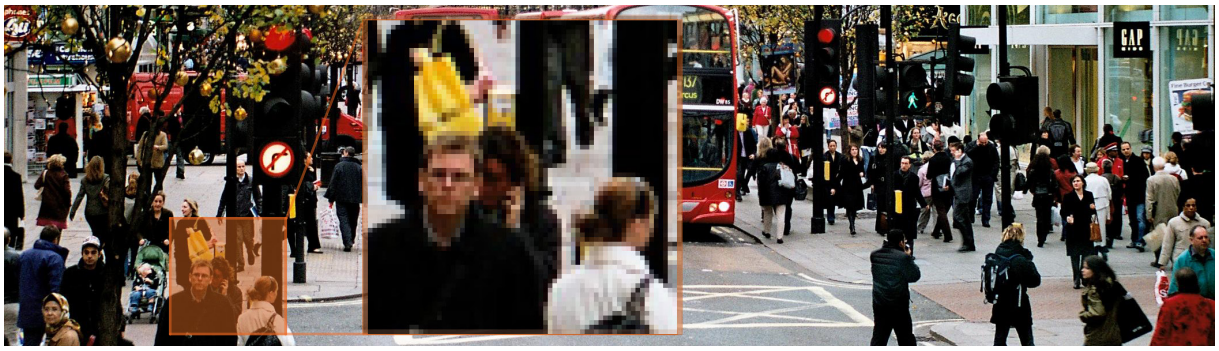
An introduction to video content analysis – industry guide



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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 and Abbreviations

3.1 Glossary of Terms

Algorithm – a process or set of rules to be followed in calculation or other problem solving operation.

Camera Masking – undesired obscuring of the view

Counting – count of people or vehicles in and out of a defined area.

Direction of Flow – Identify the direction of a moving object. e.g. crowd formation, wrong way movement

Face Detection – detect and record faces, also known as Automatic Face Detection (AFD). Gender/race/age determination (from face)

Face Recognition – comparison of a detected face against a reference image, also known as Automatic Facial Recognition (AFR)

Left/Removed Object – where an item is left or removed from a predefined area.

Loitering – where an object remains stationary beyond a predefined time.

Metadata – Data that is associated with the primary video information, e.g. date, time and location. The exact nature of the metadata and the systems and methods employed will vary from one manufacturer to another and between applications.

Motion Tracking – Following a moving object within the field of view.

Object – anything which does not form a static part of the background scene e.g. person, animal, vehicle or baggage. The scene itself may be classified as an object.

Object Classification – the determining of the type of object

Privacy Masking – intentional obscuring of parts of the view such as blocking public/private areas

Scene Change – major and rapid change in the scene such as camera reorientation or masking

Sterile Zone (intruder detection) – a physical area where under normal circumstances there should be no objects.

