EN

WHITEPAPER

CAMERA SENSOR TECHNOLOGY PART 2

NEW DEVELOPMENTS AND ENHANCEMENTS

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IPF ELECTRONIC

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1 INTRODUCTION

Within the scope of our ''know-how'' series on the topic of camera sensor technology, our first introductory White Paper entitled ''What Needs To Be Observed When Using Camera Sensor Systems?'' deals with the fundamentals of image-processing sensor systems. In addition, this White Paper also covers a number of essential aspects concerning camera sensor technology as well as the technological advancements that have been made in this area (current as of July 2019). The aim is, among other things, to make clear that the potential application possibilities of camera sensors now go well beyond pure quality assurance.

2 EXTENDED 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.

Camera sensors of OC53 series: compact device (left) with integrated optics, illumination as well as electronics and a camera sensor with C-mount lens interface. (Pictures: ipf electronic gmbh)

Camera sensors are complete, software-controlled image processing units in an industrial grade metal housing (protection class IP67). They are compact devices containing the necessary optics, illumination and electronics components. The application possibilities of these devices lie between classic sensor systems, such as through-beam systems and diffuse reflection sensors, and industrial image processing. Furthermore, camera systems with C-mount lens interface also exist which facilitate a free choice of lens, thus enabling simple adaptation to specific applications (see chapter 4). Camera sensors can be used in any application where mounting, transport, sorting or packaging is performed automatically.

In particular, camera sensors of the **OC53** series feature functions and capabilities that are interesting for such or similar tasks. Here are just a few examples: Compared to pixel-based devices, the **OC53** camera sensors are largely immune to the effects of ambient 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 144 inspections per second (compact devices) depending on the scope of the feature checks.

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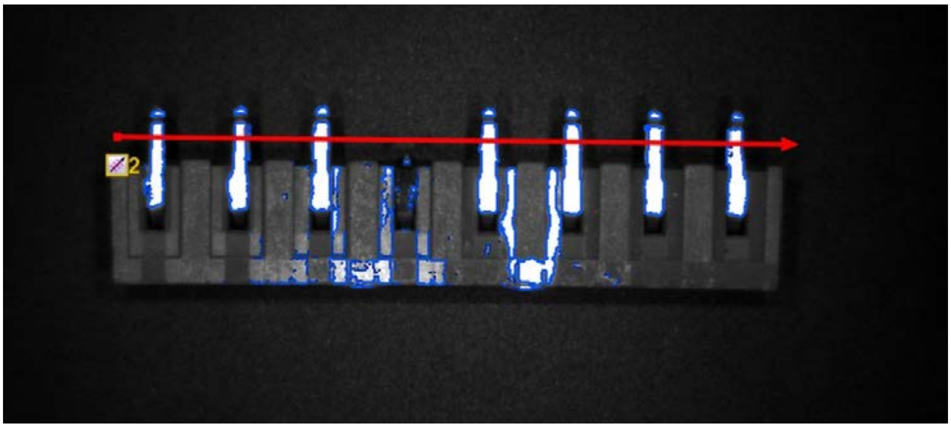
2.1 FROM PIXEL TO CONTOUR

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 current 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. The result is rapid detection, even under difficult environmental conditions. 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 gray value of each individual pixel is evaluated within a previously defined test window. If the brightness changes in a specified test area, the gray 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 ambient light is the cause of the gray value changes.

Left: image evaluation takes place after image acquisition
Right: image evaluation takes place parallel to image acquisition

2.2 OBJECT EDGE MARKS THE TRANSITION

Contours are essentially edges that identify the transition from a background to an object with specific outlines. Against this backdrop, an edge in a camera image is ultimately just a transition from one pixel to an adjacent pixel with a specific change in gray value. 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 grayscale difference between the pixels of an edge is determined accordingly, whereby the camera detects this difference.



Contour-based recognition: The completeness of contacts on an electronic component being checked with the "Count edges" tool.

