Advances in CCTV video recording

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A lot has changed since VHS tapes were the universal medium for CCTV recording, with digital systems now starting to predominate. But what’s the current state of the art in digital recording - and what new developments are just around the corner? Siemens Building Technologies, Security Products Jon Hill has the answers.

Today, there would be very few, if any, CCTV specifiers who would choose anything other than digital recording for a new system. But digital recording technology is developing very rapidly and there’s much more variation between products than there ever was in the days of VHS tape. It is, therefore, important for users to know what to look for in today’s systems and to have an idea of the trends that will shape systems in the future.

One of the first issues to address is the classification of digital recorders. In theory, digital recordings can be made on tape, and this system is, in fact, used in some consumer camcorders. In the CCTV field, however, digital recording today invariably means recording on hard disks similar to - but, as we shall see, not necessarily identical with - those used in office computer systems.

Key features: Digital Video Recorders vs. Network Video Recorders

Digital recorders are divided into two principal categories: Digital Video Recorders (or DVRs) and Network Video Recorders (or NVRs). These names are a little confusing because both DVRs and NVRs use digital recording, and DVRs are often connected to networks.

The difference is in the way that the cameras are connected to the recorder. In principle, with a DVR, the cameras are usually analogue types linked to the recorder by ordinary coaxial cables. With an NVR, however, the cameras are linked to the recorder by network connections.
In practice, many modern DVRs are hybrid types that can work with both analogue and networked cameras. It's also worth noting that it's perfectly possible to use analogue cameras with a true NVR, provided that the cameras are fitted with network interface modules. For delivering live and recorded pictures to one or more monitoring stations and for handling control functions, many DVRs and all NVRs can use a network connection.

As networked installations, at least in theory, offer lower installation costs and enhanced flexibility, the current trend is for systems to be increasingly designed around NVRs rather than DVRs. In fact, for the largest systems there may be little option, as DVRs are typically only available with up to 32 camera inputs, whereas NVRs can be configured to handle a much larger number of cameras.

However, because of their versatility, their convenience in small installations and their ability to interface more easily with legacy equipment, DVRs are sure to be around for a long while to come.
Another area of particular interest with all types of digital recorders is storage capacity. Undoubtedly the general trend, as the price per gigabyte of storage falls, is to provide more and more capacity, but there are a few pitfalls for the unwary.

The storage capacity in gigabytes of any particular recorder will be a known quantity, but what this actually means in terms of hours of images stored may be less well-defined, as many factors influence this figure. The frame rate of the recording is an obvious example - in round terms, halving the frame rate doubles the length of time for which images can be recorded on a disk of given capacity.

**Effect of frame rate and picture resolution on storage capacity**

The frame rate chosen will obviously depend on the application. In an office or a retail outlet, for example, two frames per second (fps) may well be adequate, but in a casino where it's necessary to capture events lasting only a fraction of a second, live motion recording (25 fps) is likely to be needed. One point worth noting is that for systems that include audio recording, a frame rate of at least 12.5 fps will be needed to achieve lip-sync sound.

Frame rate and picture resolution must be taken into consideration when deciding storage needs.
Picture resolution also directly affects the storage capacity needed. The lowest resolution in common use is CIF (352x288 pixels), but 2CIF (704x288), 4CIF (704x576) and D1 (720x576) are now specified increasingly often, and there is also considerable growth in the use of megapixel cameras that, as the name suggests, deliver even higher resolutions.

As a rough guide, CIF images recorded using MPEG-4 compression are around 10Kb, 4CIF images around 40Kb and megapixel images somewhere in the range 80 to 200Kb each. These figures are for a single frame.

It's easy to see that higher resolution images require much more storage capacity but, in a real installation things may not be quite so straightforward. There is a tendency, for example, to use just a few megapixel cameras to cover large areas rather than a greater number of lower resolution cameras.

This is justified on the basis that the few megapixel cameras will capture as much if not more detail than the larger number of low-resolution cameras. Clearly, if this approach is adopted, it must be taken into account when calculating the storage capacity needed.

