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System development for machine vision intelligent quality control of gas cylinders

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Abstract: An intelligent system for automated quality control of manufacturing process applications, based on machine vision is presented in this paper. The quality of many produced parts in manufacturing processes depend on dimensions and surface features. The presented automated machine vision system analyzes those geometric and surface features and decides about the quality by utilizing statistical analysis. Refined methods for geometric and surface features extraction are presented also. The efficiency of processing algorithms and the usage of an advanced analysis as a substitution of human visual quality control are investigated and confirmed.

1. Introduction

Many industrial processes use or require visual inspection in quality control as an integrated part of their production stages. Such processes are based on visual perception principles to successfully determine levels of product quality by quantifying its visual appearance in general and some specific visual features, respectively. A visual inspection system is based on machine vision principles by using acquisition cameras and also, one or more industrial computers. The main motivation for machine vision implementation is economic factors, which constantly require less production costs. One of these processes is the production of gas cylinders. The high level of explosion of the product requires the application of the highest criteria to ensure superior quality in its manufacture. To ensure safe operation during product lifecycle and to prevent imitation, it is necessary to use technical means for tracking it from the manufacturer's factory through the distributor to the end customer. In addition, continuous tracking between the end customer and the distributor of charged gas cylinders ensures safe operation. To achieve these high goals helps visual quality inspection systems and readers of the visual code of the product.

2. Description of an application system.

In the manufacture of gas cylinders, a number of parameters are considered for their reliable operation. One of these parameters is reading the identification label on the inside of the gas cylinder handle. A series of measurements are performed giving information both on the value of the coded expression and on the quality of the printed code. The value of the encoded expression is of particular importance. Without a correct code value, no traceability of the gas bottle can be achieved throughout its entire life cycle. A second important parameter is the correct diameter of the handle of the gas bottle. Due to the wide variety of different types of gas cylinders, it is possible that the components of the product are confused. It is possible to bring a handle of a small diameter gas bottle to be fitted to a larger diameter gas cylinder or vice versa. A third important parameter is the correct positioning of the handle against the company logo on the bottle. The correct positioning of the handle collars when welding them is important not only for the aesthetics of the gas bottle. It provides correct access to the gas bottle valve.

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Thus the probability of incorrectly fitting the reducer valve by the user is minimized. The company logo is used to correctly position the supports as a marker.

All these qualitative features can be tested using a high-performance visual inspection system such as OMRON FH. For all these different types of measurements a single camera is used. Such a technical solution implemented with the Keyence XG-X Visual Inspection System uses not one but four cameras. A high-quality visual quality inspection system is implemented according to the following example scheme described in Figure 1.

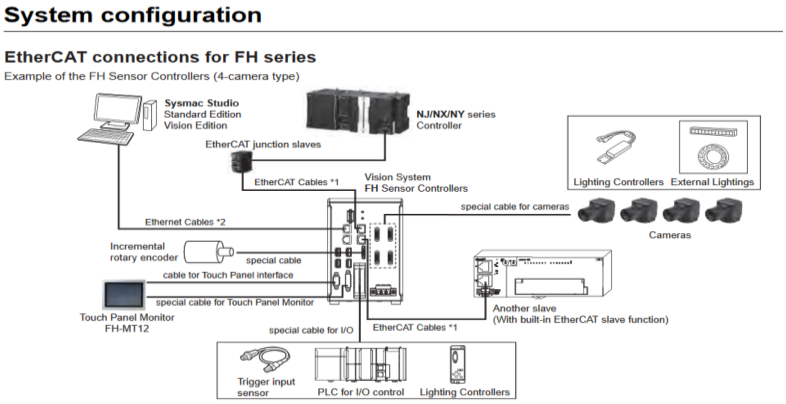

Figure 1.

