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an introduction to **video content analysis** industry guide

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1. Introduction

Video Content Analysis (VCA), also known as Intelligent Video Analytics (IVA) is the name given to the automatic analysis of CCTV images to create useful information about the content. VCA has a wide range of uses, for instance it can detect intruders, left packages and wrongly parked vehicles as well as counting events such as people entering or leaving an area. In theory any 'behaviour' that can be both seen and accurately defined on a video image can be automatically identified and an alert raised.

VCA has a broad spectrum of applications. Facial Recognition and Automatic Number Plate Recognition (ANPR) are application-specific uses of VCA where the technology has been used to identify people and vehicles respectively. While these are both applications of VCA in the broadest sense, they generally use specialist cameras and VCA tools which are outside the scope of this guide.

Buying a VCA system is little different from buying any other piece of technology. However the emerging nature of VCA – it has become a reality only in the last three to five years – and the number of producers entering this new and exciting field means that the range of products and the installation implications can be confusing for potential buyers. Also it is fair to say that earlier premature attempts to deliver systems using pixel-based Video Motion Detection suffered from a combination of over selling and under performance. The market today is rightly cautious when it comes to buying a VCA system.

VCA can be used to increase the effectiveness and return on investment into CCTV systems by adding enhanced or increased capabilities to detect events and analyse post-event video.

VCA can be successfully used in a variety of applications:

- External and internal intruder detection
- Monitoring of plant or buildings for health and safety
- People counting
- Automatic traffic event and incident detection
- Safety enhancements for public areas (PA announcements etc)
- Smoke and fire detection
- Camera failure or sabotage detection

2. Scope

This guide is aimed at end users and integrators/installers considering the introduction of VCA technology for the purposes of security, safety, people and traffic management or event counting. Its purpose is to provide a basic understanding of the technology and its delivery as well as offering general advice helpful for assessing suppliers and their products.

3. Terms, Definitions and Abbreviations

3.1 Terms and Definitions

Metadata

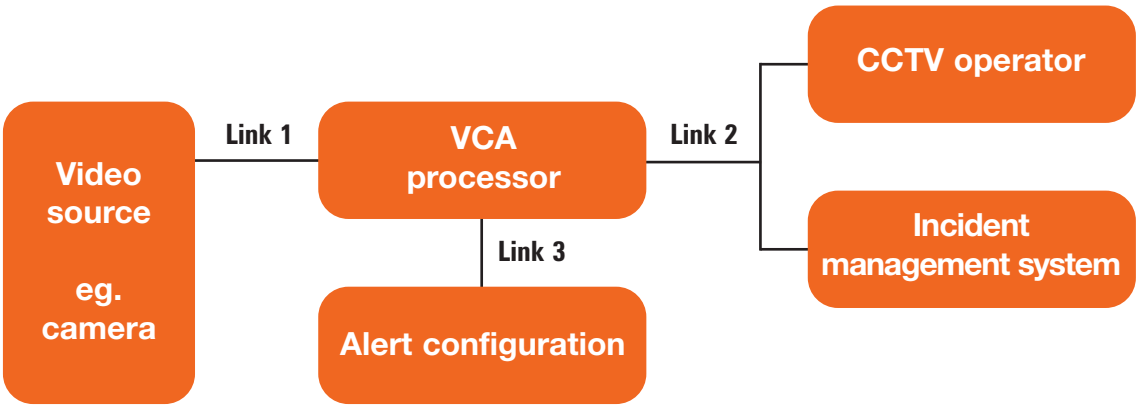
This is data used as a supplement to other data. The exact nature of the metadata and the systems and methods employed will vary from one manufacturer to another and between applications. Different techniques may be combined to achieve specific results.

