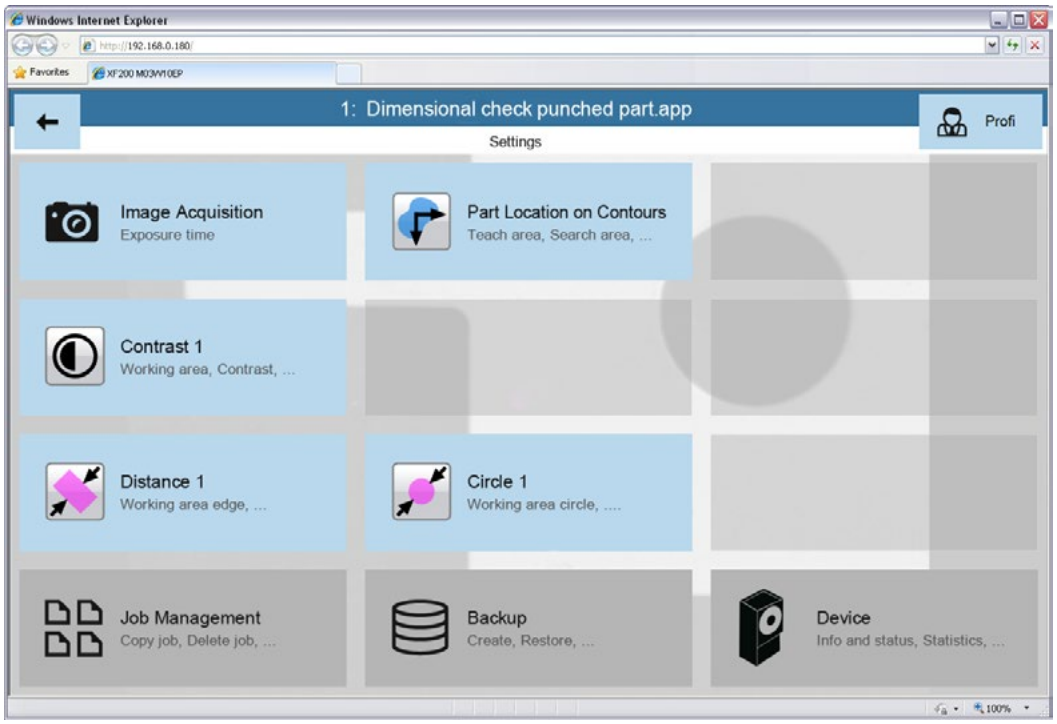
Technical Report – What actually is a vision sensor?

# Yin-Yang as a true all-rounder

To some machine builders, a "vision sensor" is still an unknown species. Maybe because the term sounds contradictory in itself. Indeed, it reminds a bit of "Yin" and "Yang" – opposites yet related to each other and forming the whole. Of course, every engineer knows about "Yang", in technical terms the sensor – in the form of a light barrier, inductive sensor, precision switch, etc. But what about "Yin"? Less familiar "vision" refers to "machine vision", meaning the eyes of a machine in industrial image processing.

Vision sensors close the gap between image processing and sensor technology. It's a product between the worlds – halfway between a complex camera and PC-based image processing system and a simple light barrier. And fairly obvious, this product concept is experiencing an ever-growing demand in the marketplace. The idea is quite simple: Take all components a conventional image processing system is made of – camera, lens, processor, software and interfaces – and bring them together in a small, industry-capable housing with "sensor appeal". Moreover, in additional all options for individual settings are limited to a manageable scope to enable nearly "everybody" to configure it for the particular vision task. In practice, a vision sensor has to be configured for example in terms of exposure time, feature checks or interfaces. There is no need for programming. To put it in a nutshell: the vision sensor is a compact, easy-to-configure image processing system and like a "classic" sensor it will output sensor information. In other words: inbound "Yin" (image processing) and outbound "Yang" (sensor). Now it is also clear why a camera is different: it just supplies the image.


*VeriSens*® vision sensors by Baumer in C-mount design with flash controller (left), integrated optics and white illumination (front) resp. infrared illumination and daylight filter (right).




The *VeriSens*® web interface can be configured to adapt inspection task parameters directly at the machine by the tip of a finger and in the running process.