The system consist of following important components: FH Sensor controller, Cameras, Lighting, Lighting Controller, Touch Panel Monitor. A major advantage in the OMRON FH controller is the multiprocessor structure. Depending on the controller's modifications it may have 2 or 4 processors, allowing a maximum of 8 visual inspection cameras to be connected to one controller. The multiprocessor structure leads to a dramatic increase in performance. Comparison of image processing in the conventional single processor and multiprocessor system discussed in the present article is shown in Figure 2. It is no longer necessary to wait for the beginning of the process to be processed for the image processing and output. With the multiprocessor structure, it is possible to process multiple inspection tools simultaneously like shown in Figure 3. The multi-processor system uses the multi-trigger technique. When multiple images are used for measurement, the conventional vision sensor repeats processing after image capture until all images are processed because only one trigger can be input in one flow. In contrast, the Multi-trigger imaging function to input multiple shutter triggers in one flow allows the FH series to capture images and process them in parallel, leveraging the speed of the multi-core processor.

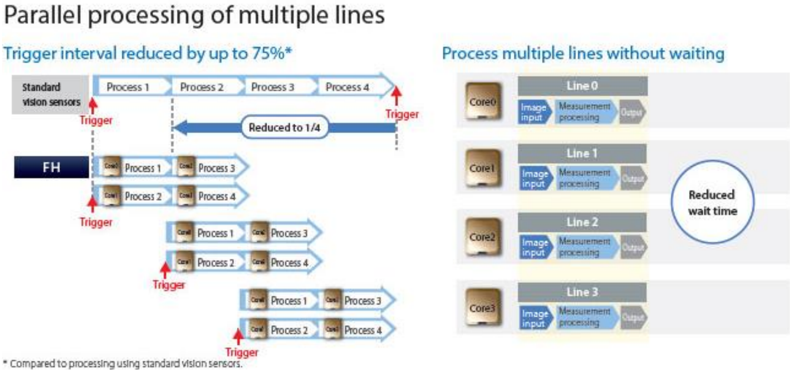

Figure 2.

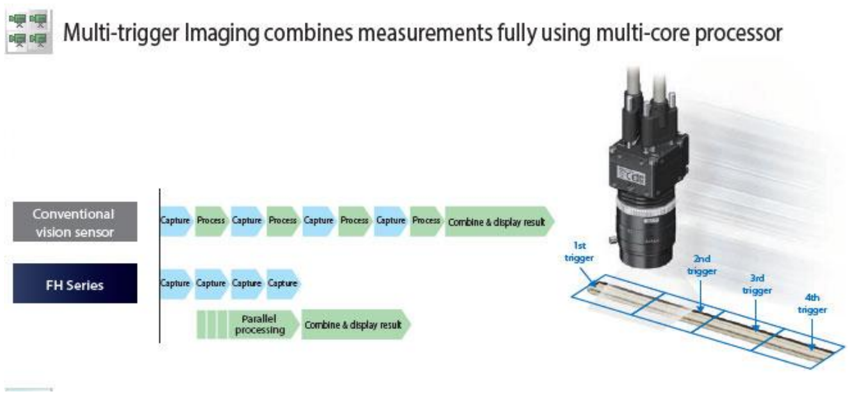

Figure 3.

All these quality inspections of gas cylinders are implemented in the quality control system shown in Figure 4. The system consist of monochrome high-speed CMOS camera FH-SM02 with resolution of 2 million pixels and external explosion proof illumination.

