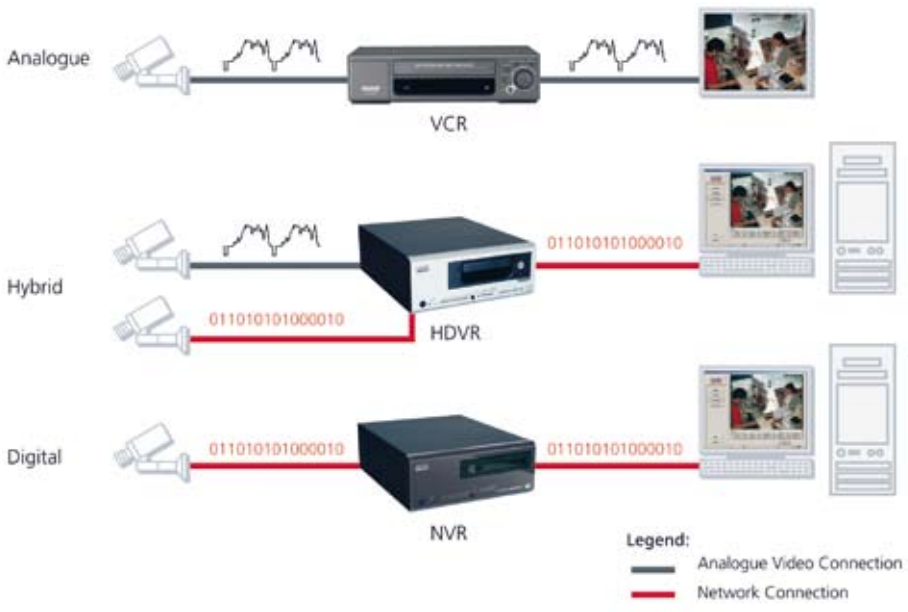
Faster. Better. Further.

This slogan doesn't just reflect the improved performance of the world's top athletes, but just as ably describes the rapid development within the security industry. Innovations and new presentations chase each other in a continuously upwards spiral and previous product specs are dwarfed by the most recent ones. However, in contrast to Olympic athletes, product performance can only be evaluated with considerable effort because up until now there has never been any standardised measuring method for objective comparisons between CCTV systems. The revolutionary developments of the last few years have changed the product landscape within the field of security to such an extent that even professionals within the video industry are in a genuine quandary when deciding on one method over the other.

By Michael Gwozdek



Schematic view: Analogue - Hybrid - Digital

Where once CCTV specialists „only" had to consider the special features of analogue video technology, the correct planning, installation and commissioning of a digital CCTV system requires explicit knowledge of the IT field and special, additional knowledge of network technology and management. Additional, mind you, because even fully digital systems do not relieve you of professional camera planning, setting to the millimetre of lens focal lengths, a well thought-out lighting of the scene as well as a careful selection of products for transfer, recording and video analysis – and all of these are just a few of the functions of video monitoring systems. All-in-all, this is no mean task and up to the present the industry has failed to develop uniform evaluation criteria and standards for objective assessment of the performance features and functions manifested in brochures and data sheets.

Even the numerous training courses and technical papers from manufacturers can't even begin to close this knowledge gap – only highly motivated, idealistic providers within the video branch manage to market a product both as quickly and as profitably as possible while at the same time communicating special in-depth knowledge to the end-user. These circumstances are hardly surprising. Increasing competition and pricing pressure combined with ever-shorter development times, minimum product lifetimes and inflated investment costs are a clear contradiction to the time-intensive training of the basic principles of CCTV technology. Even multivendor institutions only manage to communicate rudimentary specialist knowledge in a comprehensive manner within their seminars. And so it is that this year the „Crème de la Crème of the security industry" will meet at the Security Trade Fair in Essen where more than 1,000 exhibitors will be aiming to make a lasting and positive impression of their new developments on up to 40,000 visitors. Trade exhibitions do provide a suitable platform to inform you on the current state of the art. On the other hand, anyone who has already paid a visit to the largest security trade fair in the world knows that queasy feeling of being confronted with an unmanageably large range of products with an increasing number of new functions.

