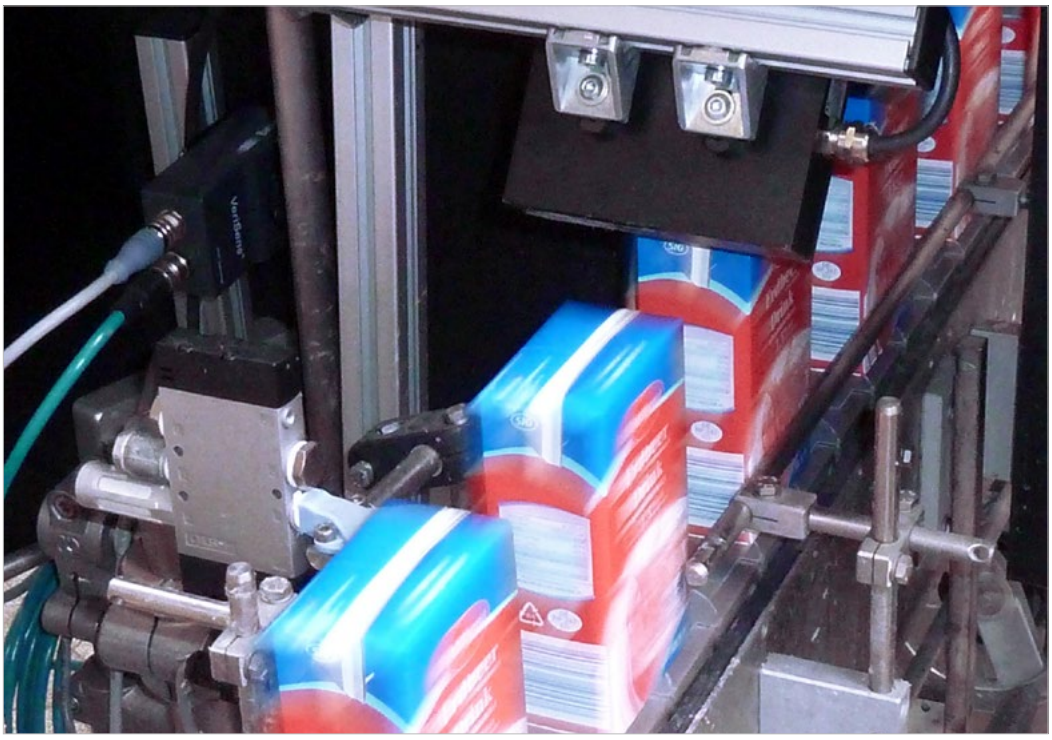
Technical Report – How do vision sensors work?

The "seeing" sensor

Eyesight is the most important human sense and supplies up to 80 % of the information content from the environment. Consequently, expectations on a "seeing sensor" are high, and present-day technology is capable to fulfill many of them. But this brings up the question: Do the majority of engineers know how to handle such sophisticated sensing technology?

Like human sight, which is much more than just "information intake", a vision sensor combines image acquisition and image processing. That's where the name comes from: a vision-based detector in a compact housing. To take up its tasks, the sensor is usually configured on a PC using specific software – if desired even for the time of the entire service life. Their specialty: The capability of performing several feature checks at the same time – which is something no standard sensor can do. Vision sensors acquire digital images, either permanently or by trigger signal (e.g. from a light barrier). They acquire the configuration-related object information, optionally also under consideration of set limits or reference values to be observed. Accordingly vision sensors provide results. These are supplied as data telegram or issued via digital output. Image evaluation is done by integrated, intelligent software tools ("feature checks"), which acquire relevant information at defined spots as configured in the inspection task. It is essential to compensate for the variance of position and orientation of the object virtually, for example when detecting unaligned parts on a conveyor belt. Humans doesn't have any issue to see the "top" and "bottom" or "North" and "South" of an object. Machine vision requires some kind of

Vision sensors are compact image processing systems in the shape of a sensor. The industry-capable housing integrates what it takes to master an inspection task: C-mount interface with flash controller (left), IP 69K-rated protective housing (right), with integrated optics and white illumination (front).



Throughout all industries, vision sensors master vision-based inspection tasks, here in quality control at beverage packaging which is checked upon presence and position of the drinking straw.