3.2 Abbreviations

ANPR	Automatic Number Plate Recognition
CCTV	Closed Circuit Television
FAR	False Alarm Rate
IP	Internet Protocol
IVA	Intelligent Video Analytics
PA	Public Address
Pd	Detection Probability
PTZ	Pan-Tilt-Zoom
VA	Video Analytics
VCA	Video Content Analysis

4. Generic VCA System

VCA systems from different suppliers may vary, but the diagram below indicates the main elements in their simplest form:



Link 1 is the feed from the video source (e.g. camera) to the VCA Processor. Today this is most often standard CCTV cabling, but it can involve fibre optic links where distances are involved and as IP cameras gain ground Link 1 will become a LAN/WAN network link, which can include wireless as well as cabled connections. Link 1 can also contain a mixture of these technologies.

Link 2 carries the alert message to a CCTV operator and/or an incident management system. The latter will automate the response, pointing PTZ cameras, making PA announcements, locking doors, book-marking DVRs etc. Link 2 is normally a network connection, but it can also be a simple relay contact.

Link 3 is used for alert configuration and maintenance purposes. It can be a direct keyboard/screen/mouse connection to the VCA processor or a network connection from a separate PC.

Installation and commissioning is covered later, but it should be said here that the physical installation into a system using existing cameras is very simple indeed.

VCA platforms are typically offered in two types of package:

- Central or core based – typically rack mounted for use in CCTV control rooms. The video sources are analysed centrally.
- Edge based – a smaller – occasionally ruggedised – unit that can be integrated within or placed close to the camera.

The above equipment can be used for real-time alerts and, where recording equipment is provided, post-event analysis can be used for forensic applications.

The term "embedded" is also used to describe when the VCA software is designed into the camera, DVR or other unit, either as a dedicated part of its design or as an add-on card.

5. How analysis works

Different products do things differently, but in general CCTV images are broken down into their component parts, covering both 'static' background shapes and moving foreground objects or 'blobs'. Information on each object is distilled by the software into its position, size, direction of motion, time in view etc. The exact data – referred to as metadata – is very much tied to the individual VCA product. In some cases, parallel methods of extracting metadata operate at the same time because some perform better than others depending on the application and the scene. The process of capturing metadata is frequently separate from the alert rules. That is to say the image processing algorithms are unaware of what the user is looking for. This independence allows recorded metadata to be searched using different rules at a later date for forensic purposes.

The alert rules are set by the configuration element in the above diagram. This effectively defines the conditions that must be matched by the metadata in order to generate an alert.

Certain important fundamentals follow on from the above:

- Firstly – today at any rate – most VCA systems need a static background, and therefore operate only with fixed cameras. Some systems can also operate with PTZ cameras but only when parked at set positions.
- Only objects that move at some point can generate an alert. If an object never moves then de facto it is treated as part of the background scene – even though it may have the potential to move, like a car.

  Importantly not all objects that do move are of interest. In fact most of them are not. Leaves on trees, shadows and reflections fall into this important category.
- Each scene is different and each camera needs to be individually tasked.

It is worth touching on the use of perspective and colour in VCA.

Perspective setting

For every camera view the analysis software needs to know the approximate size of people, vehicles and other objects when they appear at various points in the screen – typically much smaller, farther away at the top of the screen than closer to the camera at the bottom. This is a set-up issue that affects all VCA systems and is referred to as 'camera perspective'. There are many different approaches to setting and checking camera perspective. A wrongly set perspective is one of the most frequent causes of missed detections and false alerts.

Use of colour

Colour would seem to be an obvious aid to detection but it is seldom used because of the massive amount of additional computation involved and also because of the difficulty of defining a colour accurately under varying lighting conditions. Some systems do however include colour as an attribute in the metadata once an alert is generated. Also a system that operates on grey scale only can be used equally well with thermal cameras.

6. Key technology challenge

By far the two most important performance factors in any VCA system are its Detection Probability (Pd) – the probability that the system will detect what the user wants to see - and its False Alert Rate (FAR) – the number of times the system creates an alert when nothing of interest is happening – otherwise known as a false positive.

VCA has a sub-class of false positives known as 'nuisance alerts'. These occur when the alert is not exactly what the operator wanted to see, but is caused by a real event and the system is doing exactly what was asked of it. Imagine a maintenance engineer moving through a building at night triggering an intruder alert.

