – 15 Mbit/sec	64, 128, 192 kbit/sec up to approx 2 Mbit/sec
Supported frame rates (fps=frames per second)	Camera / Video Server dependent	25/30 fps	25/30 fps	Any, up to 30 fps
Resolution	Any	320 x 288 320 x 240	320 x 288 320 x 240 720 x 576 720 x 480	352 x 288
Image quality	Low to Very good	Good	Very good	Low
Target application	Still images	Digital video on CD (VCD)	DVD, HDTV	Tele-conference
Basic algorithm	Digital Cosine Transform (DCT)	DCT with motion vectors	DCT with motion vectors	DCT with motion vectors
Standard	ISO/IEC 10918	ISO/IEC 11172	ISO/IEC 13818	ITU-T H.263

* Since the MJPEG and MJPEG 2000 standards are primarily for still image compression techniques, they do not have set limits on frame rate, image resolution, image quality or target bit rates. MJPEG bit rate is dependent on available bandwidth and transfer capacity of the camera or video server.

The table demonstrates that the H.261/263 method requires less bandwidth capacity, but at the expense of a lower image quality. The MPEG standards, are focused on video at different resolutions and at good or very good image quality.

Negotiating the trade-offs determines the right compression

As we've discussed above, the main factors that differentiate compression techniques and determine which compression technology is best for which application, are the level of resolution in video and audio; desired frame rate; and network capacity needed to monitor and play back video. We should add to this two other important considerations: image-processing capacity on the receiving end and the level of acceptable "latency".

The storage space a user will need, or the amount of bandwidth required to transmit video, is based on the compression technique used, frames recorded per second (if applicable), and image quality or resolution desired.

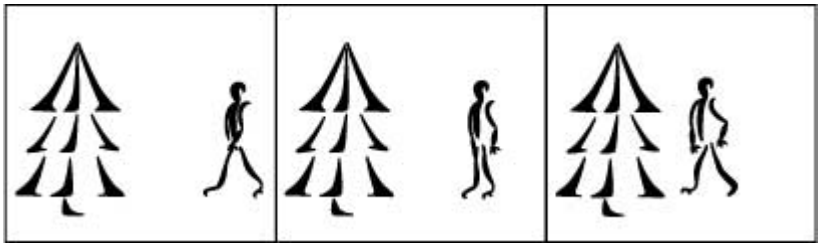
The most appropriate compression technique depends on the trade-off the user is willing to accept between recording frame rate, video image quality and bandwidth consumption. Also for a video surveillance system based on MPEG-compressed video, viewing the MPEG stream requires that users have a computer capacity and system memory at least four times higher than that required for MJPEG images. For users who want to view video real-time, latency, or the amount of time required for compression, becomes important. The latency increases with increased complexity of the compression technique and the installed system. Latency can be around one second. In applications such as teleconferencing no latency is acceptable, whereas in surveillance applications it has minor implications if the security manager receives the images one second after the event occurred.

Image Quality or Frame Rate?

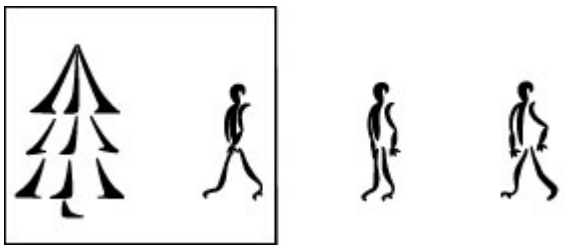
When transmitting a complete image every time with MJPEG, image quality is never compromised. To achieve this level of image quality, while keeping bandwidth (storage) demands manageable, the frame rate is reduced. This method is most suitable for applications that stress the importance of details—for example, monitoring product quality on an assembly line. When a reference image and continuous updates are used, a compromise is made between image quality and a higher frame rate. This method particularly suits applications where we want to see an ongoing flow of events at a site, but not the minute details.

Although consistent image quality is important to the vast majority of security application users, it does come at a price—high bandwidth demands on the network and related costs. High bandwidth usage is prohibitive in many applications and perceived as a distinct disadvantage by users who want high quality, full-motion video and audio combined but comparatively low bandwidth consumption. Is there a way to minimize the apparent required trade-off so as to achieve a sufficiently high frame rate at good to excellent image quality, without overloading the network?

MJPEG and MPEG-2 Side by Side



Consider the video sequence displayed above. Frame one is on the far left, the picture in the middle frame two, etc. The video sequence is a man walking from right to left in front of a tree that stands still. In Motion JPEG and MJPEG 2000, each image in the sequence is coded as a separate, unique picture. But with MPEG compression, only the new data in the video sequence is included together with information on the moving parts. This same video sequence, when MPEG-compressed for transmission (or storage) would appear as below. However, when displayed on screen, the images appear as in the original video sequence with all the desired information. MPEG compression simply removes the redundant information in each frame.



Increasingly, the security market is demanding a compression methodology that can deliver full-motion video and audio at DVD-quality over the network while consuming a reasonable amount of bandwidth. MPEG-2 uses approximately one-third the amount of bandwidth as MJPEG. MPEG-2 offers the unique advantage of low bandwidth requirements relative to its high quality of video and audio. For those surveillance applications where identification of suspected perpetrators is the top priority, the MJPEG technique boasts high quality for every frame. MPEG-2 quality and advanced capabilities is perfect for users who want high resolution and high quality video at a fixed bandwidth, as opposed to high quality pictures for each frame.

Conclusion and recommendations

As we've seen, the most appropriate compression technique for an application depends on the trade-off the user is willing to accept between frame rate, video image quality and bandwidth consumption. Recent technological developments have led to the presence of two major compression standards, MJEPG and MPEG-2, successfully minimizing that trade-off, so real-time surveillance application users can choose the standard appropriate to achieve a sufficiently high frame rate at required image quality without overloading the sending or receiving network. MPEG-2 is the choice for applications where 25/30 fps

is required at all times, synchronised audio is a requirement, and bandwidth can be guaranteed. For most other applications, MJPEG is the compression method of choice. In both cases, users of either MPEG-2 or MJPEG can have the confidence that comes from using existing, proven standards in transmitting and storing their all-important recorded information.

Axis Communications

Axis develops solutions for user-friendly and secure communication over wired and wireless networks. The company is a worldwide market leader in network connectivity, with products for office, facility and industrial environments. Axis was founded in 1984 and is listed on the O-list (Attract 40) of Stockholmsborsen (XSSE:AXIS). With more than 300 employees, and offices in 14 countries, Axis operates globally in cooperation with distributors and OEM partners in some 70 countries. Markets outside Sweden account for more than 95 percent of sales.

Information about Axis can be found at www.axis.com

Contact Axis

info@axis.com

Head office, Lund

Axis Communications AB
Emdalavägen 14
SE-223 69 Lund
Tel: +46 46 272 18 00
Fax: +46 46 13 61 30