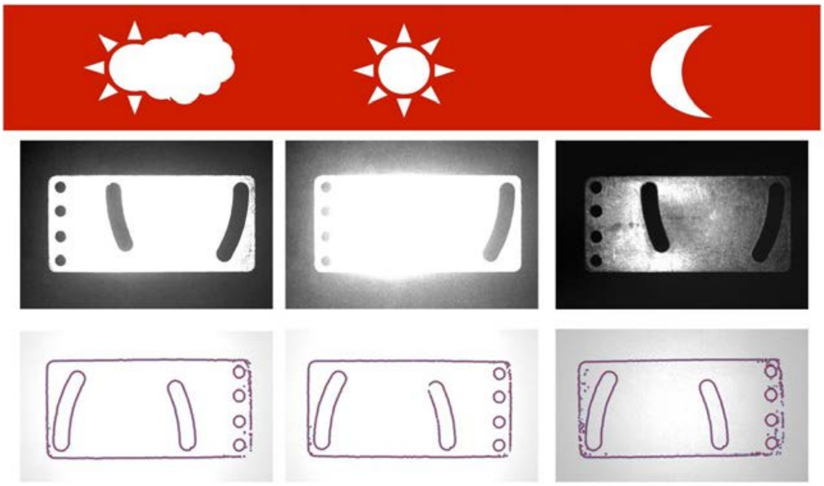
2.3 STABLE DETERMINATION OF THE CONTOUR

If ambient light is incident on a test surface, this generally affects the entire detection area. The grayscale 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.

For illustration purposes, a greatly simplified but generally understandable example: Consider, theoretically, a pixel with a gray value of 80 that represents the background of a test surface. Another pixel with a gray 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 gray value levels. If ambient light influences the test area, both the gray 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 gray 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 in-formation 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 ambient light, simple shading of the test surface can suffice with today's camera sensors of the **OC53** series depending on the inspection task.



The advantages of contour-based recognition (bottom) compared to pixel-based recognition (top) become clear under different light conditions.

3 PART LOCATION: INCREASED FREEDOM

A further advantage of the named camera sensors is their wide range of part location functions 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 newer systems, one is completely freed of this topic .

Part location on contours, edges, circles or lines of text (from top to bottom).

3.1 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.

4 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, compact devices as mentioned in chapter 2 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. For this reason, the **OC53** camera sensor series from ipf electronic includes devices with C-mount connection. Such solutions enable selection of the lens most suitable for the desired focal distance of the respective application.

Camera sensors with C-mount connection facilitate a free choice of lens and thus enable a broad range of applications. The individual components of the lens interface are: baffle ring for varying the close-up limit, lens, lens spacer and protective lens cap (from left to right).

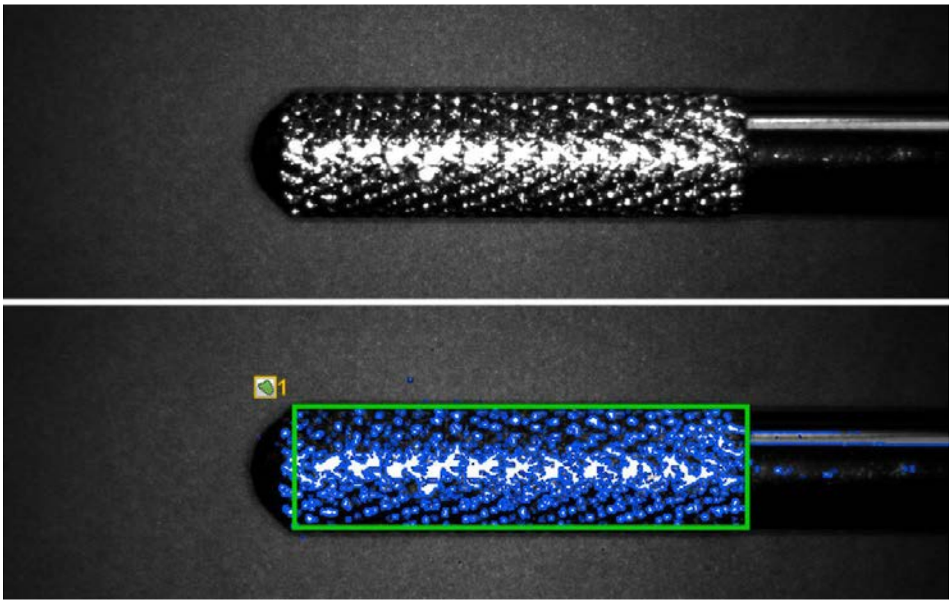
In addition to choosing the correct lens and the correct focal distance, the illumination must, of course, also be correct. Camera sensors with C-mount connection therefore feature an integrated flash controller that provides the necessary support for the use of external illumination. The controller supplies the external illumination not only with voltage but also with the synchronous flash pulse corresponding to the exposure time and required for multiplying the brightness of the illumination. More on this topic can be found in chapter 7.

