White Paper

Camera Sensor Technology (Part 2) - New Developments

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Introduction

Within the scope of our "know-how" series, our first white paper, under the title "What Needs To Be Observed When Using Camera Sensor Systems?", covered the essential fundamentals of image-processing sensor systems. Expanding on this topic, this white paper focuses on current technological advances in this area. The aim is also to make clear that the potential application possibilities of camera sensors now go beyond pure quality assurance.

New functions and features

When a user encounters an application, a camera sensor must be user-friendly, though "simple" is not enough. Simpler and, if necessary, versatile: these are the features that are increasingly demanded of such systems (fig. 1) .

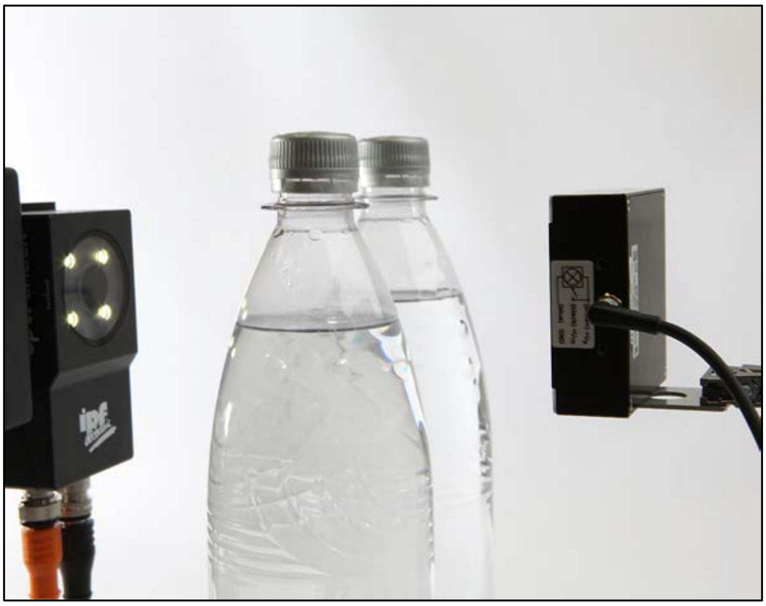

Fig. 1: Simpler and, if necessary, more versatile: these features are increasingly expected of camera sensors.

Camera sensors are complete, software-controlled image processing units in a compact metal housing that integrate optics, illumination and electronics. The application possibilities of these devices lie between classic sensor systems, such as through-beam systems and diffuse reflection sensors, and industrial image processing. Thus, camera sensors can be used in any application where mounting, transport, sorting or packaging is performed automatically.

In particular, camera sensors of the latest generation feature new functions and capabilities that are interesting for such or similar tasks. Just a few of the features: compared to pixel-based devices, the new developments are largely independent of the influences of external light and offer, for example, a series of extended functions with various tools for the position-independent inspection of components. Through image evaluation that takes place practically in real-time, such devices can also perform up to 6,000 inspections per minute depending on the scope of the feature checks. Furthermore, the camera systems also facilitate a free choice of lens if necessary and, thus, easier adaptation to specific applications.

From pixel to contour

Even in dreary weather, a person's sight is still capable of clearly recognizing and distinguishing trees and houses from their contours. The contour-based recognition of new camera sensors functions in a similar way, whereby their special image sensor calculates the contours of objects in real time, i.e., in parallel with the image evaluation (fig. 2). The result is rapid detection, even under difficult environmental conditions.

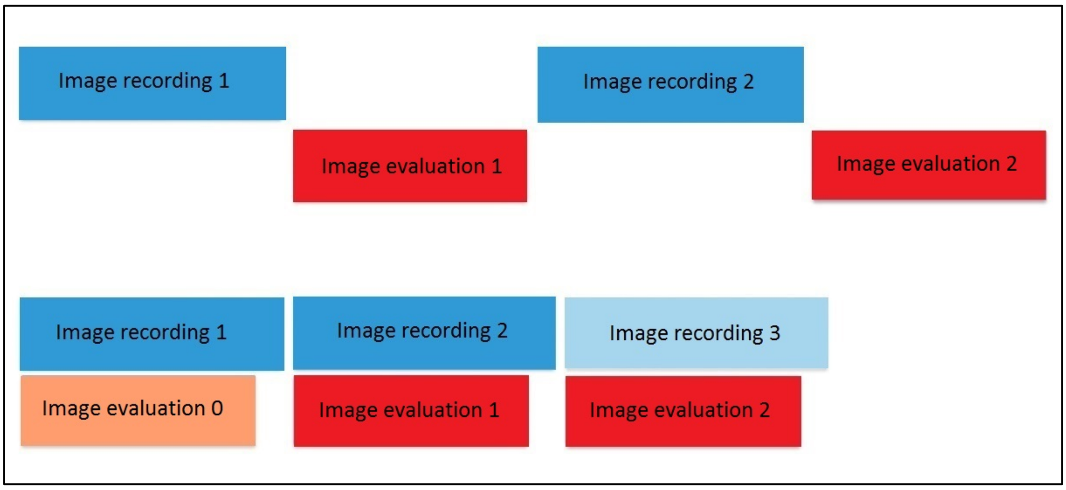

Fig. 2: Image evaluation takes place in parallel with image acquisition, as can be seen below.

