DCRI White Paper Series #1: Defining the Right Level of Image Quality Needed for your Video Surveillance Systems

Introduction

With any kind of video-based surveillance system, image quality makes a difference. Defining the level of image quality needed is part of the system specification process, and a key question all security professional must answer is: “what level of video information do we or our client need the system to provide?” This is a critical question in the process of defining a system, since under-specifying the video requirements can lead to an under-performing system that fails to meet expectations; and over-specifying can lead to unexpected increases in both implementation and total cost of ownership throughout the life of the system.

The Bosch Detection, Classification, Recognition, Identification (DCRI) framework is a set of definitions for image quality applicable to optical imaging equipment under different lighting and environmental conditions day and night. The framework was created for use with optical imaging sensors in mind, creating the need for an additional performance level from thermal imaging devices.

This publication, the first of the DCRI white paper series, aims to achieve the following objectives:

- Highlight the basics of the DCRI framework – benefits to security professionals and image quality related terminologies
- Define the minimum DCRI imaging performance standards with respect to image resolution for Standard Definition (SD) and High Definition (HD) imaging
- Explain how to practically use and specify imaging objectives using the DCRI framework

Current challenge: Specifying the right level of video requirement

Often security video systems and/or products are specified with no context toward quality and purpose of the video produced. With these under-defined system specifications, manufacturers often provide night imaging ranges in the form of a single distance or range figure, frequently resulting in undelivered or unusable performance. In these cases, products that fit the “specification” may be very far off from what the user is actually expecting, resulting in a system not performing to expectation, especially when video analytics are involved.

DCRI framework: How it can help security professionals

To aid and assist in specifying performance requirements, Bosch uses the DCRI framework to help security professionals define the purpose and image quality needed for their video security systems. The framework employs a set of image quality definitions that allow security professionals to better define their imaging needs for a wide range of day and night time surveillance applications.

Moreover, application of the DCRI metrics can help security professionals select the right combination of cameras, lenses and proper illumination to ensure that customer expectations are fully met. To help illustrate this point, simply compare the combination of camera, lens and illumination required to detect a human at a distance of 500 meters versus the combination of equipment needed to identify a human at 500 meters distance. Merely determining that a potential security threat is present

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1 The original Johnson Criteria utilized three levels of imaging and is based on thermal imaging sensors. Comparatively, the Bosch DCRI scale is based on imaging relying on visible and near-infrared lighting from CCD / CMOS, allowing for greater detail and a wider range of resulting images.

2 It is important to emphasize the factors that affect night-time imaging, which include: the type of camera, the type of lens, the type and amount of illumination on scene, and reflectivity of the scene and targets. In addition to the above key influencers and depending on the application, weather, airborne obscurities, and thermal atmospheric effects can also impact imaging performance to varying degrees.
does not satisfy the need if the objective is to identify the threat as a specific individual. These are critical differences that can be easily missed or forgotten without proper attention.

In addition, the correct implementation of the DCRI framework can help prevent failures in video analytic function such as video motion detection, facial recognition and motion analysis. The framework can help define the minimum imaging performance standards needed to perform video analytics functions successfully.

DCRI framework: Qualitative and quantitative definitions

This first publication of the DCRI white paper series defines imaging levels with respect to image resolution based on usable images of humans under the optimal lighting condition of around 100 lux. A general description of the imaging levels and minimum imaging resolution requirements in the context of Standard Definition (SD) and High Definition (HD) imaging are provided below.

Note that the minimum imaging resolution requirements are defined in terms of pixels instead of percentages and remain the same for both SD and HD imaging. One of the advantages of HD versus SD resolution is the ability to provide an equivalent level of DCRI capability with a greater field of view, because the increased aperture opening from a lower focal length setting typically improves light transmission to the image sensor. On the other hand, the increased resolution of HD cameras also results in decreased light sensitivity when compared to SD cameras: in general, a standard SD camera can be up to seven times more sensitive to light than a standard HD camera.