5 SOFTWARE FOR FOCAL DISTANCE CALCULATION

''OptiCheck Toolbox'' provides an answer to the following question frequently asked in practice: which sensor or which lens is most suitable for a specific application. The free software from ipf electronic has been developed both for compact devices with fixed lens and for devices with C-mount connection. After just a few parameters have been entered (e.g. distance of the sensor to the test object, size of the required field of view in the x and y direction and the required resolution in pixels per millimeter), the software application not only offers sugges-tions for solutions with the appropriate focal distance, but also recommends accessories for the specific application. If, for example, it is necessary in a specific application case to increase the distance to the image recorder of the camera sensor, ''OptiCheck Toolbox'' indicates the number of baffle rings for the lens that are required to vary the so-called close-up limit of the device (minimum distance to an object).

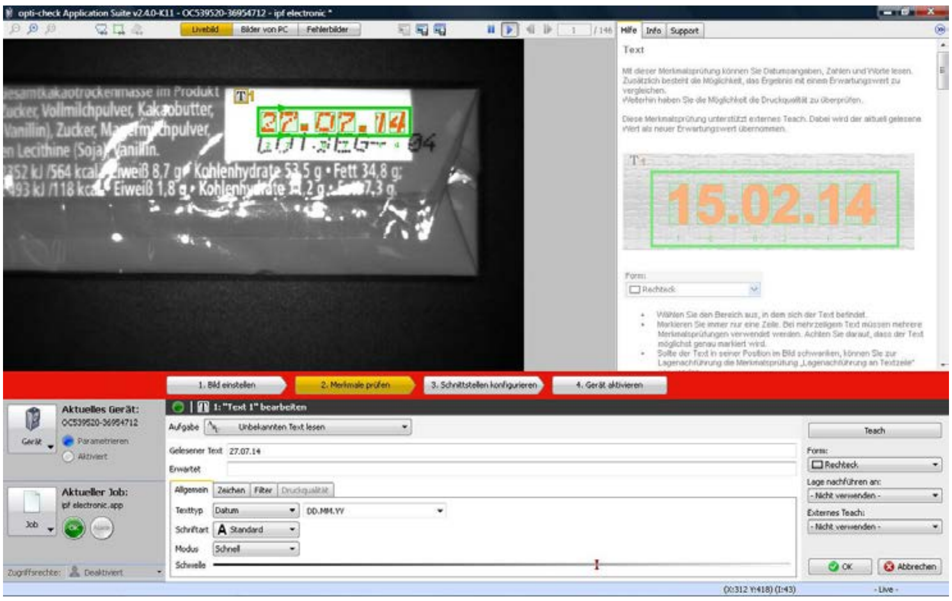
6 NO TRAINING OF FONTS

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. In the context of identification tasks, special mention should be made of the OCR function (recognition of standard fonts such as Arial, Calibri, etc.). With the **OC53**, this function requires no prior time-consuming teach-in measures, regardless of whether the object to be recognized is text (e.g. free text), a date or a numerical code with special formatting. Consequently, only the reference needs to be taught in or the desired text information specified.



Detection of the knurling on a component on the basis of contour points.

With the OC53, OCR functions can be used without time-consuming teach-in measures, regardless of whether the object to be recognized is text, a date or a numerical code with special formatting.



7 ALL A QUESTION OF LIGHT

In the introductory White Paper on camera sensor technology, one chapter briefly dealt with the topic of illumination. Illumination is one of the most frequently underestimated influencing factors when using camera sen-sors. As this topic is multifaceted and extremely complex, it is covered in a separate White Paper (part 3 of this series).

8 NEW DEVELOPMENTS AND ENHANCEMENTS

The march of progress never stops – and this is also the case with camera sensors. The following sections describe a number of key new developments and enhancements that promise many benefits, especially with regard to both the practical and future use of the devices.

8.1 PPROFINET AND INCREASED PROCESSING PERFORMANCE

In 2018, ipf electronic extended its range of camera sensors with devices equipped with Profinet interface, allowing the camera sensors to be integrated into fieldbus environments more easily using the open Industrial Ethernet standard. Furthermore, the processing performance of the camera sensors was also increased by the introduction of more powerful processors. The significantly shorter reaction time and faster image processing of the devices are particularly noticeable in the case of automatic position tracking (see chapter 3) and code and text recognition.