### What's the difference, compared to a smart camera?

Some may speak of a "smart camera" where meaning a vision sensor in fact – and vice versa. Definitions vary since the term is mainly built by manufacturers and their related marketing communication. A product definition is also available at the German Engineering Federation (VDMA) in a 2014 market survey. Here, a difference is made between "smart cameras" and vision sensors. Using smart cameras the application " (…) "is realized by editing a source code (…)" [1] and by parameterization. The definition also considers design. Hence, products with separated camera heads are categorized as smart cameras [1]. Among other criteria, vision sensors feature "specific application software" [1]. And according to the "Automated Imaging Association (AIA)", vision sensors are a sub-category of "smart cameras": "(…) At a minimum a smart camera combines a camera with image processing and MV related programs within the same housing. A smart camera is functionally equivalent to an Embedded Vision Processor. Sometimes smart cameras are called "intelligent cameras" and "Vision Sensors". The term "Vision Sensor" tends to apply to a lower-end Smart Camera." [2] Following the AIA definition, a vision sensor is "(…) A smart camera with less flexibility and programmability (…)" [2]. Also in other sources, programmability is a characterizing feature which is supposed to be more a capability of a smart camera than of a vision sensor. Even looking at different sources a clear distinction between both product catagories seems to be hardly possible. It looks like smart cameras are typically supposed to be programmable compared to vision sensors.

Vision sensors are applied in many industries for image-based quality control. Here, a *VeriSens*® vision sensor is verifying beverage packaging upon completeness.

### Why are vision sensors special?

Since light barriers, inductive sensors or precision switches are typically designed to master one task each, conventional implementation in complex applications needs several sensors or a combina-

tion of them. Furthermore, flexibility in the inspection task in sensor arrangement and alignment is limited by the sensor-specific operating range. A single shot of the object provides a vision sensor with all information needed to perform several checks in parallel. Some vision sensors are even capable of virtual object alignment, saving any mechanical alignment effort. Most striking is not only the multitude of simultaneous feature checks but also their diversity.
A simple example: In a packaging facility, the packaged unit is to be checked after the process. The content is placed on a tray, covered with cling film and provided with a label.

There is quite a lot to check:

1. Is the content present?
2. Is the label properly positioned (within the defined tolerances)?
3. Is it the correct label (packer serves several distributors)?
4. Is it the correct bar code on the label?
5. Is the date correct?

Overall, quite demanding inspection tasks in conventional sensor technology where even an additional laser scanner may be needed, text reading cannot be solved with this. Vision sensors however will check presence, position, 1D code and read the clear text (OCR) – all at the same time and by a single sensor. This does not only reduce setup effort and complexity but at the same time will enhance reliability and flexibility. Looking at the acquired images of the inspected object, many more possible tasks become obvious: roundness of bores, angle checks, comparisons to defined patterns, reading 2D codes, additional verification of clear text (OCV) – a virtually unlimited potential.

## The teach functionality

We know that "conventional" sensors require teaching operations respectively precise, repeated alignment to the switching position. A vision sensor is set up by being docked to a PC providing the operator with the configuration software. Well elaborated software will simplify sensor setup even to the non-expert. However, it is often overlooked that vision sensor solutions require knowledge about image processing. First, it has to be verified if the object is appropriate at all and which feature checks are to be made. Just a high-end camera won't make a perfect photographer, and for process-safe evaluation the sensor requires adequate ambient conditions to capture the defined object features – for example auxiliary lighting. Contour-based evaluation in real time provides decisive benefits by higher error tolerance. Maybe external lighting or specific lenses are needed, too – then it's good to have modular products in C-mount design and with a flash controller. Image processing is not an easy thing. It's the perfect interaction of lighting, movement, optics and timing – reason why the term "sensor" may be misleading.

"Cap monitoring" is a typical inspection task. The vision sensor is capable of checking presence and proper closing of the bottle cap in parallel.

Last but not least: Often the approach calls for a look beyond mere sensor technology – for example when frequent object changes call for repeated adaptation of vision sensors to the inspection task. Operator-oriented GUI concepts take care of this, for example by a user-configurable web interface allowing the adjustment of the vision sensor through the existing browser within the machine control system. To cut it short: vision sensors bridge image processing and sensor technology. Sensor simplicity is as important as

multipurpose capabilities in complex image processing tasks. What matters most depends on the application itself. In general, vision sensors simplify complex applications where usually a great number of conventional sensors would be involved.

## Sources

[1] Industrial image processing in Germany, 2014 market survey, VDMA Fachabteilung Industrielle Bildverarbeitung im Fachverband Robotik + Automation, Copyright 2014

[2] http://www.visiononline.org/market-data.cfm?id=73 (14.05.2014, 10:40 Uhr)

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