Application Note | Case Study | Technology Primer | White Paper

Imaging in Challenging Lighting Conditions — A Better Way

Choosing just the right camera for a particular application can be difficult. Common cameras specifications that are normally considered include resolution and frame rate. However, lighting is an external factor that is potentially even more important to consider. In situations where lighting may be inconsistent, dynamic range and gain are crucial factors in capturing a successful image. This document highlights how high conversion gain (HCG) and low conversion gain (LCG) camera capabilities can be beneficial in challenging lighting conditions, along with examples of imaging applications where these challenges commonly occur.

Challenges with Inconsistent Lighting

Lighting is crucial when setting up a vision system. Inconsistency in the lighting can cause issues where image data becomes difficult to use if the light level becomes too low. A common solution to increasing the signal is increasing the gain of an image. However, this introduces an increase in noise which reduces image quality. In other cases, too much light may cause an image to be overexposed. Image data is then also reduced because of the pixels not being able to capture all the light, effectively blanking out areas of the sensor that are overexposed.

Importance of Dynamic Range

By having a high dynamic range, a vision system is able to capture more detail. This is because the dynamic range of an image refers to how dark and how bright image data can be without losing clarity. In a system with low levels of light reaching the sensor, captured images may not meet the requirements for a given application. If a vision system has too much light it can also affect image quality. In this case the image will be overexposed and bright areas will cause the image to be washed out. This occurrence can prevent image software from analyzing important data such as the license plate characters on a vehicle as it passes a tolling station.

Vehicle license plates captured as vehicles pass through a toll station.

If an image is captured with little light, then it may appear dark. This is because when not enough light is being captured by the sensor, the light-deprived areas appear as black. These dark images are under exposed and might not be able to have image data to identify subjects of interest. Increasing the gain on a camera can improve the overall sensitivity of a sensor, which can be crucial for imaging in dark environments. However, the downside to increasing gain is the added noise it will introduce into an image. That means there needs to be a balance between the amount of gain a vision system will use with the noise that can be introduced at the same time. This relationship is called the signal to noise ratio (SNR). Read the Teledyne Lumenera blog for a better understanding on dynamic range and SNR.

High Conversion Gain

Unlike traditional gain that most sensors support, Sony® Pregius® Generation 3 sensors in select Teledyne Lt Series Cameras offer a High Conversation Gain (HCG) feature. The main difference between traditional gain and HCG is that a sensor with HCG can allow more light to be imaged while reducing the read noise. This allows for imaging in darker environments without the need to worry about noise affecting the image quality. Noise can create artifacts in an image that interfere with image processing software that needed to analyse an image to determine the desired characteristics of a scene or target. This can be invaluable for applications such as traffic imaging where the natural light from the sun can drop as the sun begins to set. The trade off is that HCG offers superior low-light imaging with a small reduction in dynamic range.

HCG enables imaging in dark environments by preventing underexposure.

Low Conversion Gain

The other main acquisition and readout mode found in some of the newest Teledyne Lt Series Cameras is Low Conversion Gain (LCG). With this mode the sensor's main goal is to reduce the exposure of the image. Like the HCG mode, the LCG mode can be useful in traffic because it can prevent an overexposure in very bright environments. This results in a higher read-noise, but a significantly larger full well capacity. This can improve dynamic range when imaging bright scenes where gain amplification can be kept to a minimum.

When too much light reaches the sensor LCG mode prevents overexposure.

Applications

Outdoor imaging has some of the most varying lighting and can, therefore, significantly benefit from having a camera with either a high dynamic range or the HCG / LCG modes. In traffic applications such as speed and toll enforcement, the sun's position can affect the angle that light hits the camera. At certain angles, strongly reflected light into the sensor can cause overexposed areas. A variety of weather conditions like rain, clouds, fog, humidity, snow, and condensation can also cause a great deal of change in lighting that impacts images. The HCG / LCG modes offer greater detail for challenging surfaces such as license plates which can be highly reflective

on sunny days or improve visibility in low light to identify the number of passing vehicles.

In life sciences, the sensitivity of a camera can be a key factor in imaging performance. When imaging under a microscope the sample may only be able to be illuminated for short exposures to ensure the light does not damage the sensitive subject. This can cause issues for many cameras which may not capture enough light to properly display the sample. By using the HCG mode these images can improve their low light performance. Teledyne Lumenera's INFINITY8-2M offers an HCG mode which allows it to be the most sensitive in the INFINITY8 microscopy camera series. By reducing both full well capacity and read-noise the images captured with this microscope camera clearly depict all the detail from the large 1.1" sensor.

In machine vision applications such as automation and robotics, using HCG / LCG can help with inspection. Having the ability to adjust the mode based on the lighting in a factory environment can allow for the camera to adapt. Instead of increasing the amount of lights on an assembly line, the camera can capture more detail with reduced lighting. This can aid in inspection tasks such as bottle fill levels or mechanical assembly. However, in many factories there may be an abundance of light and it can be difficult to set up each area of inspection so that only the perfect amount of light is illuminating the subjects of interest. LCG mode helps provide flexibility for vision systems so that the chance of overexposure is reduced.

Factory automation can adjust to challenging lighting with cameras that have the option to switch between HCG and LCG.

Other than isolated environments where lighting is consistent for a specific test, such as in a room in a laboratory for calibration, it can be difficult to have consistent lighting when there are several camera systems all imaging different scenes. By using the HCG / LCG modes enabled by the Sony Pregius Generation 3 sensors, the Lt Series Cameras provide a solution for challenging lighting conditions. Beyond quantum efficiency, the main aspect of a camera that effects sensitivity is the read noise. By using the HCG mode, the camera can reduce the read noise while providing a brighter image for a variety of applications.

For more information, please contact Teledyne Lumenera's imaging experts.
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