But why is the contour-based image acquisition in many cases superior to the pixel-based mode of operation of camera sensors where there are effects from external light? A comparison:

With pixel-based image processing, the grey value of each individual pixel is evaluated within a previously defined test window. If the brightness changes in a specified test area, the grey values of the pixels contained therein change as well. If these changes are too strong, a test object is incorrectly evaluated, since the image processing system cannot recognize whether a component variation or the influence of external light is the cause of the grey value changes.

Object edge marks the transition

Contours are essentially edges that identify the transition from a background to an object with specific outlines. Analogous to this, an edge in a camera image is ultimately just a transition from one pixel to an adjacent pixel with a specific change in grey value. New camera sensors can be "taught" which criteria are relevant for determining an edge and, thus, a contour of an object from such pixel information. With a contour, the specific value of a greyscale difference between the pixels of an edge is determined accordingly, whereby the camera detects this difference (fig. 3).

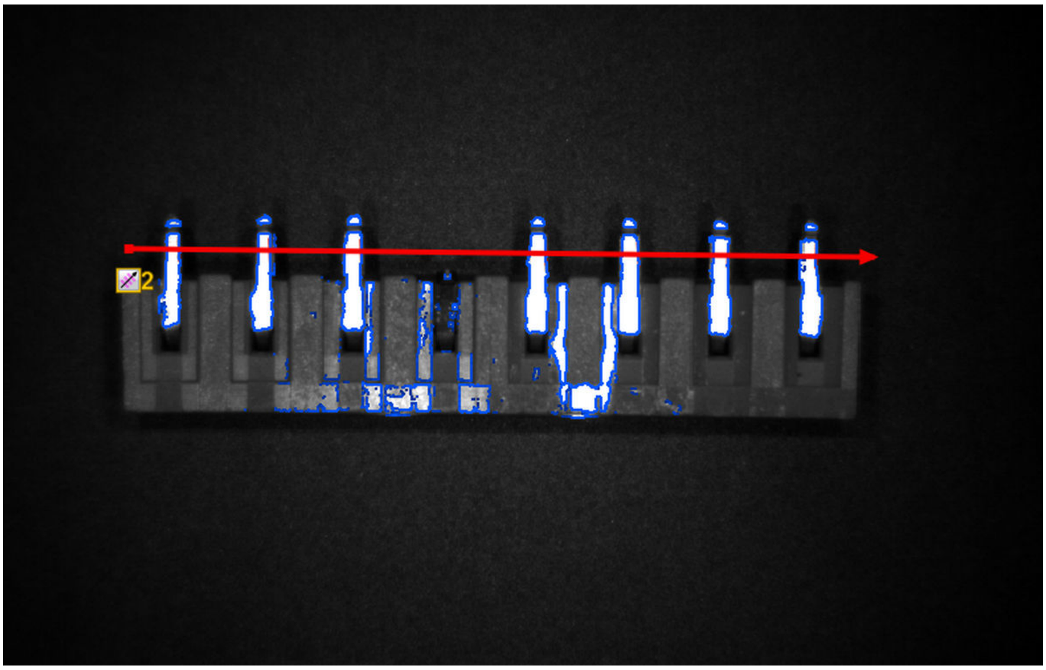

Fig. 3: Contour-based recognition: the completeness of contacts on an electronic component is checked with the "count edges" tool.

Stable determination of the contour

If external light is incident on a test surface, this generally affects the entire detection area. The greyscale difference between the pixels on an edge thus remains constant over large areas, thereby facilitating the reliable detection of objects that is, thus, relatively insensitive to external light (fig. 4).

