Article

Perfect Pixel Count

Meeting your operational requirements

AXIS COMMUNICATIONS

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1. Introduction

This step-by-step guide helps you select the best cameras for your operational requirements and surveillance scenarios.

Lack of industry standards and the complexity of the matter cause many integrators to lose sight of a key prerequisite in any installation: the operational requirements or the true purpose of the surveillance.

In this guide, we present the Pixel Density Model – a method that allows you to relate the operational requirements of your system to modern surveillance video and IP cameras.

2. Moving into IP

Selecting the appropriate surveillance camera to fulfill operational requirements has always been a challenge.

With the introduction of IP cameras, and especially through the development of megapixel and HDTV cameras, the need has emerged for a new way to determine how to meet operational requirements. In these six steps, we describe a model to relate operational requirements to modern video and IP cameras.

When recommending cameras and discussing what is the "best" camera on the market, it is easy to focus on datasheets and technical specifications. This causes many integrators to lose sight of a key prerequisite in any installation, namely the operational requirements or the actual purpose of the surveillance.

Previously when surveillance was all analog, selecting a camera to match an operational requirement was mostly about selecting the appropriate lens since there wasn't a wide variety of resolutions to choose from. Most CCTV systems are designed to monitor human behavior, so the human body was used as a yardstick. In order to differentiate between diverse types of scenarios, various categories were established based on percentage representation of the height of a human body within the field of view. While not a global standard in any way, it became quite common to distinguish between the need for detection, recognition, and identification.

Category	Abbr.	Operational requirement	Body height – 4 CIF
Identification	Id	Detail should be sufficient to enable the identity of an individual to be established beyond reasonable doubt.	100% from the UK source quoted – 150% is also quite commonly used
Recognition	Rec	A high degree of certainty whether or not an individual shown is the same as someone seen before.	50%
Detection	Det	Enable to determine with a high degree of certainty whether or not a person is present	10%

Figure 1. (UK Home Office Scientific Development Branch, 2009)

As correct as the percentages in Figure 1 might be for a standard analog resolution, they pose a few challenges when moving into the diverse resolutions of IP cameras. To bridge the gap, attempts have been made to translate from TV lines to pixels to produce tables like the one shown in Figure 2, where the way of thinking about analog operational requirements in terms of percentages has been translated for IP. This might be correct, but it is difficult – if not impossible – to work with complexity such as this in a real-life context. Surely there must be a better way.

Category	PAL	1080p	720p	WSVGA	SVGA	VGA	2CIF	CIF	QCIF
Identify	100	38	56	67	67	84	139	139	139
Recognize	50	19	28	34	34	42	70	70	139
Observe	25	10	14	17	17	21	35	35	70
Detect	10	4	6	7	7	9	14	14	28
Monitor	5	2	3	3	3	5	7	7	14

Figure 2. Reading the table, the vertical body height percentage representation for Identify should be 38% with a 1080p HD camera.

3. Pixel density

The growth of IP surveillance forces us to a make paradigm shift in the way we define our operational requirements.

Advancements in camera technology have resulted in a multitude of resolutions and formats. Instead of using vertical height and percentage, we should focus on pixel density in the horizontal dimension. The term pixel density in this context refers to the number of pixels representing the object of our operational requirement – commonly a human, or more specifically, a human face.

One reason why we have chosen to use the face is its distinct identifying features. Furthermore, the variances in face widths are less than those of body lengths or widths, which results in a smaller margin of error. The average human face is 16 centimeters wide (= 6.3 inches wide). Following suggested operational requirements from SKL, the Swedish National Laboratory of Forensic Science, and supported by our own test results at Axis Communications, we have chosen to use 80 pixels as the requirement for facial identification for challenging conditions . (see Figure 3).

To some, this number might sound high, and in fact some vendors or independent sources recommend 40 pixels for a face or 100 pixels per foot for recognition. The argument behind the higher number is that for identification, there are limited other telltale signs. For recognition, previous knowledge adds factors such as how a person moves – a property easy to observe and recognize, but difficult to identify and describe accurately. To ensure sufficient video quality even if the object isn't facing the camera straight on, or if the lighting is not optimal, the higher number provides an adequate safety margin.