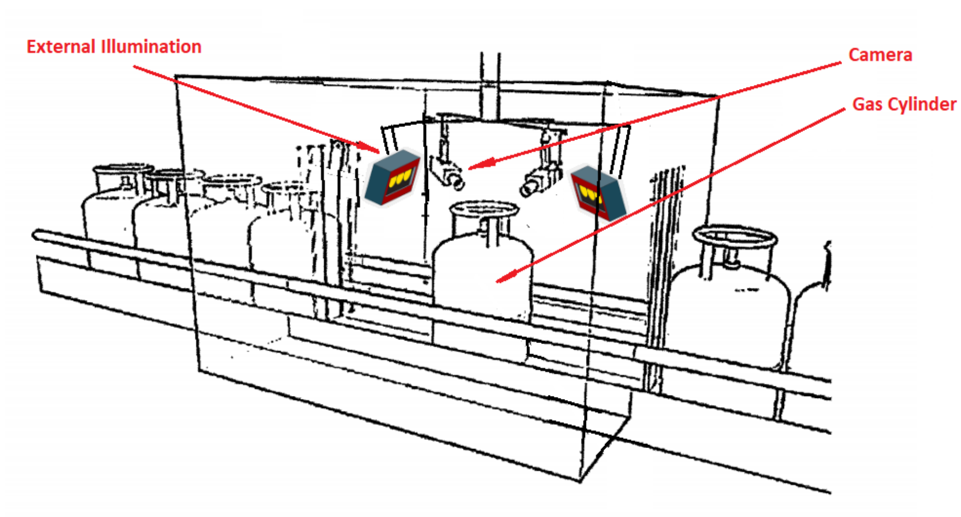

Figure 4.

In order to check the gas bottle identification code, it is necessary to operate several tools at the same time. In many cases, complex machine vision processing tasks begin with object location. The system is trained to recognize a specific pattern that it will then locate in various images featuring a variety of backgrounds. A common example of something a machine vision system would be expected to locate over and over is a two-dimensional barcode such as a Data Matrix. The system must find a barcode before it can decode it, and it must often do this extremely quickly as products bearing the codes fly by at high speeds. The controller OMRON FH has the following search tools: Pattern Search, Shape Search III , EC Circle Search, Sensitive Search. Search Processing Mechanism: reference image patterns are registered as models and then search is performed for the parts of input images that most resemble the models. The degree of similarity is represented with a correlation value, inspection for defects and different parts being mixed in can be performed. The search process is performed over several distinct stages. For the correct identification of the position of the identification label, the best results are achieved with the tool Shape Search III. This function is for detecting user-defined target to estimate target position and pose precisely. The correlation value indicating the degree of similarity, measurement target position, and orientation can be output. In shape search III, edge information is used as features, whereas in a normal search mode, color and texture information are used. It enables highly robust and fast detection robust to environmental variations including shadings, reflections, lightings, shape deformations, pose and noises. Since state-of-the-art object detection algorithm is exploited in shape search III, it can provides much more reliable position and pose estimation with higher speed compared to shape search II. Furthermore, it has much more parameter to tune to support a wider variety of applications. The use of the tool Shape search III in the task of inspecting gas cylinders is shown in Figure 5.