8.2 MULTIVIEWER DISPLAY VIA WEB BROWSER

All camera sensors of the **OC53** series can also be configured during the ongoing production process by means of a web interface that is compatible with all standard browsers. Further developments in this area include, for example, the possibility of using the web interface to visualize up to 16 camera sensors simultaneously in real time on a large screen. The multiviewer delivers a quasi live image showing the mode of operation of all cameras installed in the current production process. Moreover, depending on the settings, for each device it is possible to call statistics (e.g. the number of detected OK and NOK parts), to select inspection tasks on the sensor or to configure feature checks. In addition, the camera-internal release levels for various user groups enable these possibilities to be varied individually depending on release status.

8.3 NOT JUST SIMPLE CALIBRATION

It is thanks in particular to the configuration software of the **OC53** camera sensors with its versatile combination options that new application areas with interesting potential for practical use constantly emerge. Users have 19 different tools at their disposal, using which up to 32 feature checks per inspection task can be performed, whereby up to 255 inspection tasks can be stored on a camera sensor.

At the beginning of 2019, ipf electronic launched a new version of the configuration software for the **OC53** monochrome cameras with Profinet connection. The key features of the software are described below.

8.3.1 AUTOMATIC CORRECTION OF PERSPECTIVE EFFECTS

It is often the case that a camera sensor cannot be installed exactly perpendicular above an inspection area to be detected, e.g. if a robot arm is used for material handling or if reflections are to be avoided when detecting shiny or reflective material (e.g. scanning barcodes under film packaging). If, however, an **OC53** is mounted at a certain angle relative to an object to be checked, this will lead to distortion of the camera image and therefore to deviations in the checking result, which previously had to be corrected with considerable effort using the configuration software.

However, the camera position can now be simply taught in by using a calibration target. After the camera has been mounted, the calibration target is placed under the device and aligned (fig. 10). An **OC53** can then be cali-brated virtually at the push of a button, whereby the camera corrects the recorded image automatically in real time. Furthermore, the calibration plate and world coordinates can be used for simple conversion of pixels into a measuring unit.

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By using a calibration target, the camera sensor can be calibrated at the push of a button in order to correct an image in real time.

8.3.2 INTEGRATED SHADOW CORRECTION

Another useful feature of the software for the monochrome devices with Profinet is the integrated shadow correction used to compensate inhomogeneous brightness distribution over an object to be detected. Such shadow effects are caused e.g. by major variations in the operating distances of the camera (inclination of the device), but also by the camera lens as well as illumination of the device. These effects too can now be correct-ed by the configuration software at the push of a button.

8.3.3 IDENTIFICATION OF OBJECT POSITIONS

Furthermore, the camera sensors with the latest version of the configuration software (current as of April 2019) are now able to find several identical objects in the search area based on a previously taught-in part, and to determine their position. This function is of particular interest for robotics applications, e.g. bin picking, especially because the camera also checks object overlapping as well as the gripper area of a robot. An additional fea-ture is the camera's ability to determine the number of objects.

9 TECHNICAL FEASIBILITY STUDY

As this white paper shows, camera sensors are very versatile and, in combination with the powerful parameterization software for the device series and a large selection of lighting solutions (see the white paper Camera Sensors Part 3- It's all a question of light), have already proven themselves in very different industrial processes. Potential areas of application for camera sensors include the plastics industry, the electronics industry, the automotive industry, mechanical engineering, bottling plants (breweries, champagne producers, etc.), sawmills, manufacturers of hygiene products, and much more.

9.1 TARGETED TESTS

Whether a camera sensor is actually recommended as a technological solution for use in a specific application and which device or which device combination of camera sensor, lens and illumination is suitable for this can basically only be clarified after an initial examination of the specific application and subsequently, if necessary, by a technical feasibility study. This service, offered free of charge by ipf electronic, has the decisive advantage that the product specialists for the area of camera sensor technology can deal in detail with a customer application and, among other things, develop an optimal solution on the basis of test setups in the in-house laboratory with customer OK and NOK parts.