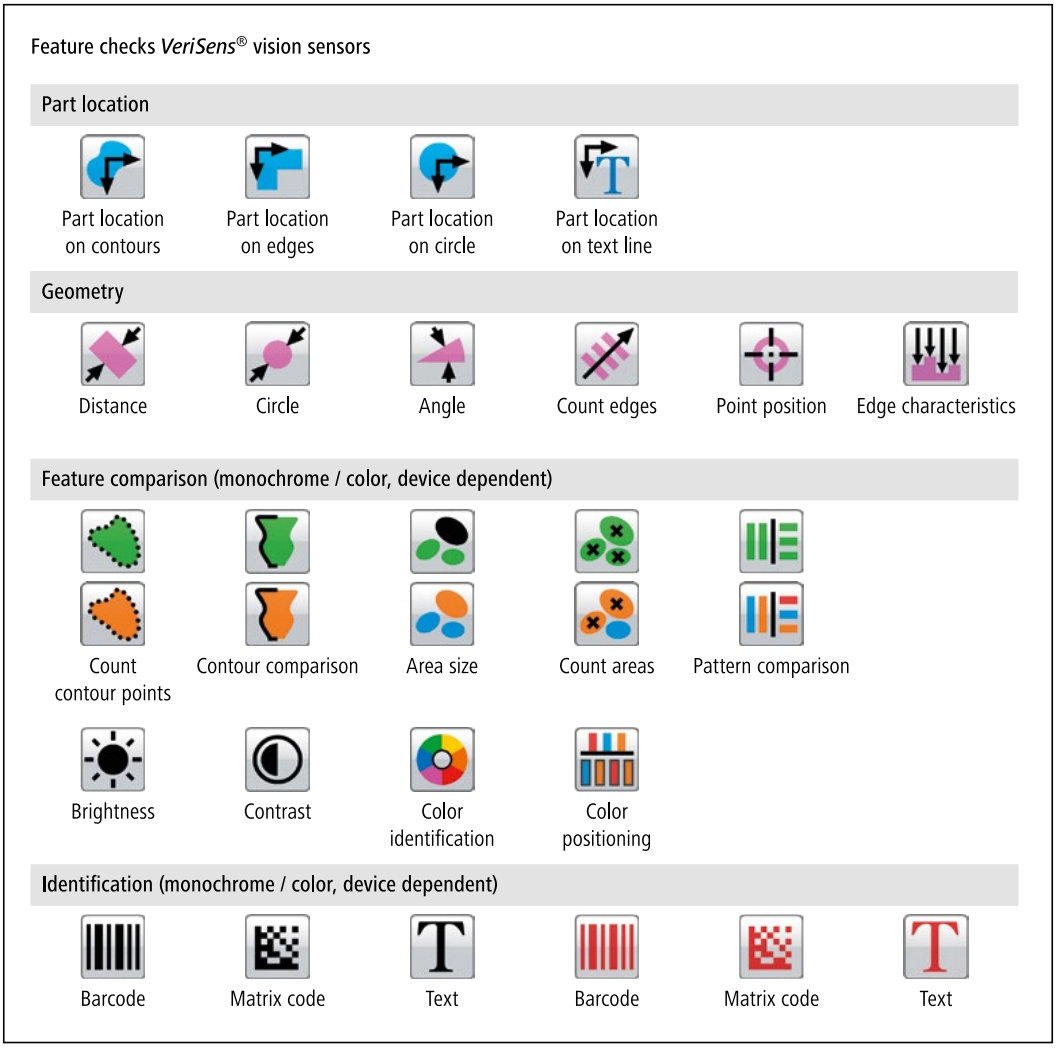
intelligence to recognize this. As a basic function, position tracking is therefore a must for a vision sensor. Accordingly, differing position or deviant orientation of the object don't impact the evaluation. For pick-and-place applications of robots the positioning information is furthermore essential. Image acquisition is by CMOS or CCD sensors. The follow-up image evaluation is particularly determined according to manufacturer-specific aspects – under consideration of cost, performance, long-term component availability and know-how. Here we encounter the entire bandwidth of present-day processing technology such as DSPs, ARMs, FPGAs and Intel Atom.

Several feature checks use one single image

Feature checks open up multifaceted application fields. It quickly becomes clear why vision sensors have conquered almost all industries. Virtually everything can be detected, read or checked: position, orientation, colors and color arrangements, grayscale values, plain text (content and readability, OCR/OCV), distances, bore hole diameters, number of objects, angles, contrasts, contours and last but not least bar and matrix codes. An inspection task may use all these feature checks in any combination so that one single image is sufficient even in complex applications. Ideally, the sensor setup is in a few intuitive steps. The contour-based object recognition as featured by Baumer *VeriSens*® vision sensors with patented *FEX*® image processor play to their strengths. Contours of objects are still recognized even in less stable ambient light conditions.

Easily implemented, simply reconfigured

Once the inspection task has been set up and configured, the data output must be defined. Is there any need for outputting partial results? How should partial results associate for the overall result? What is the required output timing? Vision sensors like *VeriSens*® master sorting tasks without a PLC. Outputs can be configured to consider individual timing related to partial results. This makes sorting parts on a conveyor belt into different boxes an easy thing. The monitoring of the belt speed by the vision sensor encoder input ensures the consideration of deviating rate of feed. Human machine interface (HMI) capabilities are another key factor. When setting up the application, most likely an engineer interacts with the set-up software. In the later manufacturing process maybe a non-expert operator has to switch between jobs in running operation or has to perform parameter adjustments. For this reason, a customer and application-specific configurable user interface is absolutely required. To the user, it is furthermore a visualization tool to better understand the vision sensor which is often believed to be a mysterious "black box". By implementing such HMI as



Baumer *VeriSens*® vision sensors offer 30 tools for up to 32 feature checks in one single inspection task.