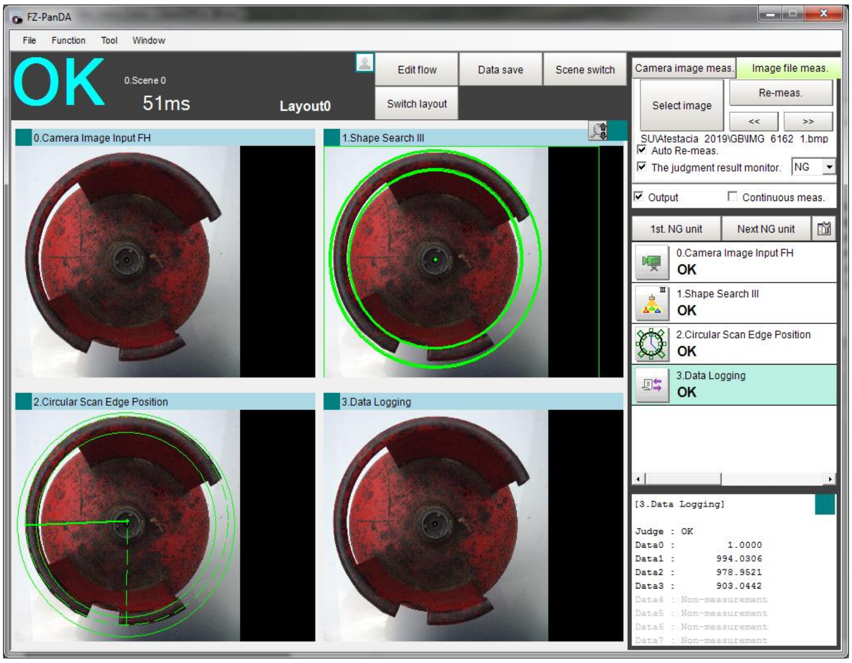

Figure 5.

The identifier is located in the manner shown in Figure 6

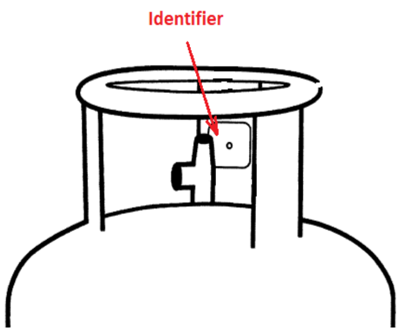

Figure 6.

Once the identifier has been found, it is now possible to read the saved unique code. The vision system Omron FH has a powerful 2D code reading capabilities. The dedicated algorithm for stable 2D code reading under adverse conditions is implemented. Data based on the print quality specifications can be output, which contributes to stable printing. Printing quality evaluation based on ISO standards is supported. Applicable standards: ISO/IEC 15415 (The data matrix standard in ECC 200 is supported) and ISO/IEC 15416. With 2D Code, detailed communication and reading result can be output: Code type, Code color, Code length, Mirror setting, Magnify level. Reading 2D code remains stable under such difficult conditions as: Changing ambient brightness, After processing/washing, Poor printing quality in high-speed line, Poorly printed on coarse surface. Machine vision can also recognize and verify human-readable symbols, tasks known as Optical Character Recognition (OCR) and Optical Character Verification (OCV). These are important functions because many items bear humanreadable codes alongside the machine readable ones, and both types of marks needs to be read to verify that the data matches. OCR is used to do the actual reading, and its strength is in reading characters even when they are deformed. These processing items provide the functions that are required for inspections of characters such as dates and lot codes.Characters in images can be recognized and read as text information using the internal font information without the need to prepare dictionary data. It is also possible to prepare a custom user dictionary to recognize characters in special fonts. OCR provides a higher level of recognition stability than character inspection when reading closely spaced characters, curved text strings, and other deviational characters. Setup is easy because there is no need to create a dictionary. The Omron FH vision system provides stable reading of difficult-to-read characters (OCR). Printed characters can be too close to each other, and characters can be printed on curved surfaces. Even in these cases, stable reading is possible. Easy installation with built-in dictionary. Many previous character reading methods required dictionary setup before usage, which was a tedious step. The built-in dictionary developed through Omron's long and rich experiences on Factory Automation sites includes a variety of fonts and possible character variations, eliminating the need of dictionary setup. The gas cylinder identifier also provides information about the manufacturer's name and serial number. With these functionalities reading this information is not a problem. The design of the identifier is shown in Figure 8.

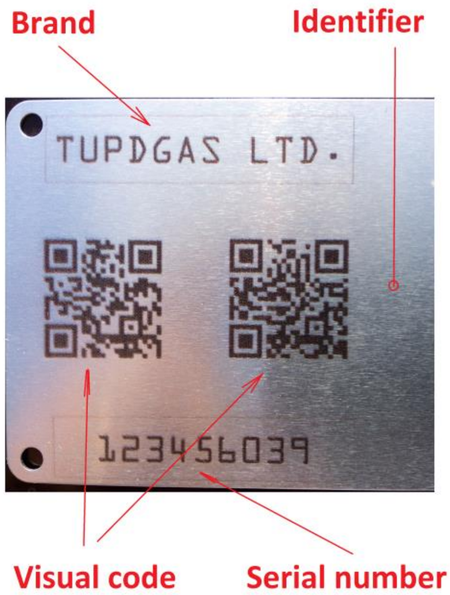

Figure 8.