Operational requirement	Horizontal pixels/Face	Pixels/cm	Pixels/inch
Identification (challenging conditions)	80 px/face	5 px/cm	12.5 px/in
Identification (good conditions)	40 px/face	2.5 px/cm	6.3 px/in
Recognition	20 px/face	1.25 px/cm	3.2 px/in
Detection	4 px/face	0.25 px/cm	0.6 px/in

Figure 3.

[1]Challenging conditions: Situations with very varying or weak lighting. People, objects and vehicles are seen from an angle where details are in shade, or facing away from the camera. It could also occur in situations where people, objects and vehicles are moving at very high speed through an area. More often occurring in outdoor situations without additional lighting, or indoor situations during very dark conditions.

[2]See European Standard EN 50132-7:2012 by CENELEC www.cenelec.eu

[3]Good conditions: Situations with decent lighting. People, objects and vehicles are moving at reasonable speed, and seen from an angle where sufficient details are visible. More often occurring in indoor situations where lighting is even, or outdoor situations with additional lighting.

4. A simple model

Axis offers a simplified model of a complex reality.

Just like with the previous analog models, the goal is to assist when specifying a camera and its field of view to meet a predefined operational requirement, rather than to define a minimum, fixed standard. There simply is no way to guarantee that complying with this simplified rule of thumb will enable a camera to fulfill the operational requirements, even at the given pixel densities. To make matters even more complex, one cannot say that one operational requirement will not be met if an installation does not comply with the guidelines. The reason is that the real world is far too complex for a simple mathematical equation that does not take into consideration complex issues such as light direction, intensity, and dynamics. Nor does the model deal with issues like image compression or quality of optics. Choice of optics is particularly important, and a science on its own, which is why it is advisable to work with vendors who supply cameras that have been tested end-to-end with the included lens.

Defining operational requirements

As with the analog percentage method, the operational requirements should be specified to a point or line at 90 degrees of the camera axis within the field of view. This is vital, since the further away from the camera an object gets, the more the pixel density decreases. At Axis, we call this imaginary line across the field of view the capture line. However, just as the expanded percentage scale is not a very usable yardstick in real life, neither are human heads. For everyday use, we need a standardized measurement. Figure 4 illustrates the operational requirements for an average face, and the calculations for pixel density for centimeters and inches. Once we know these numbers, we can use them in a multitude of ways. Figure 5 illustrates the three operational criteria, with recognition shown on the left and detection shown on the right.

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Figure 4.

Figure 5. In the main image the three operational requirement criteria. Enlargement of Recognition (Left) and Detection (Right).

5. Use the model

Now you have all the necessary information – it's time to apply the method.
Looking at the Operational Requirements (OR) for a given scene, we can use the numbers to identify the minimum resolution required. Let's say your client has a loading dock 12 meters wide, and the OR is to recognize people walking across the dock. Looking at the table, we see that we need a minimum of 1,200 cm/1 px per cm = 1,200 pixels to solve this OR. A 720p camera with a horizontal resolution of 1280 pixels is therefore sufficient for the job, provided the capture line is the entire width of the dock.

Find the maximum scene width at a given resolution
Another customer is monitoring an office space and wants to know the maximum width of a scene where identification can take place. Using the maximum horizontal resolution of the sensor, we can calculate this. As full HDTV resolution is 1920 x 1080 pixels, we see that the maximum width of a scene where the operational requirements for identification is met is 1920 px / 5 px per cm = 384 cm.

For a lower resolution, the maximum scene width is narrower, as seen in Figure 1. Both images have the same horizontal field of view and similar pixel density for the person's face.

In the larger image, the capture line is further back, placing the person further back in the image, thus providing a wider capture line and a larger identification area. The effect of this can be seen in the field of view illustration in Figure 6.

An advantage of this method is that it is easier to communicate when dealing with customers in a site survey situation, since it brings operational requirements into the physical domain. The integrator can now show and clearly describe the scene in which the customer can expect fulfillment of these requirements.