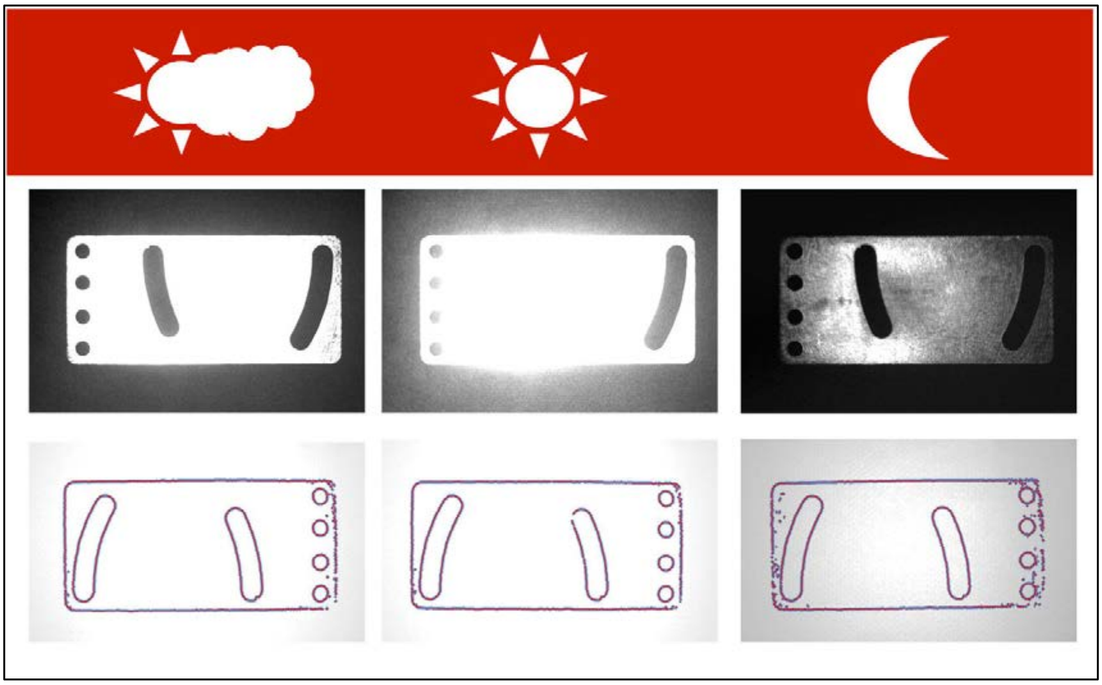

Fig. 4: The advantages of contour-based recognition (bottom) become clear by comparing with pixel-based image processing (top) under various light conditions.

For illustration purposes, a greatly simplified but generally understandable example:
consider a theoretical pixel with a grey value of 80 that represents the background of a test surface. Another pixel with a grey value of 120, on the other hand, marks a test object on this surface. Between the background pixel and the object pixel, the pixels change by 40 grey value levels. If external light influences the test area, both the grey value of the background pixel and that of the object pixel would be elevated by the same ratio. As a result, the change in pixel values would still be 40 grey value levels.

The advantage for practical applications: if the brightness conditions should change in a test area, it would still be possible to determine the contour of a component from the camera image, since its edges are used as information for the detection. The determination of this contour remains very stable over a large range even in the case of changing environmental conditions (brightness in the test area increases or decreases, e.g., due to failure of a hall light). In situations where, in the past, it was sometimes necessary to completely enclose a camera to protect it from the influence of external light, simple shading of the test surface can suffice with today's new camera sensors depending on the inspection task.

Part location: increased freedom

Another feature of the latest generation of camera sensors is their diverse functionality in the area of part location, which is used for the position-independent inspection of components. Part location means first of all that the position of an object that is to be detected can be determined in the image area of the camera. If this position deviates from the configured location, the object can be virtually aligned for the detection task by means of a 360 degree part recognition function. Older sensors also have a part location feature, whereby emphasis is on "a," since every inspection point placed in an image section is linked with the part location once it is set. With the new systems, one is completely freed of this topic.

The combination can decide

It is possible, for example, to define a part location for a test specimen that acts only on three of five planned test functions. To be more specific: two test functions always take place at the same location in the image area independent of the component position, while the remaining test functions are geometrically tracked according to the position of the component. In this context, the camera sensors offer the possibility to combine multiple part locations with one another to thereby be able to assign each individual test command a certain part location.

Here is an example: assume an object with an undefined position needs to be inspected to determine whether there are bores at certain positions. As the same time, it is to be ensured that the component is in a predefined position on a conveyor belt with appropriate deviation tolerance for subsequent processing. These tasks can only be realized if the test points (bores) can be ascertained by means of a corresponding part location function. Parallel to this, however, an additional test tool must also be able to determine the rotation of the component, whereby the tool must not track the position of the component in this case. Otherwise, the object, if located in the wrong position for subsequent processing, would be identified by the camera sensor as a part that is OK.

Variable lens selection and flash controller

If such or even more complex tasks need to be performed at a specified operating distance on working surfaces that may be larger or smaller in size, conventional camera sensors can be pushed to their limits. The reason for this is that a permanently mounted lens unavoidably has a specific magnification due to its focal distance.