However, it is not only the task that a camera sensor has to fulfill in a specific application that ultimately leads to an optimally matched solution. For example, certain environmental conditions or object properties as well as several other factors influence the selection of a truly suitable system. In the run-up to a technical feasibility study, the product specialist from ipf electronic therefore first works out a checklist together with the customer. An application request for a technical feasibility study can also be submitted directly via ipf electronic's app for mobile devices, where a number of specific questions also need to be answered.

In the application request via the IPF app, among other things, some important information about the application is requested.

Some information relevant to the checklist is given here as an excerpt:

- Description of the task
- Information on environmental conditions (e.g. lighting conditions, temperature, dirt, etc.)
- Size and speed of the object to be tested
- Object condition (material) incl. specific characteristics (e.g. color, gloss level, etc.)
- Necessary image field size for object detection
- Required cycle time, which is specified by the respective application, among other things

Once the essential questions about the application have been clarified using the checklist, the detailed technical feasibility analysis can begin. An example of the procedure for such an analysis in practice is illustrated here.

9.2 POWERFUL SOLUTION REQUIRED FOR FILLING STATION

In a wine and sparkling wine cellar, among other things, up to 21,000 bottles of mixed beverages are filled per day. The products on the bottling line change throughout the day, involving not only a change of beverage but also of bottle types with different colored crown caps. In this specific case, it was clear from the outset that checking the bottle caps for correct fit and any damage could only be accomplished by using an image processing system, especially since six bottles per second have to be checked in the station. Since the different colored crown caps vary in their degree of gloss, one challenge was to find suitable lighting that would eliminate such influences almost completely. For in-depth preliminary tests, ipf electronic received some bottle samples with faulty caps from the customer.

For testing purposes in the laboratory, the wine and sparkling wine cellar also provided some NOK products with faulty crown corks.

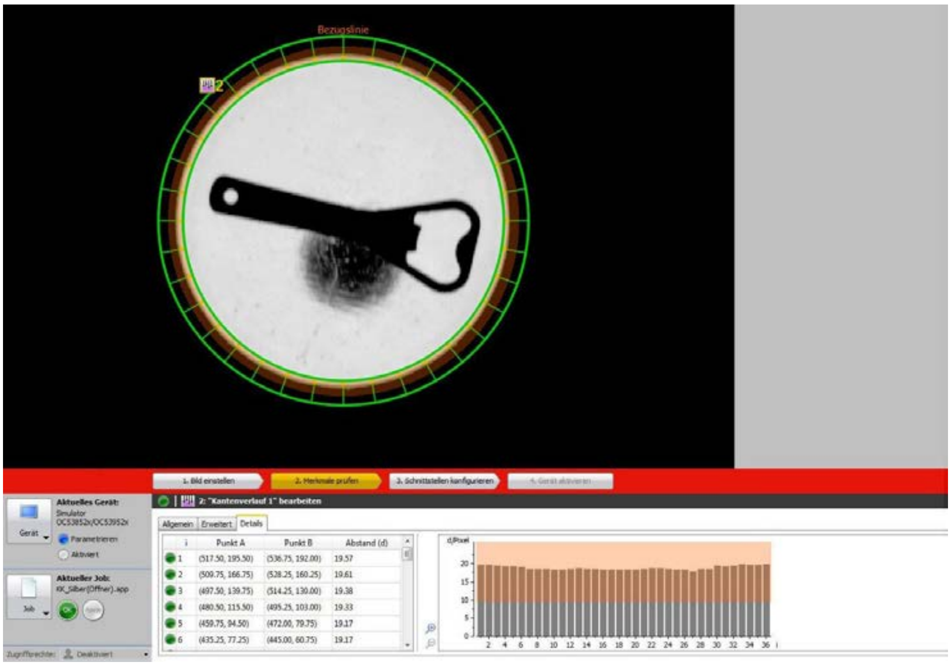
9.3 EDGE CONTOUR PLUS POSITION DETECTION AND TRACKING

In ipf electronic's laboratory, these samples were used to test various camera sensors in combination with possible illumination solutions. A compact camera of the **OC53** series with a dome illumination proved to be the best choice in the course of the tests. This illumination solution provides a diffuse, shadow-free light for a sharp, high-contrast image of the test object when inspecting the crown caps, which vary in color and gloss level.

One of the main focuses of the technical feasibility study was the question which feature check of the software to the camera sensors should be used to check the correct fit of the bottle caps. One of the factors to be taken into account was that the bottles can easily change their positions in the detection range of the camera sensor during rapid transport on a conveyor belt. The laboratory tests showed that the feature check ''edge contour' was most suitable for checking the crown caps. With this function, an object contour can be scanned with several software search beams and the contour distance determined per search beam can be compared with previously defined conditions.

