EMVA 1288 Standard for Machine Vision

Objective specification of vital camera data

Choosing the suitable camera for a given machine vision application often proves to be a challenging task. The data sheets provided by the manufacturers are difficult to compare. Frequently, vital pieces of information are not available and the user is forced to conduct a costly comparative test which still may fail to deliver all relevant camera parameters. This is where the EMVA 1288 Standard comes in. It creates transparency by defining reliable and exact measurement procedures as well as data presentation guidelines. Version 3 of the standard has been released officially in March 2010. The standard has meanwhile gained international attention and its procedures have been verified by an international field test including labs from all over the world.

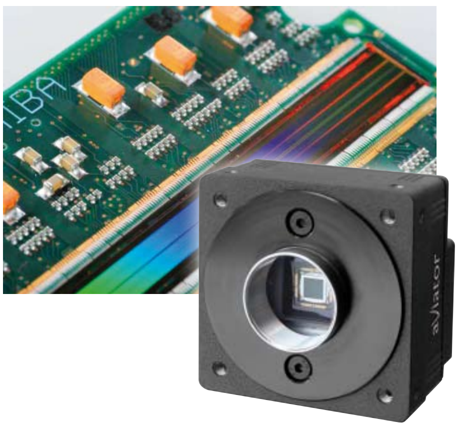

ABB. 1: **Not only camera manufacturers, such as Basler, offer 1288-compliant products. The standard covers image sensors as well.** (Sources: Basler, Awaiba)

The EMVA 1288 Standard has been developed by a working group of over 20 leading manufacturers, vision users and research institutes within the European Machine Vision Association (EMVA). The group was founded in 2004 with the aim to assist users of industrial cameras in their selection process. The quality and the parameters of a camera not including the lens (or of an image sensor) can be described by objective criteria because the operation of any digital camera system is based on elementary physical principles, which are well understood. Consequently, the aim of the working group has been to define a set of objective parameters that cover the complete functionality of line-scan and area-scan cameras, the necessary measurement procedures and data presentation guidelines. All this is contained in the EMVA 1288 Standard.

Benefits for Users and Vendors

The EMVA 1288 standard allows users of image sensors and cameras a true datasheet-based comparison of different products. Specifications are clearly defined as are the measuring methods. This helps the user to take an objective decision. The definition of data presentation guidelines further increases transparency and comparability. In this way, it assists in modeling and optimizing image sensor performance for a given application.

Manufacturers of image sensing equipment also benefit from the EMVA 1288 standard: By complying with it they can clearly communicate the performance and quality of their product to their customers and help them select the most suitable camera or image sensor for the planned application. Numerous manufacturers also use the standard in their R&D departments when developing and testing new products. This has already had a positive impact on camera quality and performance.

Five Parameter Categories for Camera Performance

The basic parameters that are provided by the EMVA 1288 standard are easy to understand. They can be reduced to just a set of five categories and are described in the following.

Sensitivity: The intensity of a camera signal or brightness of a camera image does not adequately describe its quality. The relevant parameter is the ratio between signal and noise, the so-called signal-to-noise ratio, abbreviated by SNR, at a given sensor illumination (irradiation) and wavelength. It turns out that the SNR of a camera with a linear characteristics is just determined by two parameters, the quantum efficiency, i.e., the fraction of photons that are converted into charge units in a pixel and the standard deviation of the dark signal noise. The best sensor theoretically conceivable would have a quantum efficiency of one and zero dark noise. This theoretical limit is used to describe how much the actual sensitivity of a real camera system falls short of the ideal one. For a good sensitivity at low irradiation, a low dark noise is most essential parameter, because the quantum efficiency does not show so much variation as the dark noise from camera type to camera type. For a low SNR at high irradiation it is important in addition that the sensor can collect as many

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charge units as possible, this parameter is called the full-well capacity.

Linearity: A number of applications, especially measuring tasks, require a good linear relationship between the intensity of illumination and the digital gray scale value. Therefore, the EMVA 1288 standard specifies a measure, the linearity error, that describes the deviation from a linear regression as the mean of the most positive and most negative deviation in per cent for a illumination range covering 5 % to 95 % of the sensor saturation.

Dark current: In an image sensor, a signal is generated which is not dependent on the intensity of the illumination but created by purely thermal effects. This so-called dark current accumulates charges over time. This effect determines the maximum useful exposure time of a camera. Therefore the dark current of a sensor is only important for rather long exposure times.