Nevertheless, in spite of all appearances, generally applicable evaluation criteria can be formulated in order to make a well-founded decision on the general design and construction of a CCTV system. The following synopsis should be viewed as a critical guide. When approached with suitable openness to innovation and the courage to retain technology that has been tried-and-tested, this short "primer" contains useful basic information to help the user decide on **analogue, hybrid** or **digital.**

Definition of terms:

- *Analogue Exclusive use of CCTV components with analogue signal transmission (PAL/NTSC)*
- *Digital Exclusive use of CCTV components with digital signal transmission*
- *Hybrid Mixed use of analogue and digital signal transmission*
- *VCR: Video Cassette Recorder*
- *DVR: Digital Video Recorder*
- *HDVR: Hybrid Digital Video Recorder*
- *NVR: Network Video Recorder*
- *IP camera: Video camera with network connection and digital signal transmission*

Michael Gwozdek *is an information electronics engineer, a managing director with HeiTel Digital Video GmbH in Molfsee, Germany, and by now 25 years active in the CCTV branch. He gathered detailed know how through his international work for nameable CCTV manufacturers, in particular within the fields of development, product management and marketing. Michael Gwozdek is the author of the „Lexikon der Videoueberwachungstechnik" (Encyclopedia of CCTV) as well as numerous professional articles. He holds lectures on the topics of CCTV on a regular basis.*

When planning CCTV systems with digital signal transmission and processing, the following aspects must be considered:

- Much higher image resolutions can be achieved using high-resolution IP cameras than when using conventional technology. When using such cameras, make sure that all of the downstream components – such as HDVR, NVR, etc. – also really do support the respective picture format.
- In contrast to systems that are analogue throughout, all CCTV components connected to a network – IP cameras, HDVR, NVR, etc. – allow access to and data exchange with any network node. Typical functions within this method are parameterisation, as well as playback and control of both live and archived pictures. By the way, hybrid system solutions also provide the same flexibility.
- Because IP cameras and HDVR or NVR are usually provided by various manufacturers, make sure that the image compression method used is compatible. When using recording systems from third parties, often only those IP cameras can be used that generate (M)JPEG sequences (single image compression). Under these circumstances, you must plan in a much higher network load in comparison to the motion picture compression method.
- A flexible expansion of the system is possible in principle but the maximum number of IP cameras is still limited, even in digital systems. Among the various limiting factors are the network infrastructure (most importantly the bandwidth) and the scalability/ performance of the downstream systems such as the video server, HDVR and NVR.
- External disturbances (noise) critical within analogue transmission paths that may negatively effect the quality of the video signal are usually uncritical in digital signal transmission.
- Even in digital systems, the maximum transmission length is limited (considering the max. segment length of network lines). However, any distance can be achieved using suitable network components such as repeaters, routers, etc.
- In principle, video, audio, control data and power supply (POE) can be transmitted by a shared network connection. Usually several lines are required for this within analogue systems.
- The storage capacity and/or recording time can be expanded as required, irrespective of the provider of the digital CCTV system.
- IP cameras are often based on the Progressive Scan Method. The picture is thereby not scanned using the line skip method so typical for analogue cameras, but full-frame. This avoids the well-known jitter effect.
- In contrast to general expectations, many IP cameras – even today - do not reach the standards set by analogue cameras regarding light sensitivity, colour fidelity, dynamics and even picture resolution.
- In comparison to analogue cameras, megapixel cameras often only provide relatively low frame rates (fps) at their highest comparable resolutions. Smooth, jitter-free representation and recording in realtime at high resolution is therefore limited.
- The offer on the market for megapixel lenses still remains limited.
- When selecting system components, great care and attention must be paid to compatibility. This particularly applies to IP cameras because the image compression method and functions are not standardised. This means that they must be individually implemented for all downstream components and devices such as HDVR and NVR. Within this context, you should check whether the HDVR, NVR manufacturer can also provide guaranteed support for future IP cameras and consider the costs of subsequent integration.
- When integrating IP cameras, some limitations to their functions may have to be accepted because not all of the features are always supported by the central devices such as HDVR, NVR, etc.
- Use of a motion picture compression method (e.g. H26x, MPEG-2, MPEG-4) may in some circumstances result in considerable latency times, i.e. to delays when operating PTZ systems/dome-cameras.
- Suitable protection mechanisms to prevent unauthorised access or manipulation require much more effort than when using conventional analogue technology, especially when using existing networks and computers.
- In addition to the configuration of the video parameters, considerable extra administrative effort must be planned for network-specific parameterisation of e.g. routers, switches, repeaters, servers, etc.
- The much-lauded cost-savings by using Power over Ethernet (PoE) applies only to a point because the network structure and max distance must always comply to the technical guidelines for the use of PoE.
- Network solutions implemented outdoors – especially over longer distances – have other conditions than wiring indoors.
- Existing network connections can be used, but additional effort and expense for laying stub lines from the IP camera to the nearest network connection should be taken into consideration.
- The most decisive question of cost for an analogue, hybrid and digital solution can only be seriously answered in direct comparison taking into account all performance features, including wiring costs and investments for peripheral network components. The cost of installation, commissioning and maintenance must be considered as well.