In this context, the scanning areas can be designed in any shape and theoretically an unlimited number of search beams can be placed in them. Theoretically, because the number of search beams always has an influence on the evaluation time and thus the reaction time of the camera sensor. Therefore, the required cycle time in an application must always be taken into account when selecting the number of search beams.

The crown corks of the bottles (more precisely: the outer contour of the closures) are to be inspected vertically from above in the filling line described. This is done by means of a circular scanning area placed over the outer contour of the crown cork, with a total of 36 search beams within the circular ring thus created.



To test the edge contour, a total of 36 search beams were applied within a circular ring surrounding the outer contour of the cap (here a crown cork with the motif of a bottle opener).

To test the edge contour, a total of 36 search beams were applied within a circular ring surrounding the outer contour of the cap (here a crown cork with the motif of a bottle opener).

9.4 DIFFERENCE VALUE DETERMINATION CHECKS OVALITY

The edge contour feature check described above can initially ensure that a crown cork really is completely positioned on a bottle. In the case of an incorrectly positioned cap, however, the outer contour is partially outside the ring-shaped scanning area. At these points, no distance to the outer contour of the crown cork can be determined via the affected search beam(s). The closure is thus rated as NOK and the bottle in question is ejected from the filling line after the inspection.

However, if the camera sensor detects a contour distance across all search beams, an additional inspection of the crown cork is performed using a predefined limit value. The distances between the longest and shortest search beams are compared and the difference is calculated. The difference value thus marks a tolerance range for the permissible out-of-roundness or ovality of a closure. If this is too large, the cap is not seated correctly and the bottle must also be rejected.

In addition to the position of the closure, the ovality of the crown cork is checked using a predefined differential value.

The tests in ipf electronic's laboratory also took into account the frequent product changes at the filling station. Therefore, a separate test program was created for each closure variant via the software to test all different colored closures and stored in the camera sensor. For the actual application, it was later planned that an employee at the filling station would select the respective inspection program via a switch when changing products.

9.5 MEANINGFUL ANALYSIS REPORT

If the technical feasibility study is successfully completed and the customer decides in favor of ipf electronic's solution, he will receive a meaningful report with the following contents:

- Description of the test result including photos of the test setup
- List of hardware used in the analysis (camera sensor, lenses, illumination, etc.)
- Listing of the software parameters used for the test setup as an orientation for the later customer parameterization of the camera sensor in the specific concrete application
- Description of the individual test steps
- Detailed results of the object inspection with clear feasibility statement

9.6 ENORMOUS TIME SAVINGS AND EASIER COMMISSIONING

The practical example illustrates that a technical feasibility study based on customer samples can sometimes involve a great deal of effort in order to obtain an optimal system solution for an application. In the end, the customer saves this effort because he does not have to invest time in his own tests and, thanks to the specialists from ipf electronic, he obtains a customized system that is optimally adapted to the specific application.

As a result, this also significantly reduces the effort required for the installation and commissioning of the solution on site. At the customer's request, ipf electronic's engineers also provide on-site support for parameterization.

The inspection station inside the filling line. Illumination and camera are located in an enclosure for protection.

The system solution described in the practical example has already been in operation for some time and, according to the customer, works perfectly. The camera sensor detects all bottle caps 100 percent of the time and reliably detects all faulty crown caps, regardless of which product is currently being filled in the line concerned.

