Bosch Security Systems

Technical Note
Intrusion Detection FW 6.30

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Intrusion Detection FW 6.30

This technical note describes the best practices for and answers common questions regarding intrusion detection using Intelligent Video Analytics or Essential Video Analytics with FW 6.30.

Applications

- Perimeter protection
- Sterile zones
- Warehouse after hours
- Solar plants
- Façade protection
- ... and wherever and whenever no one is supposed to be within an area during a certain time

Common product platform (CPP)

- Bosch cameras can be clustered by their common product platform. As different platforms offer a different amount of processing power, this can make differences in the performance. For an overview of the different product platforms and the cameras belonging to them, see the tech note on Video Content Analysis (VCA) Capabilities per Device.

Limitations

- Different performance and setup options on Intelligent Video Analytics on CPP4 and Essential Video Analytics on the one hand, and Intelligent Video Analytics on CPP6/7 on the other hand
- Does not work for well-populated and crowded scenes
- Does not work on elevators or other conveyance belts
- Does not work if camera is moving

Overview

- What is an intruder?
- How can I distinguish intruders from animals?
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What is an intruder?

If we talk about intruders, we typically mean people entering areas which are off-limits to them. Depending on the application, however, the people may also sit in vehicles or bikes. Furthermore, professional intruders typically do not walk into the area, but crawl or roll to present the camera the least view of them that is possible.

Intruders: Walking, crawling, rolling

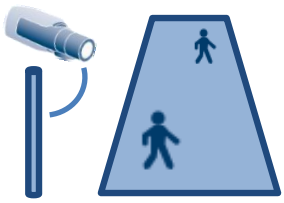
How can I distinguish intruders from animals?

You can't. It is possible to separate standing and walking people from smaller animals like dogs, foxes or rabbits by their size, but if we talk about professional intruders crawling or rolling into the scene, then most of the time the difference to the animal in question is not large enough for a robust classification. There is currently no video analytic for intrusion detection on the market that can really solve this problem. If you are only interested in walking / standing persons, the automatic object classification can be used. See the tech note on object classification for configuration details.

A crawling person looks similar to a dog

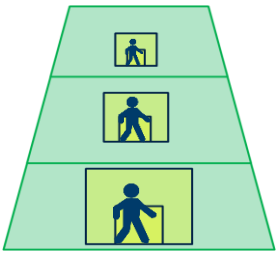
What is a camera calibration and when do I need it?

A camera calibration teaches the camera about the perspective in the scene. Due to perspective, in the rear of the video images the persons appear smaller, they cover less pixel in the image, though their real size is the same. Perspective is thus needed whenever the real size and speed of objects is needed, as well as an automatic perspection correction of object sizes. Calibration becomes more important the larger the area covered by a single camera is. For small areas (10-20m distance), the perspective effect is typically neglectable, for larger areas, it becomes essential for robust performance. Note that the longer the distance, the less reliable object size and speed estimations become, as less pixel are available per meter.



Perspective: Objects in the rear appear smaller

To calibrate, the position of the camera in relation to a single, planar ground plane is described by the elevation of the camera, the angles (tilt, roll) towards the ground plane and the focal length of the lens. As calibration is only done in reference to a single, planar ground plane, scenes with stairs, escalators, several ground levels, facades or rising ground cannot be calibrated correctly. If the rising ground only differs a little from the planar ground plane, a best effort calibration can be tried. In all other cases, please refrain completely from using a calibration and set the object size filters, if needed, for the different image regions by hand.

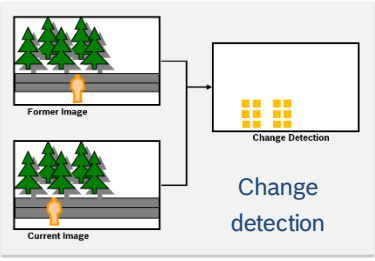


Manual object size filter (yellow) can also compensate perspective

Where do false alerts in trees come from?

All video analytics algorithms for intrusion detection are based on three core technologies: Change detection, motion estimation and background subtraction.