Some useful information on video analysis:

- The advertising messages of manufacturers of digital CCTV systems often lead one to believe that the newly-offered video analysis functions are to be attributed to the accomplishments of digital CCTV products. It is correct that the video industry has conjured up impressive new analysis functions within the last few years, but the one thing has very little to do with the other. Both developments simply ran parallel to each other, and video sensor technology (which has now been established for several years), is simply video analysis in its classic form. In principle, video analysis also functions combined with digitised PAL/ NTSC signals. Noteworthy is also that most algorithms do not even exploit the high resolution of the megapixel camera to increase the detection accuracy or the capture range.
- The term „video analysis“ is comprised of several subareas that are substantially different from each other both in application and in the evaluation method. The following summary provides a survey of the most important video analysis functions:

Sensor system

- Application: Motion detection or optimal use of the storage space within the area of the video recording and alarming in case of undesired events.
- Typical product names: Activity Detection, Motion Detection, Motion Detector, Video Sensor
- Method: Determines changes to the picture within defined areas, taking into account simple features specific to the object such as size, speed, etc. Much higher requirements are made of the evaluation method in the outdoors.

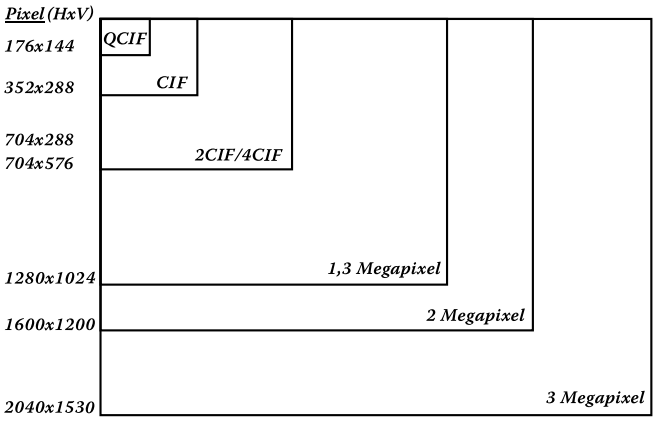
Object detection

- Application: Following, detecting and counting persons, recognising number plates, fire detection in tunnels, detection of unattended luggage, reporting in case of non-movement, e.g. traffic jam/congestion
- Typical product names: Object Recognition, Loitering, Tripwire, Leave Behind Detection, Video Sensor
- Method: Search-and-find of predefined objects within a defined image area, taking into account features specific to the object such as shape, size, speed, trajectory/path of motion

Biometrics

- Application: Face recognition used within access control (maxi-

Typical picture formats of PAL and megapixel cameras



The picture quality is influenced as follows, depending on whether **analogue, hybrid** or **digital**:

	Analogue	Hybrid	Digital
PAL/NTSC standard	x	x	
Transmission medium (cable length, electrical disturbances, etc.)	x	x	
Bandwidth of transmission medium/network		x	x
Picture compression method		x	x
Resolution, light sensitivity of sensor	x	x	x
Resolution, transmission level of lens	x	x	x
Lighting of the scene	x	x	x
Resolution of all downstream system components, e.g. DVR/NVR	x	x	x

Table: Picture resolution (pixels) vs. bit rate and storage space

Picture format	QCIF	CIF	2CIF	4CIF	1,3MP	2MP	3MP
Picture resolution	176x144	352x288	704x288	704x576	1280x1024	1600x1530	2040x1530
Picture size in KB without compression	50	198	396	780	2,560	4,781	6,096
The following values are based on a compression factor of 15, typical for single image compression							
Picture size in KB	3.30	13.20	26.40	51.98	170.67	318.75	406.41
Number of pictures than can be stored per GB	274,693	68,673	34,337	17,441	5,311	2,844	2,230
Bit rate in mbit/s	0,03	0,10	0,21	0,41	1,33	2,49	3,18
Number of pictures that can be transferred per 100 mbit/s	3.879	970	485	246	75	40	31
The following values are based on a compression factor of 60, typical for single image compression							
Picture size in KB	0.83	3.30	6.60	12.99	42.67	79.69	101.60
Number of pictures than can be stored per GB	1,098,774	274,693	137,347	69,763	21,246	11,376	8,922
Bit rate in mbit/s	0.01	0.03	0.05	0.10	0.33	0.62	0.79
Number of pictures that can be transferred per 100 mbit/s	15,515	3,879	1,939	985	300	161	126

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mum-security wings/prisons) or electronic access control (login in IT)

- Typical product name: none known
- Method: In general, the evaluation of physiological characteristics and typical behavioural features and, when used in facial recognition, determination of the characteristic features of the face

Search in picture archive

- Application: Automatic search for defined changes to the picture within picture archives/ recordings and reduction of evaluation time
- Typical product name: Smart Search, Post Search, Motion Search
- Method: In principle, procedures used within the sensor system method, as well as that of object detection, can be used. However, „sensor detection" is normally the basis used for automatic searching within archives