In order to obtain more information from a detection range in this context, a camera sensor with a variably selectable lens and, thus, a variable focal distance is necessary. With the latest camera sensors, this is possible with at least part of the sensor series, as these sensors are equipped with a C-mount connection. As a result, the optimum lens can be selected for an application quickly and easily according to the desired focal distance.

In addition to choosing the correct lens and the correct focal distance, the illumination must, of course, also be correct. New camera sensors therefore feature an integrated flash controller that provides the necessary support for the use of external illumination. The controller supplies the external illumination not only with voltage but also with the flash pulse required for multiplying the brightness of the illumination.

No training of fonts

With regard to the potential fields of application, the camera systems leave nearly no user wish unfulfilled given the aforementioned features and, not least of all, due to the wide range of feature checks in the areas of geometry, comparison and identification (fig. 5).

In the context of identification tasks, special mention should be made of the OCR function (character recognition). With the current sensors, this function requires no prior time-consuming training, regardless of whether a text (e.g., free text), a date or a numerical code with special formatting (figs. 6 and 7). Consequently, only the reference needs to be taught in or the desired text information specified.

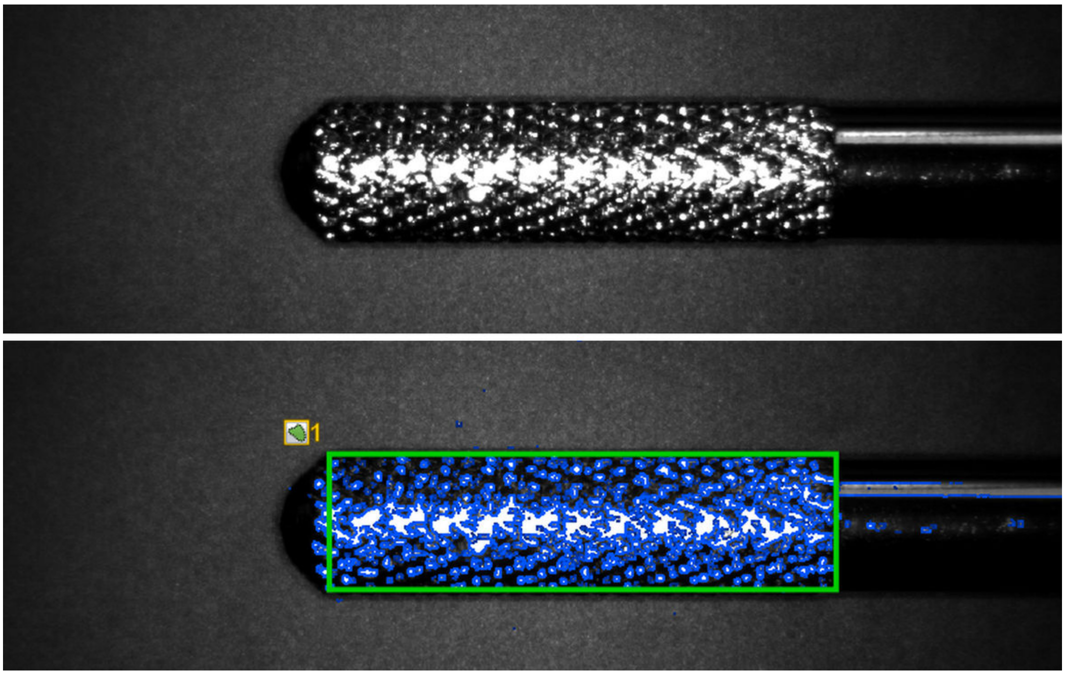

Fig. 5: Detection of the knurling on a component on the basis of contour points.