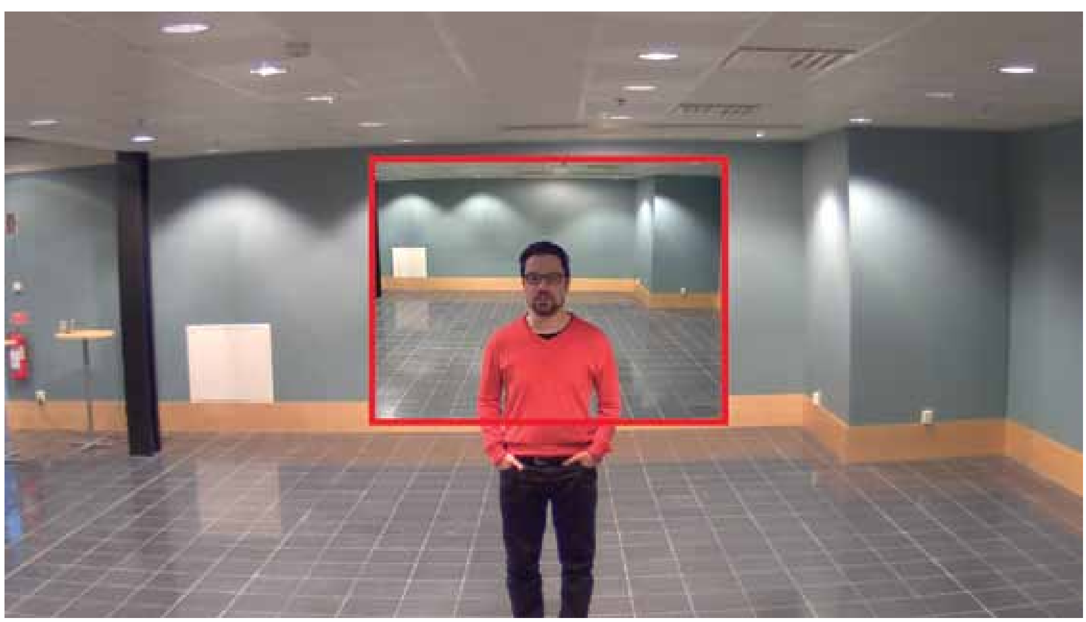

Figure 6.

6. The Axis pixel counter

Now, validate your established operational requirements.

Pixel counter
Axis' pixel counter enables the integrator to validate the operational requirements with a click of a button when setting up the camera. The pixel counter is a visual aid shaped as a frame. It can be displayed in the camera live view with a corresponding counter to show the box's width and height. It can be adjusted and moved around in the image through drag-and-drop.

A pixel counter example
A convenience store owner has requested CCTV to monitor the checkout counter. The operational requirement is to provide images that are sufficient for identification. An additional request is to see as much of the store as possible. To fulfill the OR, and using a 720p dome camera, the integrator can set the pixel counter to 500 pixels, and adjust the camera to cover a folding rule placed on the counter, as shown in Figure 7. As a last step, the integrator can redirect the camera to ensure the best possible view of the store, thereby fulfilling both customer requests. Even if the integrator does not know the exact width of the counter, the problem can be solved by placing an object of known size, such as a piece of A4 copier paper (30 cm wide), on the capture line, and setting the pixel counter for the appropriate resolution. (For identification, the setting for an A4 sheet of paper would be 5 px/cm multiplied by 30 = 150 pixels.)

Figure 7. An Axis pixel counter example.

Determine how far a camera can "see"
Another great way to use the method to communicate with potential customers is to manage expectations related to distances at which a camera can provide an adequate image – how far a camera can "see".

7. Conclusion

The Pixel Density Model together with the Axis pixel counter makes it easier to use the latest technology to build your surveillance system.

Though this is a fairly one-sided view of the complex task of camera selection, it provides us with basic guidelines for determining adequate camera properties. Furthermore, the model is highly usable and really only requires the user to remember the numbers for the three different operational requirements. No theoretical model will ever be able to take into account all the factors contributing to image usability, and still function as a guideline in the real world, but this model can shed some light on the complex issue of creating a truly purpose-built surveillance system. By providing this method we hope to make it easier for everyone working with video surveillance to work with operational requirements.

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About Axis Communications

Axis offers intelligent security solutions that enable a smarter, safer world. As the global market leader in network video, Axis is driving the industry by continually launching innovative network products based on an open platform - delivering high value to its customers and carried through a global partner network. Axis has long-term relationships with partners and provides them with knowledge and ground-breaking network products in existing and new markets.

Axis has more than 1,600 dedicated employees in more than 40 countries around the world, supported by a network of over 60,000 partners across 179 countries. Founded in 1984, Axis is a Sweden-based company listed on NASDAQ OMX Stockholm under the ticker AXIS.

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