Sabotage monitoring

- Application: Detection of picture failure, blur (loss of focus), noise, change in the image detail (rotation protection), picture manipulation
- Typical product names (examples): Synchronisation Signal Monitoring, Video Signal Monitoring, Image Content Monitoring
- Method: Evaluation of features typical to the video signal and, depending on the requirements, targeted analysis of the image content with alarm signal in case of critical differences
- In an ideal case, video analysis is free of error. However, in practice the detection accuracy is decisively influenced by the following factors:
- Bad picture quality due to blur, noise or low image resolution
- Environmental influences in the outdoors such as shifting light conditions caused by shadow, clouds, day/night operation, changing seasons, camera vibration (e.g. caused by wind), movements of bushes, trees, reflections, e.g. caused by glass areas or puddles and weather conditions such as rain, snow, falling leaves
- Insufficient knowledge of the method of function of the procedure used, resulting in incorrect configuration
- Technological limits because the video analysis is normally based on two-dimensional picture material. Three-dimensional scanning of the scene similar to that of human sight would considerably reduce the error rate but would also considerably increase the costs compared to a "two-eye camera analysis system".

Some useful information on resolution:

- Local resolution is the measure or the smallest detail still remaining visible within a televised picture.
- Increasing resolution means that more details can be seen; concomitantly, this increases the probability that the system delivers important additional information required to assess a scene.
- The resolution is always determined by the weakest link in the chain of all system components.
- However, picture quality is not only defined by the number of pixels but also by the pixel resolution (grey tone, colour fidelity).
- In case of analogue cameras, the

Table: Influence of image sensor resolution on the max. possible distance from the object (in m)

Format	Perception 50%, screen	Detection, 10% screen	Recognition, 50% screen	Identification, 120% screen
PAL	88.5	44.3	8.9	3.7
QCIF (176x144)	22.1	11.1	2.2	0.9
CIF (352x288)	44.3	22.1	4.4	1.8
2CIF *1) (704x288)	88.5/44.3	44.3/22.1	8.9/4.4	3.7/1.8
4CIF (704x576)	88.5	44.3	8.9	3.7
1.3 megapixel (1280x1024)	161.0	80.5	16.1	6.7
2 megapixel (1600x1200)	201.2	100.6	20.1	8.4
3 megapixel (2040x1530)	256.6	128.3	25.6	10.7

**1) In case of 2CIF resolution, a difference must be made between vertical and horizontal resolution because the picture is only scanned at half the line number (semi-frame)*

Table: Influence of image sensor resolution on detail recognition (details in pixels)

Format	Detection 5% screen			Perception 10% screen			Recognition 50% screen			Identification 120% screen		
	Body	Head	Scar	Body	Head	Scar	Body	Head	Scar	Body	Head	Scar
PAL	29	4	0	58	8	1	288	41	3	575	99	8
QCIF (176x144)	7	1	0	14	2	0	72	10	1	144	25	2
CIF (352x288)	14	2	0	29	4	0	144	20	2	288	49	4
2CIF (704x288)	14	2	0	29	4	0	144	20	2	288	49	4
4CIF (704x576)	29	4	0	58	8	1	288	41	3	576	99	8
1.3 megapixel (1280x1024)	51	7	1	102	14	1	512	72	6	1024	176	15
2 megapixel (1600x1200)	60	8	1	120	17	1	600	85	7	1200	206	17
3 megapixel (2040x1530)	77	11	1	153	22	2	765	108	9	1530	262	22

Body: Number of vertical lines with which a picture of a 1.7 m tall person has been taken
Head: Number of vertical lines with which the head of a 1.7 m tall person has been taken
Scar: Number of vertical lines to take the picture of a 2 cm scar

local resolution is limited by the PAL/NTSC standard.

- High-resolution IP cameras lift the resolution limits set by PAL. Megapixel cameras therefore provide much higher picture resolutions when integrated consistently. However, before deciding on this method you should clarify whether the goal of using megapixel cameras is to reduce the total number of cameras required – because the final result of this may then be a comparable or even lower picture resolution. A gain in resolution, and therefore an increase in the amount of detail that can actually be seen, would only be ensured if the number of cameras used remains the same.

Generally applicable definitions of picture quality:

- Perception: Allows an observer to see the location, direction and speed at which a person is moving as long as the area in which the person is to be expected is known in advance.
- Detection: Allows an observer to locate a single person at any location within the scene observed with almost 100% certainty. In these circumstances, a video motion detector could be used as an alarm.
- Recognition: Within the boundaries set by this quality level, an observer would recognise a person known to him/her with almost 100% certainty.
- Identification: The detail is so good that an observer is able to identify a person not known to him/her with almost 100% certainty, based solely on the image. ■