Homogeneity: Due to the fact that a camera contains an array of sensor elements, these will not have exactly identical properties and therefore certain variations will inevitably occur. The image quality is heavily influenced by the type and intensity of these variations which will show as static pattern ("fixed pattern noise") in the images. Two inhomogeneities are considered. The dark signal nonuniformity (DSNU) describes the spatial variations in the dark image and the photo response nonuniformity (PRNU) the spatial variation of the sensitivity. The standard computes values form these inhomogeneities that help to understand easily how the inhomogeneities influence the image quality. The question can then be answered whether these inhomogeneities are visible to the human eye or – for measuring purposes – what is the smallest spatial variation of intensity that can be measured with the given sensor.

Trigger behavior: In many applications, the image acquisition needs to be synchronized with external events or several cameras have to take images simultaneously. In these cases, it is essential to know the delay between the trigger signal and the start of the image acquisition (trigger delay) and to which extend this delay is varying (the so-called jitter). For the synchronous acquisition of image sequences, it is also of interest to know the stability of the camera clock.

New Version 3.0 in March 2010

The preliminary new version 3.0 of the EMVA 1288 was already presented at the Industrial Vision Days at the Vision 2009 in Stuttgart, Germany. For the first time, four companies (AEON Image Processing, APHESA, Image Engineering, and Sarnoff Corporation) demonstrated equipment to perform measurements according to the EMVA 1288 standard. This clearly expresses the growing international interest in this standard. In this respect it is of significant importance that the Automated Imaging Association (AIA), the European Machine Vision Association (EMVA) and the Japan Industrial Imaging Association (JIIA) signed a contract to jointly develop and promote global machine vision standards (see Optik & Photonik, December 2009, page 5). This will help the EMVA 1288 standard as well as other machine vision standards to become established globally.

The preparation of the release of version 3.0 of the standard was already an international effort. An extensive comparative test was performed. Six cameras were sent around and measured in laboratories worldwide. This effort helped a great deal to make the standard an easy to use and trustable procedure.

The final version 3.0 has finally been released in March 2010. This version is considerably extended beyond version 2. New is the inclusion of color cameras, defect pixel characterization, trigger delay and jitter. In the near future, the standard is planned to be further expanded to include non-linear cameras and special camera types such as time-of-flight (TOF) cameras. Close links have also been established between the EMVA 1288 standard committee and the corresponding ISO activities.

Easy Access to the Standard

The working group is open for all manufacturers, system integrators and distributors of cameras and image sensors. Institutes carrying out research in this field are also welcome to join. Participation is free of charge.

INFO

1288 EMVA Standard Compliant

The 1288 Standard is based on elementary physical principles which are clearly defined and allow an objective characterization of key properties of cameras and image sensors, such as the signal/noise-ratio (SNR).

Specification parameters currently covered
- Spectral sensitivity
- Signal/noise ratio (maximal SNR, dynamic range, dark noise)
- Inhomogeneities (DSNU, PRNU)
- Linearity of camera response
- Defect pixels
- Trigger delays and jitter

Camera types covered
- Linear camera response required
- Sensors and cameras (without lens)
- Area-scan and line-scan
- Monochrome sensors
- All kind of color sensors and cameras including single-chip cameras with Bayer patterns and multi-chip color cameras

www.standard1288.org

Producers who wish to introduce 1288-compliant products must first obtain a license from the EMVA which is also free of charge.

This article is based on a former publication "Transparency for Industrial Cameras and Sensors", published in INSPECT, issue:12/2009 (www.inspect-online.com).

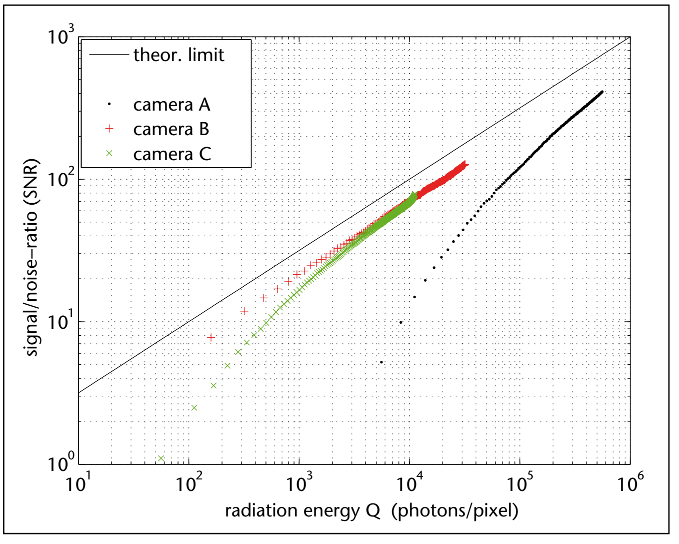

ABB. 2: **Comparison of three cameras in the signal-to-noise (SNR) plot: Camera B has the lowest dark noise and is therefore most suitable for good image quality under low light conditions. Although camera A has the highest dark noise it reaches the highest SNR (400) at bright illumination conditions, because it has a much higher full-well capacity than the two other cameras.**