An example of Omron FH OCR reading tool is shown on Figure 9.

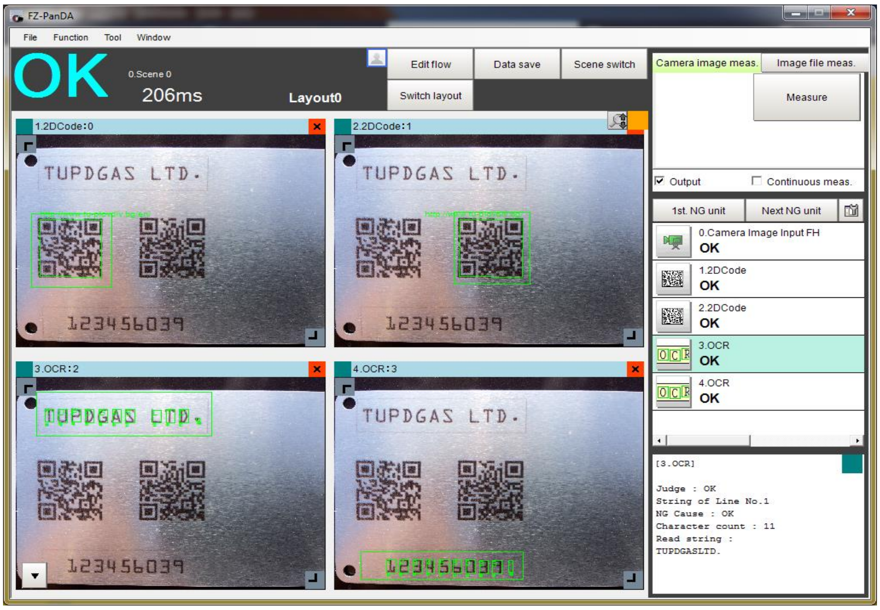

Figure 9.

The described visual inspection tools are a tiny part of the almost limitless capabilities of the OMRON FH vision system. But what will these (almost) unlimited and ultra-fast visual inspection tools serve if we do not have a high-speed network on which we can deliver data to the management system of the production process. And why is this super fast and ultra-intelligent quality control system if we have no less powerful tool to detect, document and statistically represent the defects that have occurred. To complete the picture of this quality control system, it is necessary to finish with a description of these, in fact, no less important functionalities.

The task of identifying and separating the inappropriate incoming product from the incoming good one is accomplished by the laboratory machine vision system for testing purposes shown in Fig. 10.

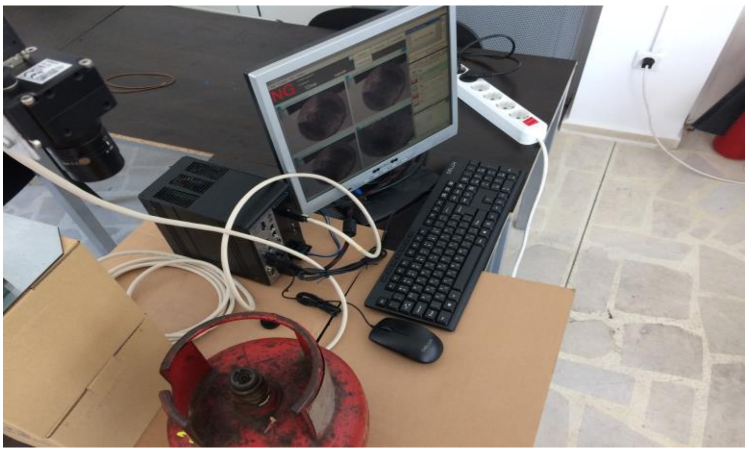

Figure 10.