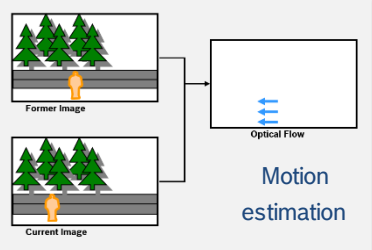
- Change detection evaluates per block whether the content of the block has changes within the last second. This technology is used in MOTION+. The disadvantage is that every change in the image, be it an illumination change or actual motion, triggers the blocks as changed. Note that the after-image of the object also triggers the blocks.



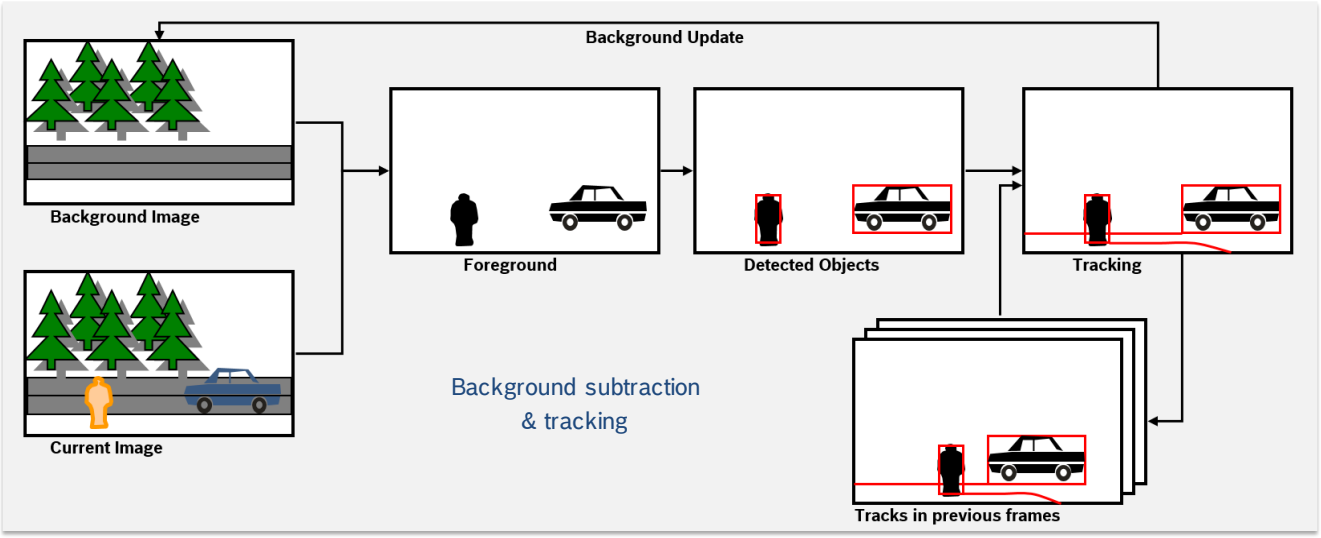
Change detection

- For motion estimation, also called optical flow, it is evaluated for every part in the image where this part was in the last image, or a second ago. Flow is based primarily on this technology.

- For background subtraction, one, multiple or stochastic background images are learned over time and updated continuously. Every difference to the learned background is then extracted as a moving foreground object and tracked over time. Intelligent Video Analytics and Essential Video Analytics use this technology in combination with motion estimation.