Minimum Image Resolution Requirement
For SD and HD Cameras

\[
\text{Camera Field of View} = \frac{\text{Camera Resolution (horizontal pixels)}}{\text{pixels per foot (or meter)}}
\]

Detection
7 pix/ft (20 pix/m)

Classification
13 pix/ft (40 pix/m)

Recognition
20 pix/ft (60 pix/m)

Identification
49 pix/ft (150 pix/m)

Note: Based on human-sized target, 1.6 ft x 5.9 ft (0.5 m x 1.8 m)
**Detection-level Imaging**

Sufficient detail and clarity is available to determine the presence of a human-sized target (assumed target size of 1.6 ft x 5.9 ft or 0.5 m x 1.8 m, w x h) in the field of view. At this surveillance level, movement such as a swaying tree, an animal, or a human typically attracts attention to the object. The object is discernable from its surroundings and can be distinguished from the background when in motion.

Detection-level video has at minimum:
- 10 horizontal pixels on target (7 pix/ft | 20 pix/m)
- 25 vertical pixels on target

**Classification-level Imaging**

Sufficient detail and clarity is available to determine if a human-sized target can be distinguished between human and animal, or between animal and small vehicle, etc. All properties of Detection-level imaging still apply. Classification-level video provides object information such as approximate orientation in space, physical stance (standing, crawling, etc.) and direction of motion.

Classification-level video has at minimum:
- 15 horizontal pixels on target (13 pix/ft | 40 pix/m)
- 60 vertical pixels on target

**Recognition-level Imaging**

Sufficient detail and clarity is available to determine if a human-sized target is determined to be a threat or non-threat based on the type of clothing worn, equipment carried and/or other contextual cues. All properties of Detection- and Classification-level imaging still apply. Additionally, body movements, different uniform types, and the presence of headgear, backpacks or other objects can be determined.

Recognition-level video has at minimum:
- 40 horizontal pixels on target (19 pix/ft | 60 pix/m)
- 230 vertical pixels on target

**Identification-level Imaging**

Sufficient detail and clarity is available to allow for an already familiar human-sized target to be determined as a specific individual. All properties of Detection-, Classification- and Recognition-level images still apply. Additionally, the target’s type of headgear can be distinguished (e.g. bicycle helmet or soldier’s helmet), and specific objects on the body can be determined (weapons, phones, etc.).

Identification-level video has at minimum:
- 75 horizontal pixels on target (49 pix/ft | 150 pix/m)
- 250 vertical pixels on target
Selecting the right camera and lens using DCRI imaging objectives

The table below guides the application of the DCRI concept in choosing the right camera resolution for a classification imaging objective scenario:

<table>
<thead>
<tr>
<th>Stated camera resolution * (Horizontal)</th>
<th>Minimum resolution required (Classification)</th>
<th>Maximum field of view ** (Horizontal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1080</td>
<td>13 pix/ft (40 pix/m)</td>
<td>57 ft (27 m)</td>
</tr>
<tr>
<td>720</td>
<td>13 pix/ft (40 pix/m)</td>
<td>38 ft (18 m)</td>
</tr>
<tr>
<td>640</td>
<td>13 pix/ft (40 pix/m)</td>
<td>34 ft (16 m)</td>
</tr>
<tr>
<td>480</td>
<td>13 pix/ft (40 pix/m)</td>
<td>25 ft (12 m)</td>
</tr>
</tbody>
</table>

* Refers to the camera resolution figures that one sees on a standard datasheet. Note that one should be looking for the effective camera resolution, which is the maximum resolution the camera can actually produce. We will cover the topic of effective camera resolution in the second publication of the DCRI series.

** The maximum width the camera can realistically handle given the stated camera resolution (horizontal). Note that there are other factors such as effective resolution, compression, and lighting that can affect the maximum field of view figures above. We will cover the topic of compression and lighting in the second publication of the DCRI series.