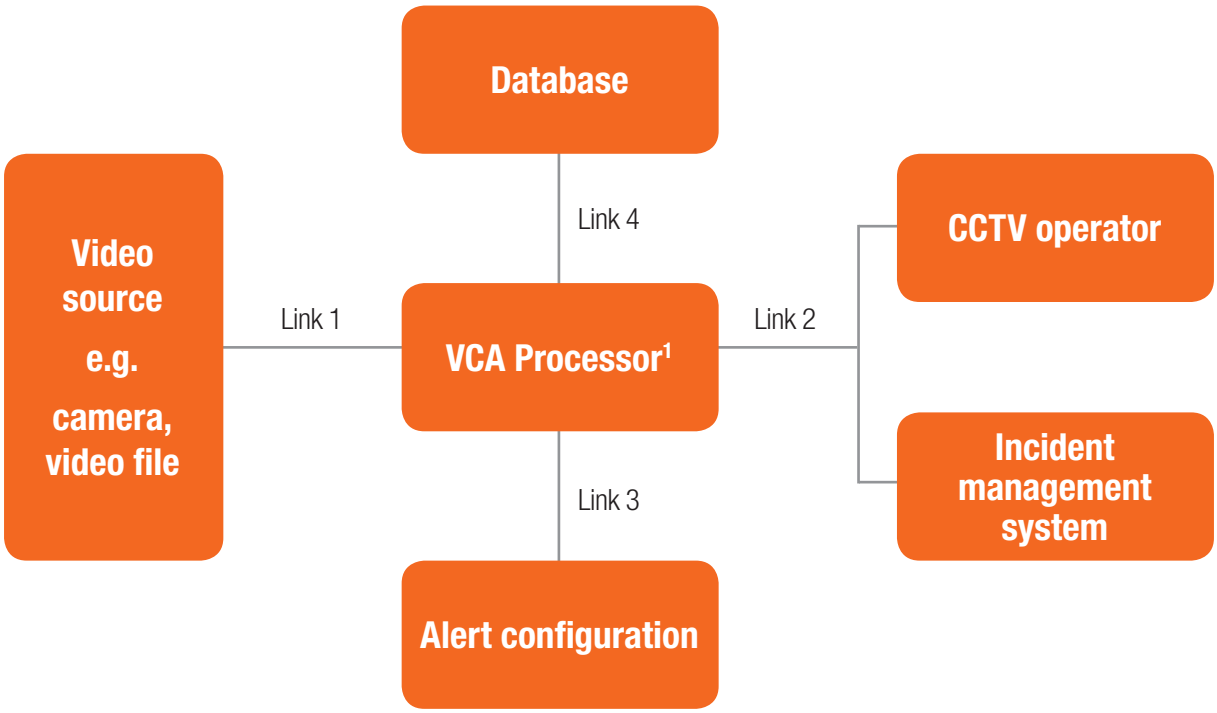
Virtual Line – a drawn line within the view that will trigger an action when a target crosses the line in either or both directions.

3.2 Abbreviations

ANPR/LPR	Automatic Number Plate Recognition/Licence Plate Recognition
CCTV	Closed Circuit Television
FAR	False Alarm Rate
FRR	False Reject Rate
IP	Internet Protocol
IVA	Intelligent Video Analytics
OCR	Optical Character Recognition
PA	Public Address
PD	Probability of Detection
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:



[1] *VCA processing can take place on board the camera, or on a separate server e.g. Camera Application Platforms, Edge analytics.*

Installation and commissioning is covered later, but it should be said here that the physical installation into a system using existing cameras is possible. However camera views will need to be configured to exacting requirements (often manufacturer specific) to ensure reliability of the VCA system.

VCA platforms are typically offered in two types of package:

- Central or core based – All analysis carried out by single/common units i.e. one device performs analytics on multiple video streams - typically rack mounted for use in CCTV control rooms.

- Edge based/distributed analytics – a system where the processing is not performed centrally – often 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 be classified to later generate an action. 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.

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 scene/horizon 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.

6. Key technology challenge

By far the two most important performance factors in any VCA system are its Probability of Detection (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 Pd 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 genuine alerts are ignored or omitted/isolated and the system would be 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

In a CCTV control room, the norm is for an operator to be monitoring several screens and behind each screen there can be many 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.

Detection types can be combined to provide improved functionality.

9. Selecting a VCA System

When purchasing a VCA system there are some areas that 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. These applications span a range of industries each with its own language and ways of describing what is being achieved.

- Systems are not 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.

- All of the features described in this document are available through different products but not necessarily available in a single product or compatible on the same CCTV system.

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	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.
Central based	It can be easier to maintain and upgrade VCA equipment installed at one central location. The equipment can be put in a physically secure location which can improve the system's resilience to failure or sabotage. When adding VCA to an existing CCTV system.	Large amounts of network bandwidth may be required.

10. Suitability of cameras

VCA is not recommended for use on PTZ cameras.

It is crucially important that the buyer confirms with the VCA supplier that his system is compatible with any proposed IP cameras. For IP systems VCA needs to understand the encoding used, any compression that is taking place which may cause a loss in image quality – such as adding spurious images (known as artefacts), resolution and image rate.

Thermal cameras may also be used in appropriate situations.