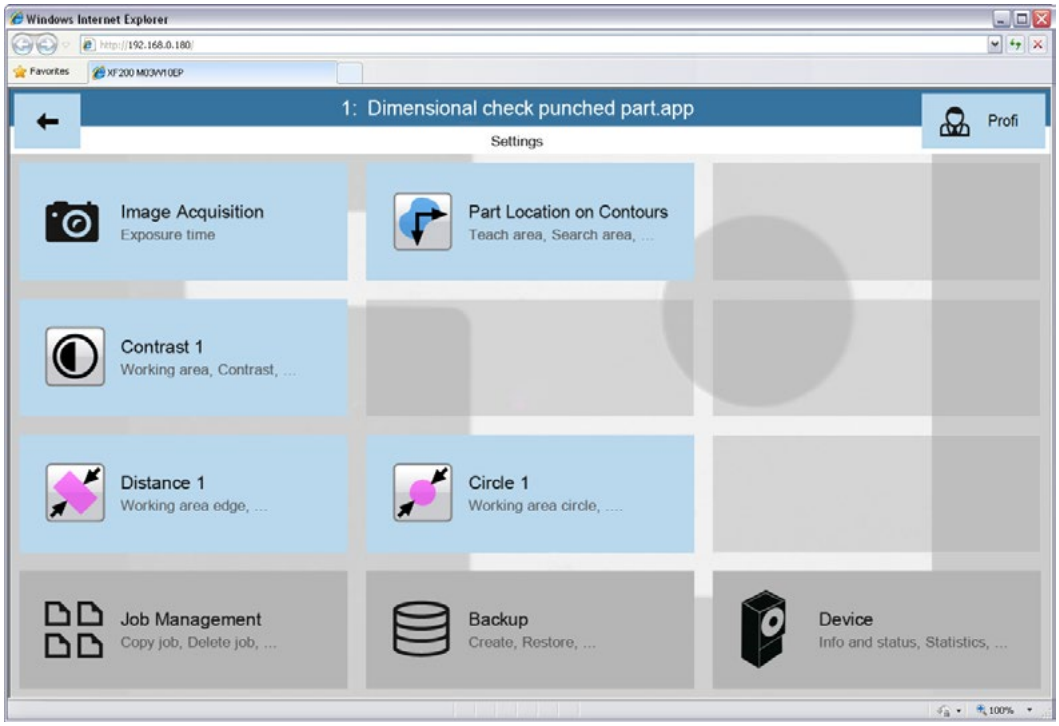
web-based interface, the machine control's web browser can be used to operate. This allows an easy integration into the human interface of the machine with virtually no extra effort.

Several product categories – several names?

Vision sensors are available as different variants. Most obvious are differences in the mechanical design. The sensor may integrate lens or provide a standard interface for interchangeable lenses (for example "C-mount"). With this even long distances between object and vision sensor can be bridged with dedicated telephoto lenses, which are typically not available as integrated optics. Furthermore, a good vision sensor provides IP 67 protection class even in cases where long external telephoto lenses are attached. The product category reflects by different names as well. One may encounter a vision sensor also as "smart camera", "intelligent camera" or just "camera". The terminology is mainly established by manufacturers and their marketing communication, which means it is subject to change. The German Verband Deutscher Maschinen- und Anlagenbau e.V. (VDMA) categorized the product groups after a market survey in 2014, giving the following definitions: "smart cameras" for example are distinguished from vision sensors because they enable the writing of source code by the end user and configuration. Vision sensors integrate "application-specific software". Also design aspects were considered, for example products featuring a separate camera head are called "smart cameras".

Illumination is the key

The center part is the image, since only that which is visible is available for evaluation and processing. Consequently, illumination is essential to solve applications successfully. Integrated illumination may not always suffice in the application, so that vision sensors supporting external illumination are beneficial. Baumer *VeriSens*® vision sensors



Live shots of the running process provided by the configurable web interface can be accessed any time. Task-specific parameterization is performed directly in the machine browser.

of the XC series are for example the only ones on the market directly supporting the efficient flash operation of LEDs with a fully integrated flash controller pulsing with up to 4 amperes without any additional hardware.

Vision sensors: "Image processing for everybody"?

By principle, image processing traditionally incorporates interdisciplinary technology which requires profound knowledge and experience by the user. Vision sensors attributed to offer "image processing for everybody" must ensure easy and intuitive operation to allow user-friendly configuration for almost any engineer within the shortest amount of time. Image processing is the logical extension of automation technology with a universal feedback channel and is much more versatile in use compared to conventional presence sensing. In view of still growing quality requirements it enables the opportunity for automated visual quality inspection. Integrated at an early point in the manufacturing process, vision sensors improve equipment productivity since faulty parts can be removed early in the process. In doing so, sensors are a significant factor in process control and pave the way to the Internet of Things (IoT) and "Industry 4.0".

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