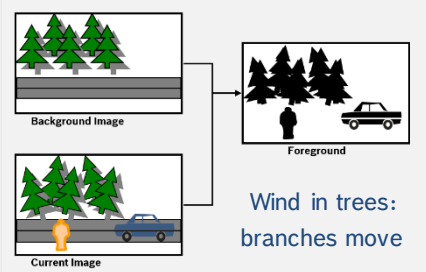


Motion estimation

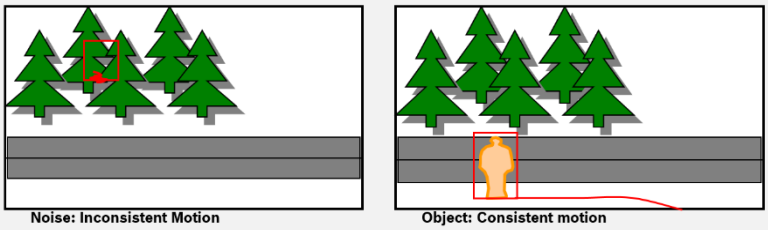


Background subtraction & tracking

Now for all three technologies, if the wind moves a branch, then there is a distinct change to the position of the branch a second ago and the branch is detected as a potential change / motion / moving object. By combining the different technologies, tracking the objects over time and evaluating the consistency of motion, robustness can be achieved even to these kind of moving objects the user is typically not interested in.



Wind in trees: branches move



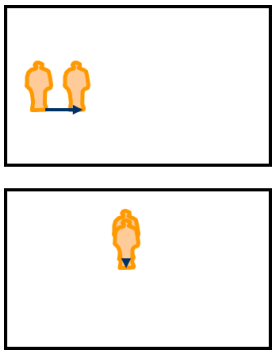
Consistency of motion

Why are objects detected so late?

Objects are actually detected as soon as they appear, however, to validate that they are interesting objects with consistent motion and not spurious detections by wind in trees or flags or the falling of rain drops and snowflakes, Intelligent Video Analytics and Essential Video Analytics hold the detection back for a few frames. To get the objects as soon as they appear, please go to MetadataGeneration->Tracking, disable the noise suppression. For Intelligent Video Analytics on CPP6/7, in addition raise the sensitivity to max.

How should I set up the camera view?

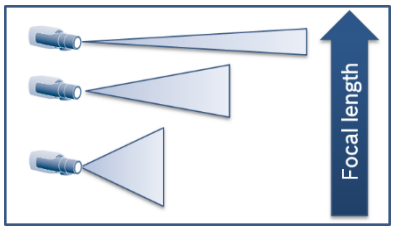
If possible make sure that intruders cross the field of view instead of walking towards the camera. Due to the perspective, a person walking toward the camera does not cross as many pixel in the image and does not have much apparent motion as a person crossing the camera view. Thus it is more difficult to detect and separate from noise. Higher elevation is preferred due to the same reason. Though higher poles are more expensive and prone to shaking, the lower a camera is mounted the less apparent motion objects walking toward the camera


Motion towards the camera is less apparent

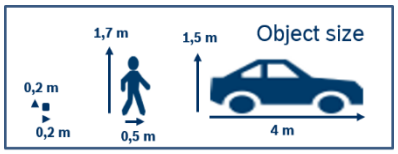
have, and the harder they are to detect. Note also that the more area is covered by the selected lens, the farther an object must travel to cross the same amount of pixel.

How far into the distance can Intelligent Video Analytics / Essential Video Analytics detect objects?

A general answer cannot be given, as this depends on the chosen camera, the chosen video aspect ratio, the camera perspective, on the focal length and on the light and weather conditions. Furthermore, both Intelligent Video Analytics and Essential Video Analytics are not directly computed on the original camera resolution but on a reduced one due to computational power limits. For an overview of which resolution is used on which camera, please see the tech note on VCA Capabilities per Device.

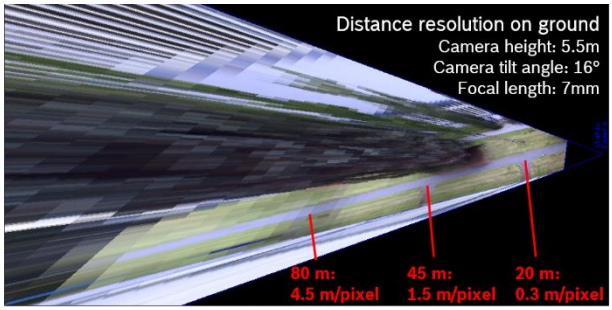


Generally, a larger focal length indicates a larger zoom factor and a smaller width of the field of view. So one can see farther into the distance but less far to the left and right than with a smaller focal length. Furthermore, with a larger focal length, the unobserved area in front of the camera is much larger as well. Another trade-off for the larger detection range of larger focal length is that motion towards the camera takes longer to detect.