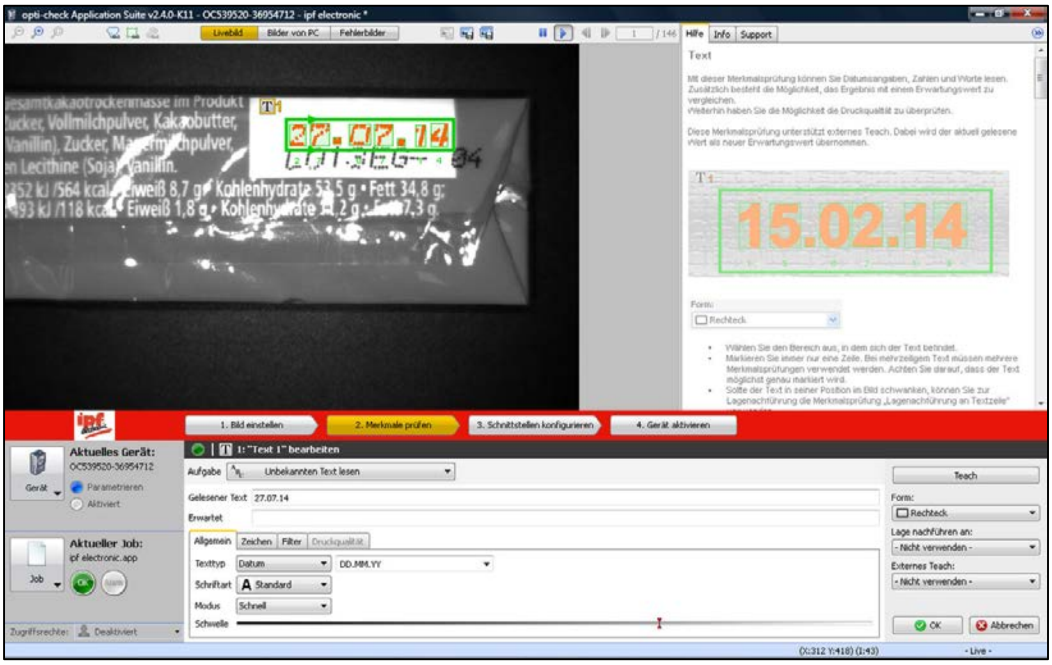

Fig. 6: OCR functions can be used with the current sensors without prior time-consuming training, regardless of whether of a text, a date or a numerical code with special formatting.


mindestens haltbar bis:
01.09.14
Gelesene Zeichen entsprechen nicht dem Erwartungswert!
indestens haltbar bis:
02.09.14

Fig. 7

Simple isn't enough

This white paper is intended to provide insight into which technological advances in the development of camera sensors could lead to solutions that offer potential for an even broader field of use. The so-called simple "usability" must not be neglected, however, as the improved OCR functions show. But "user-friendly" begins with the configuration. It should take just a few steps for a system to be ready for use. Other features that are to be welcomed include the configuration via a web interface, which is available immediately after entering the IP address of the sensor via any standard web browser. With such functions, camera sensors can be configured via, e.g., a laptop or a tablet directly in an application without needing to have the corresponding software available on the input device. The application possibilities of a web interface are still not yet exhausted, however, and depend above all on which functions are enabled for this purpose during configuration of the system. It is also conceivable, for example, to use such an interface as a monitor for viewing test images with brief statistics or to make predefined settings via this interface (figs. 8 to 10).

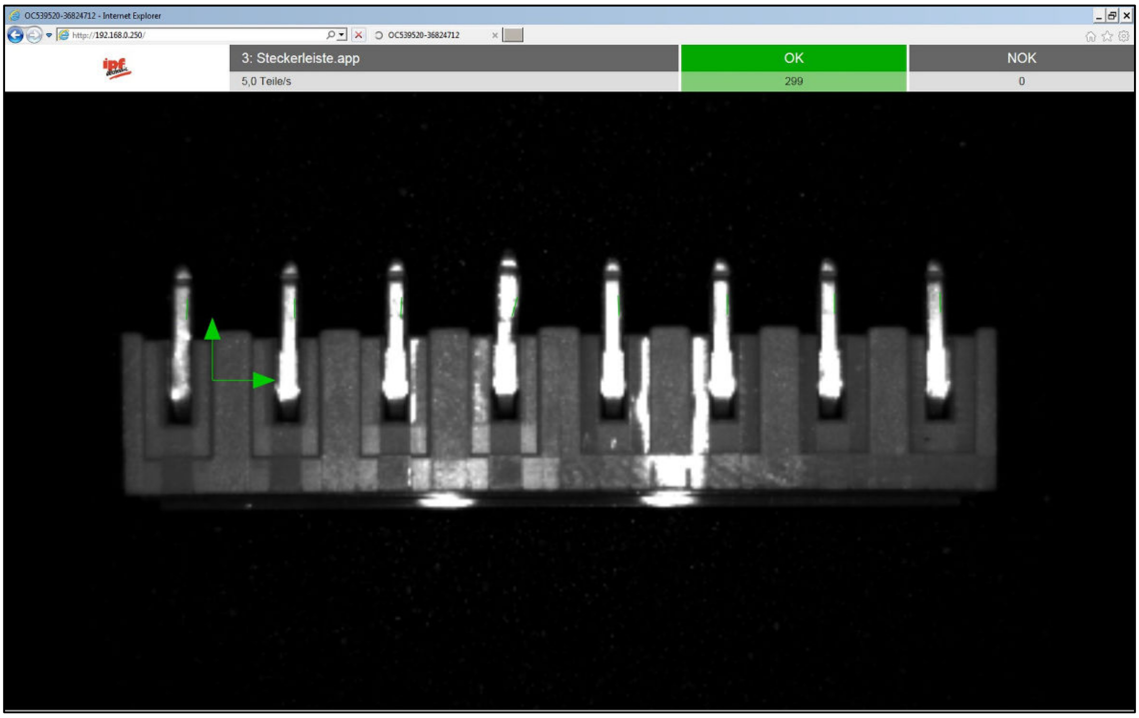

Fig. 8: Features such as a web interface offer various possibilities upon entry of the IP address of the sensor in a standard web browser, such as here for the simple display of test images. Thus, the camera software does not need to be installed on a PC, laptop or tablet for this purpose.