HD and other high resolution images will not necessarily improve the performance of a VCA system. High resolution requires greater processing power and therefore many VCA manufacturers process images at lower resolutions.

Camera view considerations:

- Detection distance
- Scene perspective
- Scene height and width
- Types of lighting
- Occlusion

It is not recommended to install any lighting near a VCA camera which will cause degradation of image due to insect infestation and unwanted reflections.

11. Considerations

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

Design Considerations

- 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 100s 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.

Cost considerations

- 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 re-use 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 licences 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.

- Consider the cost of VCA as a locally hosted function versus cloud services (especially power costs). – i.e. would there be a need to invest in the hardware (a rack of servers) or alternatively lease a cloud server externally?

- Consider the cost of storage, the use of VCA could reduce the space taken for the storage of images, as only the images required will be stored, all others will be ignored, i.e. less hard disc space used.

- It may be prudent to think of this more holistically, as there will be indirect cost and efficiency savings made in terms of:

    - less screen time for operators
    - less missed incidents
    - less time taken to find incidents from hours of recorded non-activity.

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, 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.

- Alarms generated from VCA could be used for remote monitoring by Remote Video Receiving Centre (RVRC) and could be BS 8418 compliant.

Maintenance considerations

- Ongoing support is required to ensure that the system continues to operate effectively due to environmental changes e.g. foliage growth.

- A formal maintenance contract with a reputable company employing appropriately trained staff should be considered.

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**

12. Reference documents

Home Office Scientific Development Branch (HOSDB) - CCTV Operational Requirements Manual 2009 Publication No. 28/09
http://tna.europarchive.org/20100413151426/http:/scienceandresearch.homeoffice.gov.uk/hosdb/publications/cctv-publications/28_09_CCTV_OR_Manual2835.pdf?view=Binary

Surveillance Camera Commissioner's Surveillance Camera Code of Practice (SCCoP)
www.gov.uk/government/uploads/system/uploads/attachment_data/file/157901/code-of-practice.pdf

Protection of Freedoms Act 2012
www.legislation.gov.uk/ukpga/2012/9/pdfs/ukpga_20120009_en.pdf

BS EN 50132-7	Alarm systems. CCTV surveillance systems for use in security applications. Application guidelines
BS 8418	Installation and remote monitoring of detector-activated CCTV systems. Code of practice
BS EN 62676	Video surveillance systems for use in security applications, suite of standards
BS 7958	Closed circuit television (CCTV). Management and operation. Code of practice
NCP 104	National Security Inspectorate Code of Practice for the Design, Installation and Maintenance of CCTV Systems

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 Systems Handbook and Logbooks.
BSIA Form 210	An installer's guide to Internet Protocol (IP) in the security industry.
BSIA Form 217	BS EN 62676 series – Guidance for customers about grading and other important matters.
BSIA Form 218	Graded requirements under BS EN 62676 Standards for CCTV.
BSIA Form 228	A guide for installers and RVRCs to the use of external detection in BS 8418 CCTV systems.
BSIA Form 235	A guide for installation of CCTV systems using IP technology.
BSIA Form 266	Choose a BSIA member.
BSIA Form 299	Benefits of IP in CCTV.

This document was created by the CCTV Section of the British Security Industry Association (BSIA).

The British Security Industry Association is the trade association for the private security industry in the UK. Our members provide over 70% of UK security products and services and adhere to strict quality standards.

CCTV has had a profound impact on crime prevention and detection. The UK leads the way in the application of CCTV and its use is wide-ranging, encompassing facial-recognition technology, remote video monitoring, video smoke detection, mobile systems and Automatic Number Plate Recognition (ANPR) as well as many other functions.

In order to provide guidance and simplification in the complex area of CCTV, the BSIA is very active in the European & International standards arenas and also develops its own guides and codes of practice where currently standards do not exist.

The CCTV section encourages debate on new developments and concerns, such as digital video evidence and facilitating communication protocols between different manufacturers' products. In doing so it seeks to ensure that all stakeholder interests are represented including: security companies.

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