The detection distance also depends on the size of the object, with longer detection ranges for larger objects.

Distance resolution is best near the camera, and degrades heavily into the distance where a single pixel in the internal resolution often covers several meters of ground. Here an example for Essential Video Analytics:



Find here a few collected best practices for Intelligent Video Analytics on CPP4 & CPP6:

Common Camera Platform	Aspect Ratio	Objects	Installation height (m)	Focal length (mm)	Pole to pole distance (m)
CPP4	16:9	Person	3,5	6	40
CPP4	16:9	Person	6	10	70
CPP4	16:9	Person	5-9	4	25
CPP4	16:9	Car	8-12	4	35
CPP6	4:3	Person	5,5	7	60

Configuration

Configuration of intrusion detection is separated into several applications, which all have their own characters and require different optimizations. For detection of intruding ships, please see the tech note on IVA 6.10 Ship Tracking. If you are interested in an application where you need to be alerted already if only a part of the intruder, like a hand or an arm, trespasses into the alarm zone, please see the tech note on Museum Mode FW 6.30.

Configuration: General advice

- **Alarm field preferable to line crossing**: For a line crossing to trigger, the object needs to be detected before and after the line. In combination with challenging situations like storm in trees, where detection can be delayed in favour of false alarm suppression, the placement of the line needs to be done with care. An alarm field, which triggers whenever an object is detected inside, covers larger areas and is thus inherently more robust.
- **Scheduling:** This is available on DINION & FLEXIDOME cameras. Configure one or both VCA profiles, then change the VCA configuration to "Scheduled" and define the times where which VCA profile should run.
- **Alarm-based recording / adjustment of recording frame rates:** Can be triggered by any alarm. Configurable via Recording -> Profiles, or via the alarm task editor for full flexibility

Configuration: Small, controlled environments, e.g. indoor

- **Object size**: Intelligent Video Analytics and Essential Video Analytics do not know whether a small object in the image is actually a small object, or a large object that is far away. Therefore they will detect and track even the smallest objects like leaves and small garbage blown by the wind in the foreground or small animals in the default settings. To avoid that, set the min object size, either in the MetadataGeneration -> Tracking, where it will completely suppress them, or filter them out in your alarm task.
- **Calibration**: Perspective correction of the object size is not necessary for small environments for intrusion detection.
- **Fast object detection**: In indoor applications, always go to MetadataGeneration->Tracking, disable the noise suppression and (Intelligent Video Analytics on CPP6/7) raise the sensitivity to max. Noise suppression and object validation is only needed for outdoor environments. In controlled, small outdoor applications, that is much tarmac and no trees, this can also be disabled.

Configuration: Façade protection

- **Calibration**: As the façade is vertical, calibration is not possible at all.
- **Fast object detection**: As the façade is mostly tarmac, and if no trees are nearby who's shadows can fall on the façade, then you don't need noise suppression and object validation. Go to MetadataGeneration->Tracking, disable the noise suppression and (Intelligent Video Analytics on CPP6/7) raise the sensitivity to max.

Configuration: Climbing walls or throwing across walls

- **Calibration**: Don't use any calibration. Flying and climbing objects will not be detected & tracked well if camera is calibrated.

Configuration: Large outdoor areas

- **Calibration**: If the ground is more or less flat, then add calibration to teach the camera about perspective. Only thus is the most robust detection with largest detection ranges possible.
- **Noise suppression**: Noise suppression is enabled by default and should stay that way. Sensitivity is at a medium value, suppressing short-lived and non-consistent moving objects. Use Intelligent Video Analytics on CPP6/7 cameras with noise suppression STRONG for best noise suppression.
- **Double detection distance**: On CPP6/7 with FW ≥6.30, detection distance for moving objects can be doubled by calibration the camera, using a 3D tracking mode, and setting noise suppression to OFF or MEDIUM.