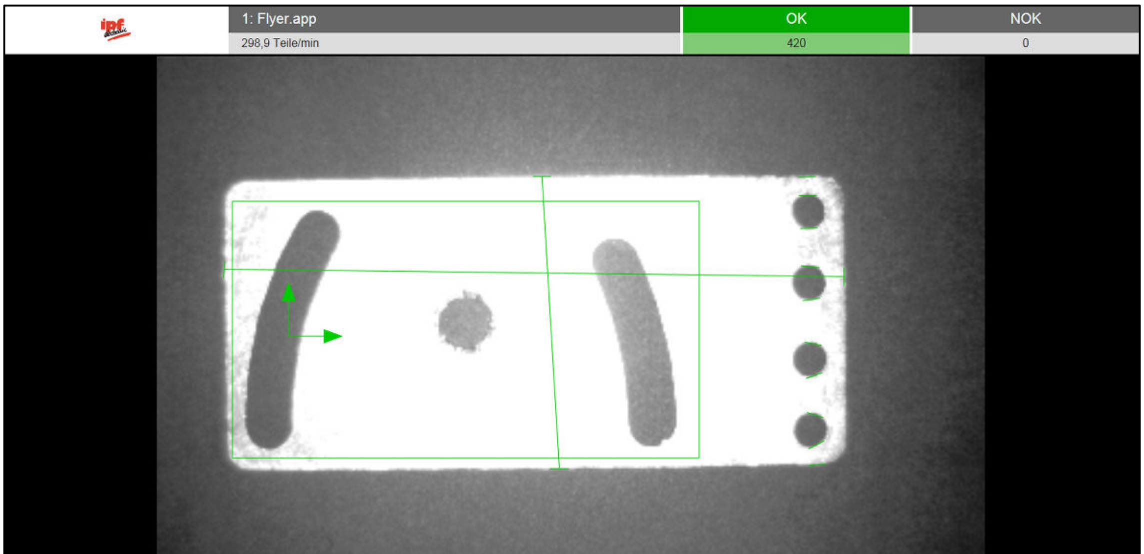

Fig. 9

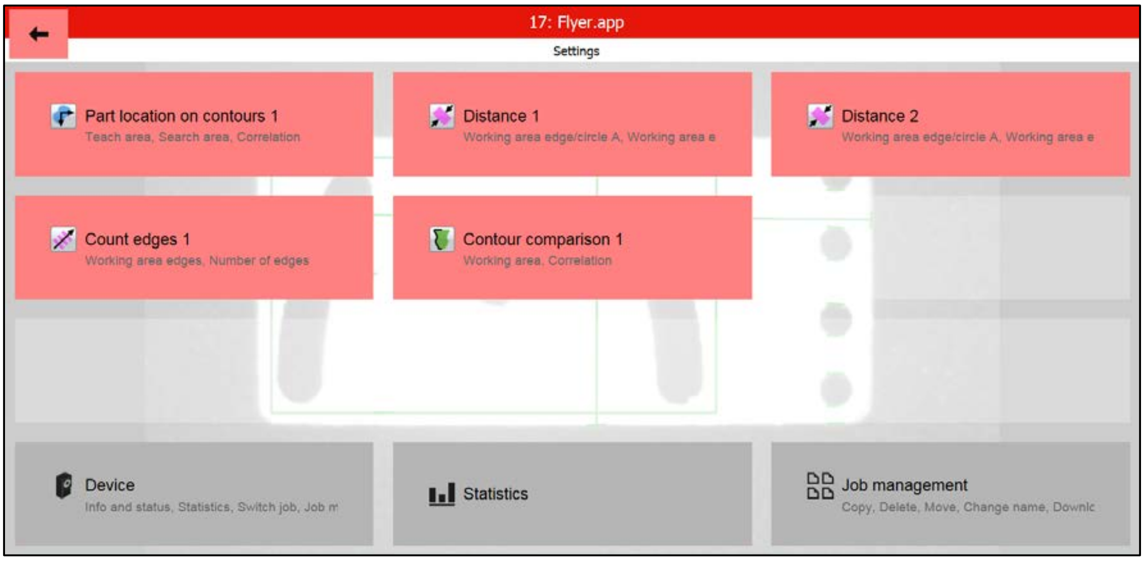

Fig. 10: A sensor can also be configured via the web interface.