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10 APPLICATION EXAMPLES

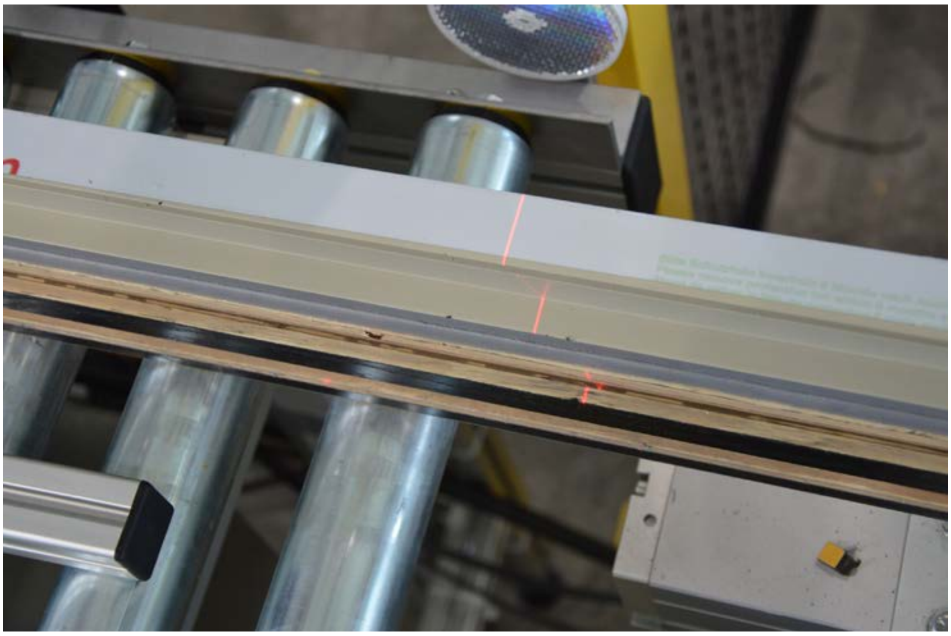
Finally, a few application examples are given to give an impressSn of the performance of camera sensors based on specific challenges from practice. Both of the following examples also illustrate how important a certain amount of application experience alone is in order to find a truly optimal solution for the use of camera sensor technology.

10.1 WITH DEVICE COMBINATION TO THE GOAL

In a special plant of a window manufacturer, around 120 window profiles are automatically provided with seals per hour. The system processes up to 50 different profile types with different colors and surface gloss levels. At the start of the special line, the PA profiles for the window frames or window sashes are manually loaded into a workpiece buffer on one side. On the opposite side, the window profiles already prefabricated by another machine are automatically transferred to a roller conveyor. These window profiles consist of an aluminum shell, PU foam as thermal insulation and a wooden profile as window support. At the roller conveyor, it must be ensured that the profile type fed in each case is correct, since the system is set up automatically for the respective workpieces. For the automated identification of the different profile types, a camera sensor in combination with a line laser was chosen.

10.1.1 CONTOUR COMPARISON WITH LASER LINE

To clearly identify the different window profile types, the ''Contour comparison'' function was selected from the test tools of the parameterization software for the camera sensor for ''Feature comparison''.



For each profile type, there is a different contour of the laser line, which is detected by the camera sensor and compared with the reference contour stored in the software.

With the line laser, a laser line is projected on the top of the profile over the entire width of a profile and detected by the camera sensor. Since the profile types differ from each other in their contours, the laser line has a different course for each type. This and other information can be stored in the software as a separate inspection program for each profile type. For the unique identification of all profile types, the relevant profiles or the respective laser line contours are therefore taught in, stored in the software and linked to the respective settings of the system for profile processing.

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10.1.2 CLEAR IDENTIFICATION

If the system is therefore converted to a new profile type, the corresponding inspection program of the camera can also be activated via the control system. By comparing the currently recorded profile with the laser line contours stored in the software for the corresponding profile type, the camera sensor can thus always clearly check whether or not the correct window profile is being fed from pre-processing. Since the tops of the various profile types have different colors and can also have different degrees of gloss, the contour comparison using the line laser proves to be particularly reliable. Once the camera sensor has detected the correct window profile type, the individual workpieces can be transported onward for processing in the special system.

Camera sensor and line laser are mounted above a roller conveyor on which profiles from pre-processing are located.

10.2 RECOGNIZE MARKINGS ON DIFFICULT MATERIAL

A company is changing the material properties and functions of glass by dipping coatings just a few nanometers thick using the rare sol-gel process. In this process, glass sheets, known in technical jargon as ''substrates,'' are dipped into a specific coating liquid and then pulled out again at a defined speed. This process is used, for example, to produce color-effect glass and optical filters for medical technology, lighting technology, industry, and research and development.

10.2.1 LAYER BY LAYER TO THE HIGH-END PRODUCT

After basic cleaning and a multi-stage cleaning and drying process, the glass panes for the optical filters are transported on a single conveyor line to a clean room, where they are positioned in a coded workpiece carrier. A robot then transports the panes to one of four coating chambers. After coating, the robot repositions the panes in a workpiece carrier. The coating is then cured in a roller hearth oven. After this, the substrate is usually fed back into the process for subsequent coatings. In chaotic production, certain products pass through the process up to 22 times over several days.