The importance of Detection Probability is pretty clear but FAR is every bit as critical. At face value a FAR of once per camera per day sounds very good, but if you have a 400 camera system then your control room will be alerted every 4 minutes or so. Under these circumstances, confidence falls away to the point when good alerts are ignored and the system is rendered ineffective.

Sustaining Pd/FAR performance under varying lighting, weather and crowded scene conditions is the single most significant challenge in VCA.

7. Impact and benefits of VCA

Most of the benefits of introducing VCA are self-evident by now. In a CCTV control room, the norm is for an operator to be monitoring several screens and behind each screen there can be several tens of unwatched cameras. There is clearly major under-usage of valuable resources. By drastically reducing the need to view hours of empty camera images, VCA is able to rebalance this situation, realising the full potential of both the equipment installed and the staff operating it.

There is an occasional misconception that VCA might replace the CCTV operator. The opposite is true. By significantly reducing the multiple live camera viewing requirement VCA leaves operators free to concentrate on managing real incidents one-to-one, confident in the knowledge that the VCA system is relentlessly watching out for routine events such as detection of intruders or wrongly parked vehicles.

VCA can have an important impact on the end-user's organisation that needs to be recognised. For example:

- In a CCTV control room the balance between real time and retrospective (evidence gathering) activity is very much shifted towards real time operations by VCA.
- Using VCA in video search activity can virtually eliminate the workload in the task and at the same time improve its accuracy.
- Applying VCA to a working site can very accurately reveal patterns of activity and trends not previously apparent and this insight can result in substantial secondary benefits in terms of operational efficiency gains – with measurable outcomes.

8. What can VCA do?

A VCA 'behaviour' is basically a question of who, what, where and when as follows:

Who	Person (tall, short) Vehicle (large, small) Object (large, small)
(Doing) What?	Moving in a given direction Stopped for a period of time Loitering for a period of time Entering or leaving a zone
Where?	Tripwire Double tripwire Zone Multi-zone
When?	Time of day Relative time

Most VCA offerings consist of a toolkit of frequently used features with the ability to draw zones or lines on the screen to indicate where those features are to be applied.

Implicit in most offerings is the ability to distinguish different types of target – for example vehicles and people – based on characteristic shape, size or motion or a combination of characteristics.

Typical features include:

- Sterile zone (intruder detection)
- Left package or its converse removed object detection
- Loitering (people and vehicles)
- Wrong way movement
- Congestion and over-crowding counting (people and vehicles)

Typical zone types can include:

- A zone covering an area on the screen – normally these can take any shape and are entered using a mouse. Alerts are generated when a target enters the zone, leaves the zone or stays inside the zone for too long.
- A virtual tripwire – a mouse-drawn line that will trigger an alert when a target crosses in either or both directions.
- A double tripwire – frequently used to register speed, or slowness of target motion through a corridor.
- Linked zones – are used to generate an alert when a target moves from one zone to another.

9. Should you consider VCA?

If you have an operational issue that needs resolving and it involves a behaviour that you can observe on a CCTV camera and describe in words then VCA can help you. Clearly the alert is only part of the solution however, and you need to consider also the other elements that will need to be introduced – for example some kind of response – to complete the solution.

10. Selecting a VCA System

There is no magic involved in selecting a VCA system. It should be considered a purchase like any other and subject to the same scrutiny that most companies use in their regular procurement processes. However in an emerging technology, some areas do need special attention:

- A common language for the technology is developing and there have been attempts at benchmarking but inconsistencies remain. Partly this is due to the range of applications that are possible – security, traffic management, people counting and safety. These applications span a range of industries each with its own language and ways of describing what is being achieved.
- Systems are not (yet anyway) truly 'plug and play' – all scenes are unique and cameras need to be individually configured, soak tested and optimised to meet the task in hand.
- At this time the skill levels required for install, commission, operation and support of the systems vary widely and this naturally impacts on the cost of these elements.
- VCA is typically heavy on computational power. Product platform cost per channel can vary widely depending on whether the supplier has invested in DSP (Digital Signal Processing) chips or not.