Application examples

Presented in the following are a number of application examples in which the new camera sensors can be used.

Length detection of metric screws

Fig. 11

A classic application for sensor systems in the metal industry: the aim is to identify the correct length of metric screws with a standard thread (fig. 11). Here, the screws are transported suspended from a rail and the parts that are not OK, i.e., the screws that are too long or too short, are sorted out after the inspection. With a camera sensor of the latest generation, this task can be completed quickly and reliably. At the same time, the camera sensor also demonstrates its strengths in the area of flexibility. If, for example, the product type changes and screws of a different length need to be evaluated, the conversion is possible with minimal work. Simply select the program prepared for the current product type and activate it in the camera sensor – finished. By capturing an image, still other product features can be checked as well, e.g., the thread length. Up to 32 product features can be queried without needing to adapt the hardware of the camera sensor itself.

Checking the quality of mass-produced items

Fig. 12

Screws and washers are mass-produced items for which the consistent quality is nearly impossible to ensure with a manual inspection. Furthermore, numerous products with various features are often manufactured, further complicating the task of a quality inspection with respect to obtaining a high degree of correctly sorted items. This application involves the correctly sorted packing of nuts (fig. 12, left) that are transported via a conveyor belt for this purpose. With conventional sensors, a predefined position of the product on the conveyor belt would be required for the feature check in order to reliably sort out defective parts. This is not necessary with a new camera sensor. The nuts do not need to be in a specific position on the conveyor belt for the evaluation and, thus, only need to be located "somewhere" in the detection range of the camera lens.
In the event of a product change (e.g., washer, fig. 12, right) or a change of the product type, it is only

necessary to activate the previously prepared program. A mechanical adjustment of the camera sensor, e.g., to adjust the operating distance, is not necessary in this case either.