10.2.2 CONTINUOUS TRACKING OF THE PROCESSES

With the variety of differently complex products that are in the plant at the same time, reliable tracking is essential. For this reason, each substrate is marked with a 2D code before it is first fed into the plant and verified directly via a camera system. Another camera is installed before reintroduction for products that have already been coated. The third camera system is located in the clean room before the infeed into the workpiece carrier. All devices are integrated into the Profibus DP installation via fieldbus nodes. The cameras with integrated incident light illumination have been in use since the company was founded and are always kept up to date with the latest technology. Nevertheless, there have been repeated problems in recent years.

10.2.3 PRODUCTION STOPS DUE TO ERROR DETECTIONS

The substrates, which vary in thickness and have different optical properties, are not always at right angles to the camera system on the conveyor line, which sometimes led to unwanted reflections, so that the cameras did not capture the 2D code. In addition, the company expanded its product range with new glass materials, with which the cameras also had problems because, for example, the material hardness may have a negative impact on the marking result.

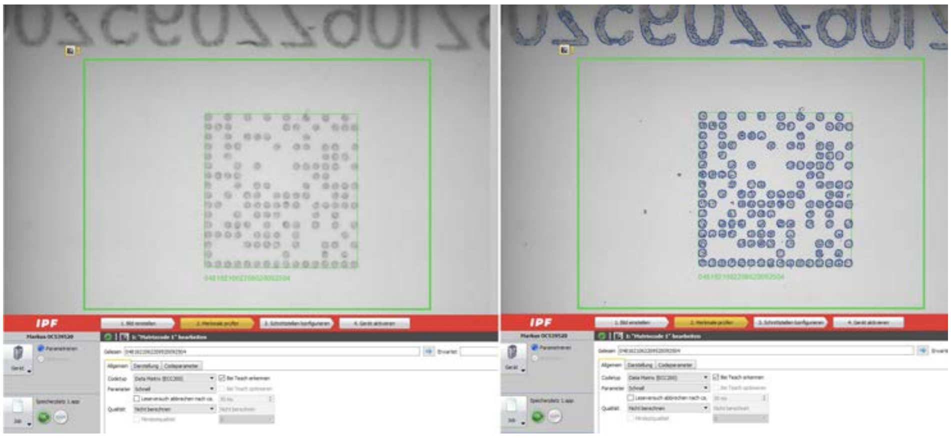
A misreading of the code immediately led to an interruption in production. If the camera in the cleanroom was the cause of this, an employee wearing the appropriate clothing had to enter the cleanroom, note down the 22-digit code and then transfer it manually to the process visualization system. In addition to being time-consuming, this always involved the potential for errors, for example because the code was noted incorrectly or not entered correctly. In addition, the camera manufacturer discontinued the systems and stopped maintaining the parameterization software, so that an adequate replacement had to be found.

One of the cameras in use. Due to transmitted light as the illumination technology, interfering reflections or the quality of the labeling no longer influence the reliable recognition of the code.

10.2.4 CAMERA SYSTEM WITH HOMOGENEOUS AREA LIGHT

ipf electronic finally recommended to the customer a camera sensor of the **OC53** series in combination with a homogeneous area light that works with the transmitted light method. After the installation of the first system in the clean room, it became apparent that even the change in lighting technology with transmitted light led to more reliable detection of the 2D code, because a slight slant of the panes as well as the quality of the marking now no longer play a role. In addition, the large image field with improved position tracking had a positive effect on the recognition of the codes.

The position tracking already mentioned in Chapter 9.3 is a powerful feature of the parameterization software for the camera sensors and makes it possible to determine the position and rotational orientation of, for example, a product, text or code on the basis of contours, edges, circles or lines. All subsequent feature checks, in this specific case the acquisition of a 2D code, are aligned with the determined object position.



One of the cameras in use. Due to transmitted light as the illumination technology, interfering reflections or the quality of the labeling no longer influence the reliable recognition of the code.

After the successful test operation of the first camera system, the two other older cameras at the initial and reintroduction points were also replaced by the new solutions from ipf electronic. The problems with the recording of the markings, the associated effort and, above all, the production downtimes could thus be sustainably eliminated.

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Subject to alteration! Version: February 2022