The maximum field of view (horizontal) can help security professionals select the appropriate camera lens for the desired application. Note that besides the camera lens selected, other factors such as effective resolution, compression, and lighting can affect the maximum distance. The table guides the application of the DCRI concept in choosing the right lens for a classification imaging objective scenario, assuming the use of a camera with 640 horizontal stated camera resolution and a 1/3" camera sensor:

<table>
<thead>
<tr>
<th>Lens</th>
<th>Maximum Field of view (Horizontal)</th>
<th>Maximum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 mm</td>
<td>50 ft (16 m)</td>
<td>90 ft (27 m)</td>
</tr>
<tr>
<td>12 mm</td>
<td>50 ft (16 m)</td>
<td>130 ft (40 m)</td>
</tr>
<tr>
<td>45 mm</td>
<td>50 ft (16 m)</td>
<td>500 ft (150 m)</td>
</tr>
</tbody>
</table>
Selecting the correct DCRI-based imaging objectives based on performance requirements

To help guide in the application of the DCRI concept to real world scenarios, an analysis of two different applications will be provided below. The two applications are: fence line / perimeter surveillance and general area monitoring.

### Fence Line / Perimeter Surveillance

<table>
<thead>
<tr>
<th>Sample scenario</th>
<th>DCRI-based imaging objective</th>
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</thead>
<tbody>
<tr>
<td>A perimeter fence line at a power substation requires 24/7 monitoring. The video surveillance system is designed to operate in conjunction with a fence line sensor array (i.e., seismic sensors around the perimeter), and will be used to assess and determine if personnel need to be dispatched when a sensor alarm occurs. It is common for the local wildlife to venture near the fence line causing false alarms, resulting in the unnecessary dispatch of security personnel. Security personnel are only needed if a person can be seen near the fence line, as this is an unauthorized area.</td>
<td>Classification – the ability to determine if an alarm is caused by a human or animal.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample performance requirement</th>
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<tbody>
<tr>
<td>The camera system shall provide human classification-level performance, providing sufficient detail and clarity to determine if a target is human or animal at the specified x feet/meters. The camera system shall provide a minimum image resolution of 15 horizontal pixels and 60 vertical pixels, and provide image quality of at least 13 pixels per foot (40 pixels per meter) to determine if a target is human or animal at the specified x feet/meters.</td>
</tr>
</tbody>
</table>

### General Area Monitoring

<table>
<thead>
<tr>
<th>Sample scenario</th>
<th>DCRI-based imaging objective</th>
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<tbody>
<tr>
<td>A busy railway facility requires monitoring of the rail yard to ensure no unauthorized personnel are present. Recently the railyard has become the target of vandalism and local gang activity, and although this is a major concern, the owners of the station are also concerned with liability if someone was injured on the property. Cameras are to be installed so key areas of the yard can be monitored for unauthorized personnel and to aid security patrols of any activity in restricted areas.</td>
<td>Recognition – the ability to distinguish between uniformed security personnel and unauthorized individuals based on clothing and objects being carried.</td>
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<table>
<thead>
<tr>
<th>Sample performance requirement</th>
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</thead>
<tbody>
<tr>
<td>The camera system shall provide recognition-level performance, providing sufficient detail and clarity to determine if a person is authorized or unauthorized based on the type of clothing worn, equipment carried and/or other contextual cues at the specified x feet/meters. The camera system shall provide a minimum image resolution of 40 horizontal pixels and 230 vertical pixels and provide image quality of at least 19 pixels per foot (60 pixels per meter) to determine if a person is authorized or unauthorized based on the type of clothing worn, equipment carried and/or other contextual cues at the specified x feet/meters.</td>
</tr>
</tbody>
</table>

Once a required image quality objective has been set, it becomes much easier to determine specifics regarding required equipment and determining objective metrics for a video system. By basing system objectives in quantifiable metrics, managing customer expectation becomes much less of an abstract art.
Conclusion

Bosch’s Detection, Classification, Recognition, Identification parameters are created to help security professionals accurately define imaging objectives of video-based surveillance systems. The appropriate application of the DCRI framework can help security professionals select the right equipment (cameras, lenses, illumination) for their security video systems as well as help prevent failures in video analytics functions. The purpose is to help security professionals accurately define imaging objectives and manage video system expectations, in turn leading to successful implementation of these systems in the field. Please stay tuned for the second publication of the DCRI white paper series, which will delve into advanced topics such as effective resolution, compression, and lighting.

For more information regarding our experience in modern illumination technologies and our products that have been tested against the DCRI parameters, please refer to our Bosch website at http://www.boschsecurity.com.