Configuration: Infrared illumination & insect swarms

Insects are drawn to the light of infrared illuminators. If the infrared illuminators are included in the camera or positioned close nearby, this means that a myriad of insects will flutter through the video and cause false alerts. Therefore always position the illuminator in at least 80cm distance to the camera.

Though false alerts due to insects cannot be suppressed completely, they are already greatly reduced in Intelligent Video Analytics on CPP6/7 cameras from FW 6.10 onward. With Intelligent Video Analytics on CPP4 cameras, with Essential Video Analytics, or to generally further reduce false alerts, use multi-line crossing or combine several single alarm rules via VCA task script language. Go to the video analytics configuration and open the task page. Right-click on the video and select Advanced -> VCA Task Editor. A separate popup with the current VCA task script will appear. Here is an example configuration, which can be copied and pasted into the VCA task script editor. Further information about VCA tasks script language and example scripts are available in the VCA task script language manual and a separate tech note.

VCA task script example: Alarm if an object enters field and afterwards, within 30 seconds, crosses the line in the middle of the field:

```
//Definition of task primitives
 Resolution := { Min(-1, -1) Max(1, 1) };
 Field #1 := { Point(-0.6, 0.95) Point(-0.25, -0.95)
               Point(0.25, -0.95) Point(0.6, 0.95)
               DebounceTime(0.50) };
 Line #1 := { Point(0.0, -0.95) Point(0.0, 0.95)
              DebounceTime(0.50) };
 //@Task T:0 V:0 I:1 "Enter Field and Line" {
 external Event#1:={EnteredField #1
                    before (*,30) CrossedLine #1
                    where first.oid == second.oid };
 //@}
```

Task wizard definition //@Task T:x V:y I:z
T:x describes the task number (Object in Field, Line Crossing,...)
T:0 describes a self-defined task. Use this for your own scripts to avoid the task wizards overwriting it
V:0 is the version number, currently always 0 I:z is the slot in the tasks page
I:1 describes the occupied slot in the GUI task list. For the slot to change to red in case of alarms, the external event / state defined in the task needs to have the same number as the task

before(*,30) means the object needs to cross the line 0-30 seconds after entering the field. As the object needs to enter the field in order to cross the line, the other temporal direction need not be checked.

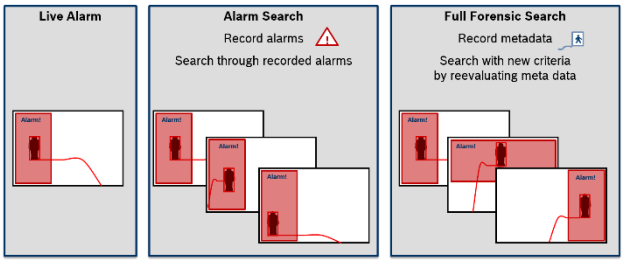
The same object has to trigger both events. Thus using where first.oid==second.oid

Configuration: Shaking / vibrating camera

When the camera shakes, the content of the whole image shakes with it. The effects are especially visible around edges, as these cause the most change. Thus, false alerts can occur and the tracking of existing objects can be disrupted. C compensation of shaking and vibrating cameras within Intelligent Video Analytics on CPP6/7 cameras was introduced with FW 6.10 and perfected with FW 6.20. It is always active there. With Intelligent Video Analytics CPP4 cameras and with Essential Video Analytics, no compensation for shaking cameras from video analytics side is possible.

Configuration: Optimization via forensic search

There are two parts of the configuration of Intelligent Video Analytics and Essential Video Analytics. The first part defines the object detection and tracking, also called metadata generation. This includes camera calibration, selection of the tracking mode, masking areas from the processing and defining idle / removed debounce times. This first part needs to be done initially and cannot be changed afterwards.



The second part of the configuration evaluates the metadata and includes tasks like line crossing, object in field and more. This second part can be fully evaluated and optimized using forensic search. To do so, record video including the events to be detected. Then use a forensic search capable viewing client like BVC. Define or adapt your alarm tasks, and evaluate whether all events are detected correctly and how many false alerts are still left.

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