For a seamless connection to the wide variety of different hardware, the visual inspection system OMRON FH supports the most common high-speed industrial networks: EtherCAT, Ethernet/IP and

Profinet. It is possible to use EtherCAT to connect NJ/NX Machine Automation Controllers and 1S/G5 AC Servo System to increase the control speed of everyday communications protocols from position detection to starting axis motion. By using of EtherCAT network data communications cycle is decreased to 125 µs.

3. **Analysis of the results obtained.**

NG analyzer is the tool which analyzes inspection and measurement results. This tool is used mainly in 2 ways: Adjustment of measurement set values during start-up and Analysis of NG causes during operation. The operation flow is as follows in Figure 11

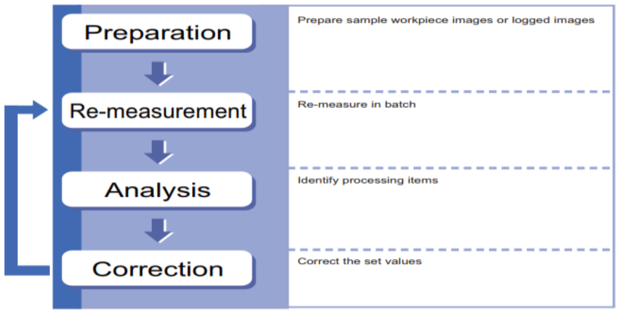

Figure 11.

The NG Analyzer Window is shown on Figure 12. The shown process is for of analyzing the results of an inspection of the identification label. The tools used are OCR and OCV.

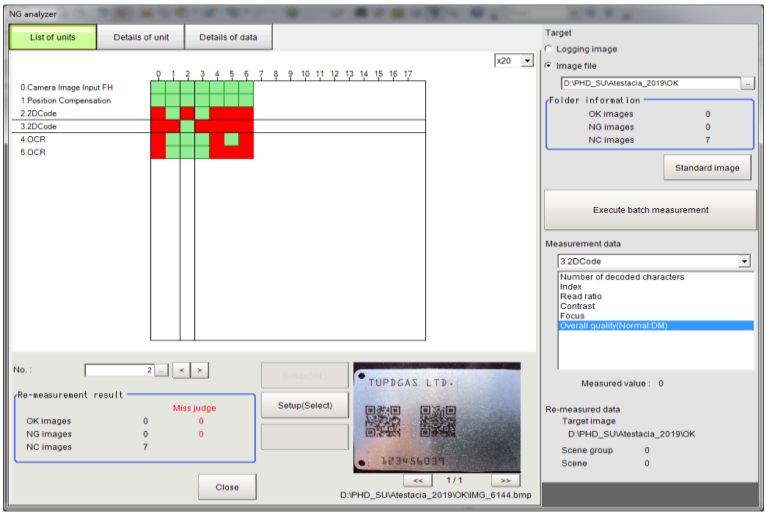

Figure 12.

The NG Analyzer tool allows a visual representation of the results of each used inspection tool. In the main box OK results are represented in green. NG results are displayed in red. We can indicate in which directories to collect the captured NG results. But the more important thing is that with this tool we can set up the system for stable operation. Based on the reasons for the NG score, it is possible to build a correlation diagram shown in Figure 13. For each instrument we use, we have a detailed sample of the measured results.