Evaluating print quality and correct labeling

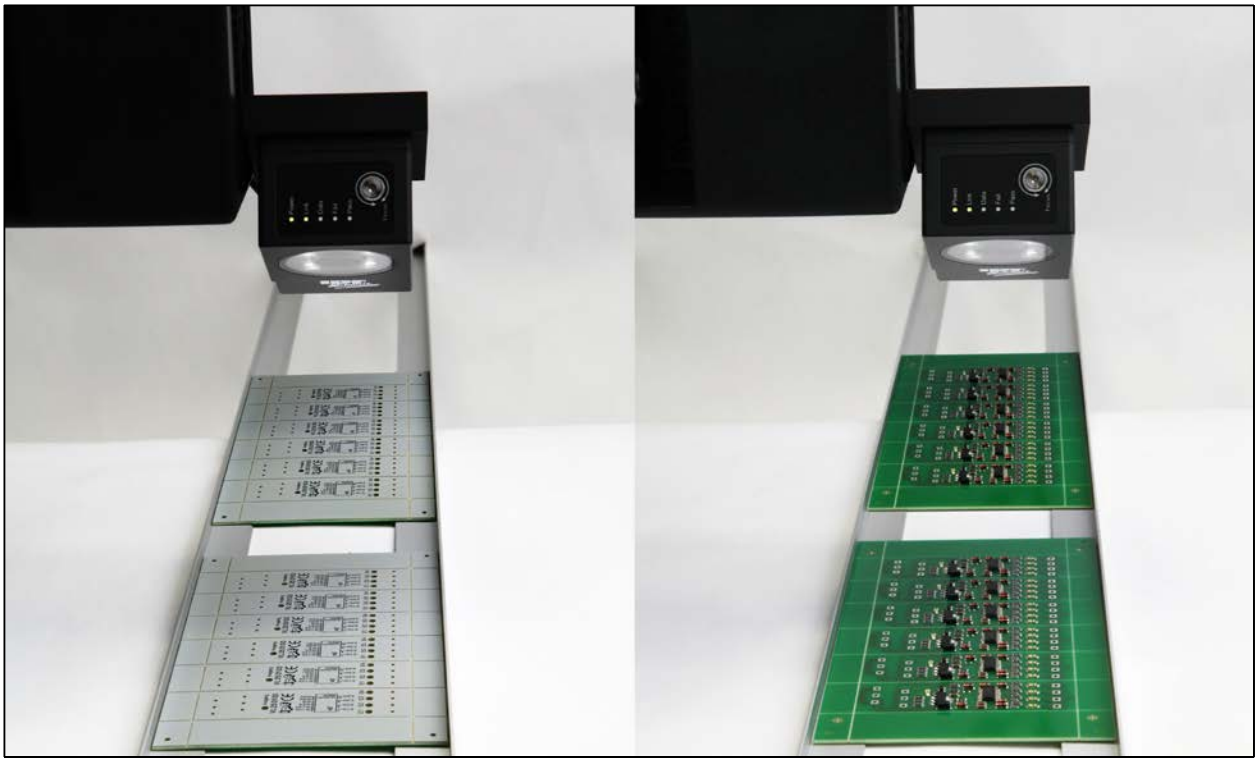

Fig. 13

The electronics industry places extremely high demands on the manufacturing quality of its suppliers.
In this application, several printed circuit boards are located on a larger circuit board (panel) (fig. 13, left). In this case, a camera sensor is not only able to reliably evaluate the quality of the printing, but, if desired, it can also simultaneously check each circuit board for correct labeling, e.g., for an incorrect or correct article number. For this comparison, the user only needs to teach-in the reference. Moreover, the character recognition (text, date or numerical code) functions without time-consuming training.

Checking the completeness

In the second case (fig. 13, right), the rear side of the circuit boards on the panel are to be checked to ensure that the electronic components are complete. Regardless of whether a circuit board is - in the worst case - not even mounted or if just one component is missing from the printed circuit board, a camera sensor detects this reliably and without complex configuration. With this versatility, it is thereby possible to implement an electronics production system that meets high as well as increasing standards at all times.

Checking the filling level

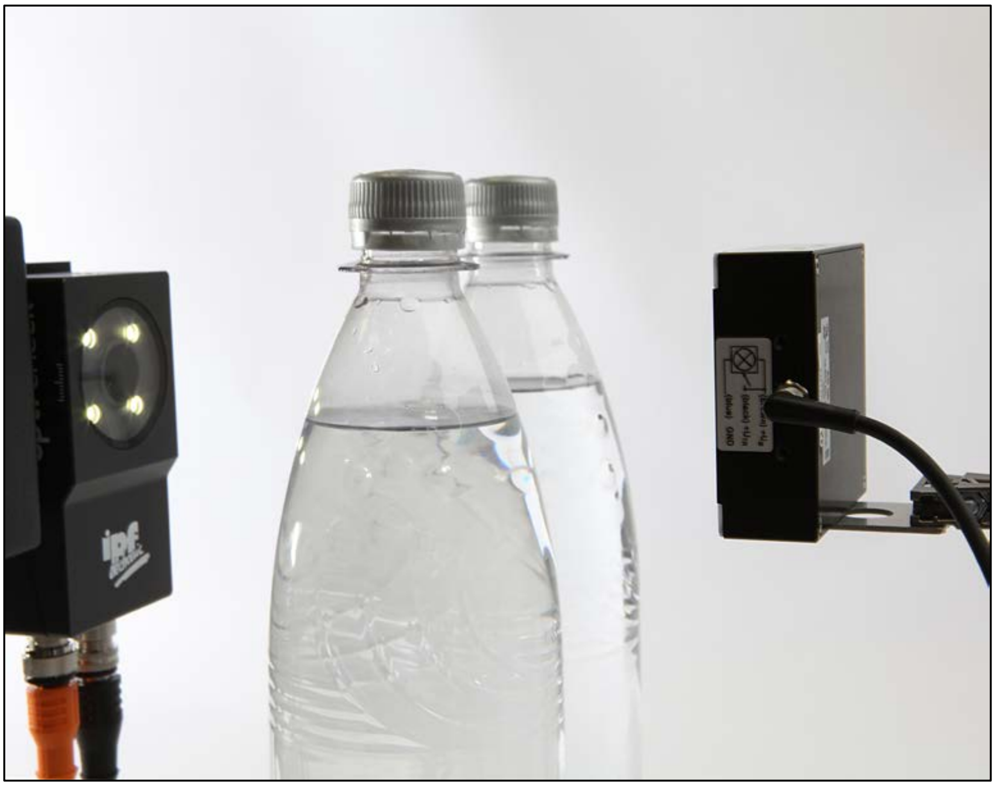

Fig. 14

Here, the filling level of PET bottles is to be inspected (fig. 14). Due to a range of factors, this is no simple task for conventional sensors: structures on the material surface, drops or wet streaks inside of the bottle, and welds in the material among other things. In addition, a very small distance between the detection area and a conventional sensor is often necessary for the fill level inspection – with the potential risk of collisions in the conveying system. These are all problems and challenges that can be solved with a camera sensor of the latest generation. The filling level is simply taught-in in the desired area of the bottle, the inspection program activated and the camera sensor is ready to begin its work. If necessary, it can perform additional inspection tasks in such an application, e.g., whether the bottle has a cap and/or if the cap is also correctly mounted. The large range of tools and their application-oriented combination make this and much more possible.