High Definition Video for Mainstream CCTV

Alex Swanson, IndigoVision's Head of Engineering, explains that the latest low bandwidth High-Definition IP cameras will accelerate the move of HD into mainstream surveillance applications.

Over the last 10 years the CCTV industry has seen a major shift from analogue to digital networking solutions for surveillance applications. In the next few years the industry will see the adoption of High-Definition (HD) IP Video into mainstream CCTV systems, as in consumer electronics. For HD IP cameras to be adopted by mainstream video security applications the issues associated with high data rates and storage need to be solved. This is now being addressed with the recent launch of HD IP cameras with low data rates.

Advantages of using HD IP Cameras

The advantages of HD IP cameras have been well documented, but in summary the three main areas where they can provide real benefits are:

General Surveillance – A single HD megapixel camera can replace several standard 4SIF cameras, thereby reducing costs. An HD megapixel camera can see more detail in the same field of view or view a wider field of view at the same level of detail.

Forensic Detail – Many existing analogue CCTV systems simply do not provide enough resolution or quality for forensic evidence. Megapixel cameras solve many of these quality/resolution issues. They are ideal for applications where the system wants to identify and record faces, vehicle licence plates or objects.

Digital PTZ – HD megapixel cameras can digitally zoom quicker and with greater detail than analogue cameras whilst still recording the whole picture for later analysis. This provides superior performance and is more reliable than mechanical PTZ mechanisms.

Resolution: **SIF** **4SIF** **HD**

All CCTV can benefit from HD technology, but at present typical applications for HD IP cameras include retail point of sale, banks, casinos, car parks, building entrances, military installations and city centre monitoring.

Technology Hurdles

In order for HD megapixel cameras to be adopted for mainstream use the current technology hurdles have to be overcome:

1. Lens – Megapixel cameras require a higher resolution lens than ordinary CCTV cameras to maximise the picture quality. These lenses are readily available but are expensive in CCTV mounts, although this will change with the higher volumes from mainstream adoption.

2. Sensor – Megapixel cameras use the same CMOS image sensors as used in still digital cameras, whereas analogue cameras typically use CCD sensors. This is likely to change with the adoption of sensors from the HD TV/Video industry. A higher density of pixels on the same sized sensor means there is less light falling on each pixel. Each pixel therefore has less sensitivity and needs more light and the 'noise' in the sensor has a larger impact because it is a higher percentage of the signal. This is why first generation HD IP cameras typically had a worse low light characteristic than analogue cameras. However, sensor technology is improving quickly, with significant R&D resources being focussed in this area.

3. Video Compression – Arguably the most important factor to consider with its impact on network bandwidth and storage requirements. HD megapixel cameras are unlikely to be adopted for mainstream use until low-bandwidth camera designs are readily available. This is now starting to happen with the launch of HD IP cameras with superior compression and hence much lower data rates.

Video Compression – The Scale of the Problem

H.264 compression technology needs to be deployed in the camera, to provide the lowest possible data rates

H.264 is the latest video codec (**co**mpressor and **dec**ompressor) standard, which follows on from the highly successful MPEG-2 and MPEG-4 video standards and offers improvements in both video quality and compression. Many of the current one and two megapixel HD cameras use MPEG-4 compression, resulting in higher video data rates. For HD to become usable in mainstream CCTV applications, H.264 compression technology needs to be deployed in the camera, to provide the lowest possible data rates. However, not all implementations of the H.264 standard deliver the same quality of compression.

The data rates from different manufacturers' cameras can vary significantly, even when comparing cameras implementing H.264. The table below details the typical data rates for a single one megapixel camera monitoring a fairly static scene such as a building entrance:

H.264 Implementation	Typical Data Rate (Mbps)	Approx. storage required for 30 days at 15fps continuous recording (Terabytes)
Best Compression Technology	<1	0.5
Average Compression Technology	5-6	3

The huge disparity in camera performance makes a significant difference in the cost of an HD CCTV solution. Using cameras with data rates of less then 1 Mbps means that HD IP cameras can use standard networks and storage and be cost-effective for everyday CCTV applications.

It is therefore very important for system designers and end-users to know exactly the data rates and storage requirements for particular HD IP cameras in order that performance and costs can be fully understood. However, some of the actual data rates are so high that it's not surprising that these figures are often hidden and difficult to determine. Take a look at a typical datasheet for a 1.3 megapixel camera from a mainstream manufacturer and you will see the camera has a framerate of up to 30fps. However, nowhere is there a mention of how good the compression is – i.e. what the typical data rate is and how much storage is required to record a stream from that camera!

Some manufacturers are forced into using local storage because their HD IP camera bandwidth is such that it cannot reasonably be streamed live across the network. This somewhat negates the distributed and scalable benefits of IP Video. By removing the high-bandwidth problem, designers are free to choose a truly distributed architecture, placing storage wherever the best system design dictates it should be - whether that is in a central location, distributed close to the camera or a fault-tolerant redundant configuration mixing the two.

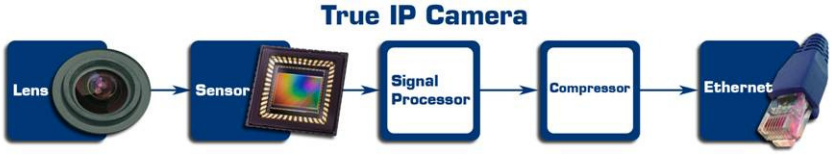
Designing a Low Bandwidth HD IP Camera

The key therefore to the adoption of HD CCTV into mainstream surveillance is the ability to develop low bandwidth HD IP Cameras. The three main elements that make up such a camera are:

1. Using a true IP camera solution
2. Excellent implementation of H.264
3. Dedicated hardware architecture

True IP Cameras

A true IP camera completely eliminates any analogue signal by connecting the digital signal processor, present in all analogue cameras, directly to the compressor chip. This ensures no additional signal noise is introduced.



H.264 Compression
There are three common compression standards used in current HD IP Cameras, MJPEG, MPEG-4 and H.264.

Video is compressed using two types of frames:

- I Frame, also known as the Index or Key Frame and contains the whole image
- P Frame, which only contains the information that is different from the previous frame.

MJPEG only uses I Frames, whereas MPEG-4 and H.264 use a combination of both I and P Frames and consequently use considerably less bandwidth them MJPEG. H.264 will require up to 50% less bandwidth than MPEG-4 to transmit the same quality image, therefore it is the chosen compression standard for the highest performance IP cameras.

The H.264 standard specifies a set of optional tools which can be used to compress video. A compliant decoder **must** implement every tool, whereas a compliant encoder **can choose** which tools to use. This means that there can be a big difference between encoders from different suppliers – some compress well, some compress badly.

To determine what information is transmitted in a P Frame the image has to be searched for motion in each frame. The quality of the compression depends on how far and how well the search is completed on each frame. The limitation to this searching is the available processing power in the camera, even more so with HD resolutions at full frame rate.

Compared to the best encoders, a poor encoder design could result in:

- A higher bandwidth for good quality video
- Increased bandwidth during high motion
- Dropped frames
- Blocky or Blurry video

Hardware Architecture
Due to the huge processing demands of a low bandwidth HD IP camera using H.264 it is essential that the compression engine is implemented in dedicated hardware such as Field Programmable Gate Arrays (FPGA). With this type of design low bandwidth HD compression can be achieved with a guarantee of no dropped frames.

In Summary

The use of HD megapixel IP cameras for CCTV monitoring offers real benefits. However, to move on from their current use in primarily specialist applications to everyday use requires HD IP cameras with the very best compression technology and low data rates.

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