The following table outlines some advantages and disadvantages of edge and central based systems:

Advantages and disadvantages of edge and central based systems		
	Advantages	**Disadvantages**
Edge based	VCA can be performed on the raw image from the video source (e.g. camera) before any compression is applied. This means the image has the maximum amount of information content therefore potentially allowing the VCA to work more effectively. Distributed intelligence around the system can increase the overall resilience to failure of the total system. Processing of locally sourced data makes the system resilient to transmission/network failures and alerts can be responded to locally or stored for transmission once the network connection is resumed. The edge device that performs VCA may be able to control the volume and quality of images and metadata sent over the network, thereby reducing the bandwidth usage by reducing frame rates, lowering resolution and increasing image compression when no events or alerts are in progress.	May require more complex devices at the edge to carry out the VCA. This is likely to result in larger units with greater power requirements than conventional analogue or network cameras. This will have to be taken into account when installing and may, for example, make the equipment less suitable for rapid or covert deployment.
Central based	It can be easier to maintain and upgrade VCA equipment installed at one central location. The equipment can be protected from power failure by using a central uninterruptible power supply (UPS), as well as being put in a physically secure location which can improve the system's resilience to failure or sabotage. In a centralised environment it may be possible to deploy more powerful processors to carry out the VCA and/or to share those processing devices to carry out several VCA tasks in parallel.	Large amounts of network bandwidth may be required to transmit high quality, high frame rate images from the image capture devices to the VCA. Analogue image feeds for VCA may suffer from attenuation and loss of high frequency content due to long runs of coax cable. This may impede the efficiency and accuracy of the VCA due to the loss of information content within the images.

Probing system references is as valuable in VCA as elsewhere. In the case of this emerging technology, valid case studies are arguably more important and at the same time thinner on the ground. It is also valuable to probe the pedigree of the technology on offer. Where did it come from? How long has it existed?

When looking at a VCA supplier you should look for the three 'P's'

- **P**edigree
  Technology origins, delivery and support organisation, availability of quality product training, references.
- **P**erformance
  Detection Probability (Pd) and False Alert Rate (FAR)
  Features including schedulers, etc.
- **P**roduct quality
  Solid hardware platform that fits the application, ease of use, flexibility, ease of interfacing

As with any new technology the VCA suppliers welcome a broad range of enquiries. Naturally some progress very quickly and others fall by the wayside. Successful projects generally contain an important problem that needs to be solved associated with a definable behaviour that is clear early on.

11. Selecting cameras

Analogue cameras installed according to UK industry standard practices can be used with all of the VCA offerings on the market. While IP cameras dominate the new installation market, they remain a small minority when compared with the number of legacy analogue camera systems. Not all VCA systems will work with all IP cameras. VCA needs to understand the encoding used by the IP camera – which is not too difficult – but it also needs to allow for any compression that is taking place which may cause a loss in image quality – such as adding spurious images known as artefacts - that in turn could impact VCA performance.

It is crucially important that the buyer confirms with the VCA supplier that his system is compatible with any proposed IP cameras.

12. Questions you should ask

Having decided that you would like to investigate VCA here are some of the more detailed questions you should ask:

How well can it do the job?

- Ask about Detection Probability and most importantly False Alert Rate. Don't forget that what seems a good False Alert Rate may not be so impressive when multiplied across 100's of cameras.
- Ask what can cause accuracy and reliability problems with the VCA system. Consider how prone your site/scenarios are likely to be to those problems, and how the system can be best designed and configured to avoid those issues.

  Examples include:
  Problems caused by shadows or foliage - may be resolved though choice of camera position, provision of illumination, regular pruning of trees, etc.

  Passers-by seen through glass frontage - position cameras to avoid confusion

  Areas of high contrast in light - use cameras with wide dynamic range or good backlight compensation to provide better quality usable video to the VCA.