**Image data: compression techniques**

In all digital video recorders, image data is compressed before being written to the disk. Over the years, there have been numerous developments in compression techniques, and these are still continuing. Today, probably the most commonly used system is MPEG-4, although it is worth noting that this is not, in fact, a single system - MPEG-4 compression comes in many versions. MPEG-4 Part 10, for example, is better known as H.264 and is starting to find favour for applications involving high-resolution images.

While it's certainly not necessary to go into the technicalities and relative merits of the various compression systems, it is
important to note one particular point: none of the systems are lossless. This means that, for a
given system, applying more compression will undoubtedly provide a longer recording time for a
particular size of hard disk, but it will also mean that more detail is lost from the recorded images.
This leads to an invaluable rule of thumb - if the recording capacity of a given digital video recorder
seems too good to be true, it probably is, especially if the recorder also has an alluringly low price
tag. The high capacity will almost certainly have been achieved by using excessive compression,
which will inevitably mean poor playback quality.

Digital video recorders - hardware

Now let's move on to hardware. Until recently, the hard drive assemblies used in digital video
recorders were virtually identical to those used in office PCs. Now, however, the best recorders use
assemblies that are optimised for CCTV applications.

The key considerations for these optimised assemblies are reliability and thermal management. The
hard drive systems for recorders will be designed with 24/7 operation in mind and also to run cool
even if the recorder itself is shut away in a poorly ventilated enclosure, as so many of them are.

Reliability is, of course, a critical issue in CCTV recording. In the best of modern equipment this is
often addressed by configuring the hard drives as a RAID (redundant array of inexpensive disks)
system. However, there are several RAID configurations in common use, not all of which increase
data security.

RAID 0 systems are often used to increase writing speed, so that images from more cameras can
be recorded simultaneously or higher quality images can be recorded. RAID 0 systems don't
provide any extra data security; for that, RAID 1 or RAID 5 systems are used. With RAID 1, all
CCTV images are written to two disks. That doubles the number of disks needed, but it also means that if one disk fails, no images are lost because the copy on the other disk is still available.

RAID 5 is somewhat more complicated. Data for the images is divided - the technical word is 'striped' - over several disks. The system also produces and stores additional parity data. If a disk fails, it can use this parity data to rebuild the images that would otherwise be lost. RAID 5 systems need fewer disks than RAID 1 systems, but they often have a lower writing speed. RAID configurations other than 0, 1 and 5 exist, but are rarely used in CCTV applications.

Removable storage for modern DVRs

Many recorders now also support removable storage, usually in the form of disk cassettes, which are also available in various RAID configurations. While these cassettes can be very useful when, for example, the police need to impound images, it's worth noting that they are inherently less secure than internal storage. It's a lot easier to make a disk cassette 'disappear' than a whole digital video recorder!

"Digital video recording systems are developing very rapidly and it is, in fact, something of a challenge for manufacturers to keep up with the opportunities offered by emerging technologies"

Next, let's take a look at making recordings available for external use, such as presentations in court. Most modern recorders will have facilities for transferring selected recordings to a DVD, and provision for recording to high-capacity, high-definition Blu-Ray disks is certain to appear in the very near future - Blu-Ray drives are already readily available for use with PCs.

Unfortunately, the high-technology solution is not always the one that's needed. The UK court system is notoriously slow to adopt new technology and even now few courts have facilities for using video recordings in any format other than on VHS tape! For this reason, it may be necessary to look at digital recorders that support this obsolescent legacy format.
Finally, it's worth touching on the topic of video analytics. The increased processing power made available by modern computer chips is making it possible to implement very sophisticated image analysis systems that go far beyond mere motion detection. A good example is ‘left object' detection where the system can automatically pick out an extra object that has been left in the scene.

Features of this type can be used not only to generate real-time alerts but also to flag sections of a recording that merit closer inspection, thereby avoiding the need for operators to manually trawl through hours of images to find a particular event.

As we said at the outset, digital video recording systems are developing very rapidly and it is, in fact, something of a challenge for manufacturers to keep up with the opportunities offered by emerging technologies. Nevertheless, this article has hopefully highlighted some of the most important considerations for systems available today - and provided a few useful pointers for developments that can be expected in the near future.

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