- Ask how easy it would be to change the size of the system (i.e. scalability).
- Assess the system for ease of use.

How much does it cost?

- Arguably the most pivotal question in terms of project cost is whether new cameras are needed or not. Analytics companies typically do not include the cost of camera supply and installation and most offerings will work very well with existing cameras as long as they follow standard UK CCTV design practices.
- Although existing cameras can work very well, and existing camera reuse may seem attractive, be aware that when installed as part of the original system the original choice of camera, lens and camera orientation may have been based on very different considerations. This could result in a sub-optimal field of view for the VCA system, so at the very least cameras may need to be revisited to re-orientate or adjust the lens field of view (which may not be possible without lens replacement if fixed focal lenses have been used).
- Most offerings are bought on a per channel basis, but don't forget to include installation, commissioning and support.
- All analytics systems require a soak testing period in order to absorb the reality of the camera situation and the behaviours to be experienced, including those behaviours that were previously hidden such as the smokers around emergency exit doors.
- You should be clear about the software licenses that apply to both the analytics themselves and also to any user software that may be needed, for example by operators or maintenance staff.
- Sometimes analytic features are bought separately, for example tripwire, intruder detection etc in an effort to reduce cost for those who are clear about what they need and don't require a full toolset.

How flexible is the system?

- Offerings vary from a toolkit of single, individually triggered alerts which are very simple to configure, requiring only a zone or tripwire to be drawn on the screen. Other systems allow conditional alerts to be created with inter-dependencies involving both analytic and external triggers, for example from access control systems. These systems are needed where more accurate targeting is required to increase detection rates or reduce false alerts or both. They do carry with them increased complexity and require more skill to set up and maintain.
- Ability to interface with other systems can also be an important factor. On the input side, supplementary triggers can be provided from surrounding systems as mentioned above, but on the output side detailed messages can be sent to other systems to trigger incident management responses from PA systems, lights, door locks or remote monitoring stations. Input and output interfaces are generally provided either by network messages or via separate relay switch units.

What is the support model?

- Support is required during soak testing, in response to unavoidable in-service scene changes (e.g. foliage growth) and to deal with system faults. All of these require access to the system by a trained operator either directly on site or via a secure network link. In the overwhelming majority of cases the link option greatly reduces running costs and increases operational readiness, but IT security policies have to be met to allow this to happen.
- If support is to be provided by an installer/integrator rather than the analytics supplier, then access to good quality product training is a must.
- Support should also include provision of training to the end-user.

13. Conclusions

VCA can multiply the effectiveness of either a new or an existing CCTV system and its benefits range across security, safety, traffic and people management and event counting applications. In many cases, it is capable of doing things that were hitherto impossible without a large army of operators wastefully staring at their CCTV screens.

If you need more information on VCA then contact the BSIA on the number listed on the front cover of this guide or alternatively visit the BSIA website for further information **www.bsia.co.uk**

14. Reference documents

HOSDB Operational Requirements Manual

BS EN 50132-7	Alarm systems. CCTV surveillance systems for use in security applications. Application guidelines
NCP 104	National Security Inspectorate Code of Practice for the Design, Installation and Maintenance of CCTV Systems
BS 8418	Installation and remote monitoring of detector activated CCTV systems. Code of practice
BS 8495	Code of practice for digital CCTV recording systems for the purpose of image export to be used as evidence

BSIA Codes of Practice:

BSIA CoP 109	Planning, installation and maintenance of CCTV systems

BSIA Guides:

BSIA Form 120	Maintenance and servicing of CCTV surveillance systems
BSIA Form 172	A basic guide to BS 8418 systems for installers
BSIA Form 196	A user guide to detector activated remotely monitored CCTV systems
BSIA Form 197	CCTV privacy masking guide
BSIA Form 199	CCTV chip and pin guide
BSIA Form 205	CCTV surveillance systems log-book
BSIA Form 228	A guide for installers and RVRCs to the use of external detection in BS 8418 CCTV systems