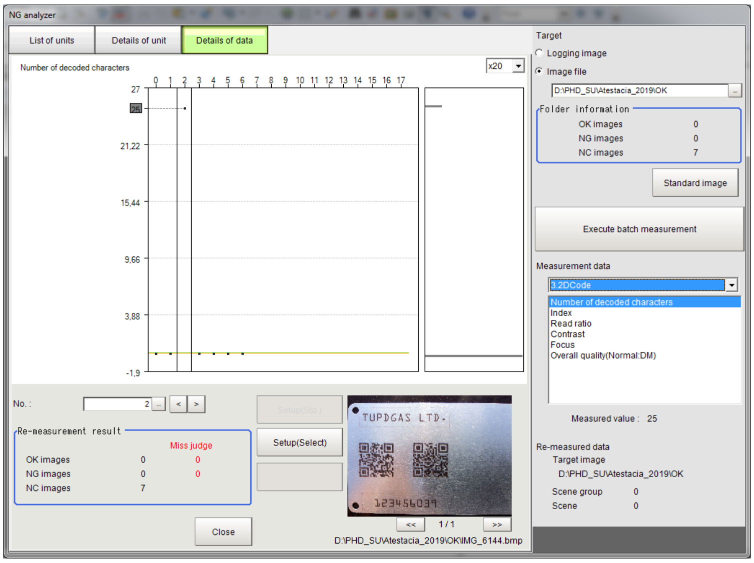

Figure 13.

Another important inspecting parameter described in this article is the diameter of the gripping brace. The NG Analyser window is shown on figure 14. Deviation in the radius of the bracelet we can trace through the “details of data” tool shown of figure 15

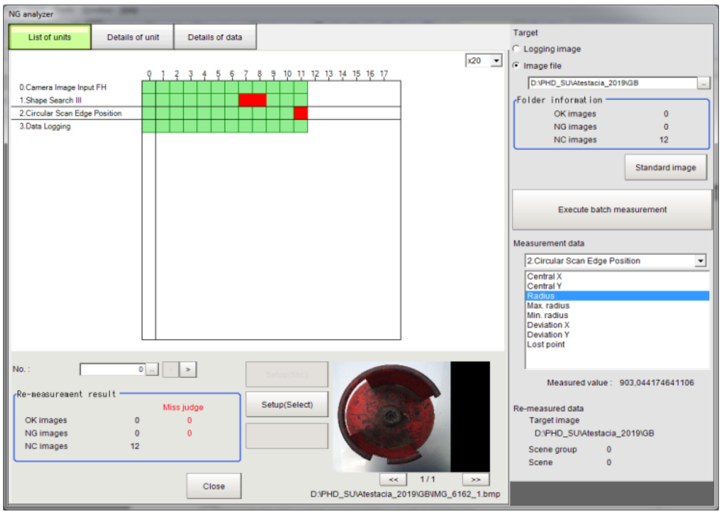

Figure 14.

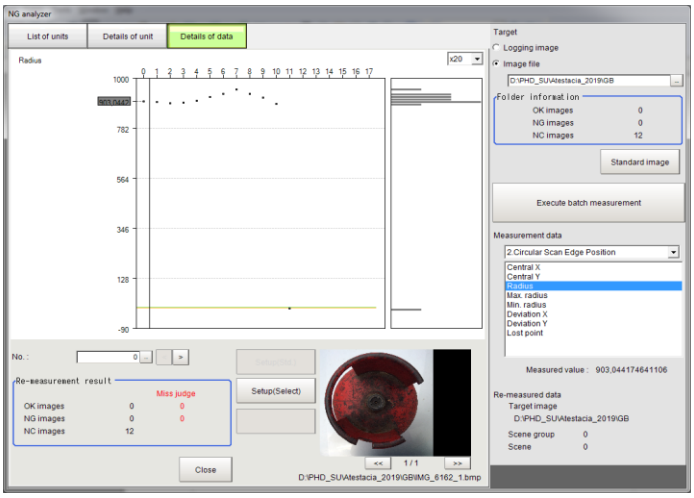

Figure 15.

Another way to analyze the results obtained is to use the datalog function that records the results of each tool in csv format. This allows them to be analyzed in Excel. Each tool used gives a number of values that can be analyzed. A view of one such setting is shown in the figure 16.

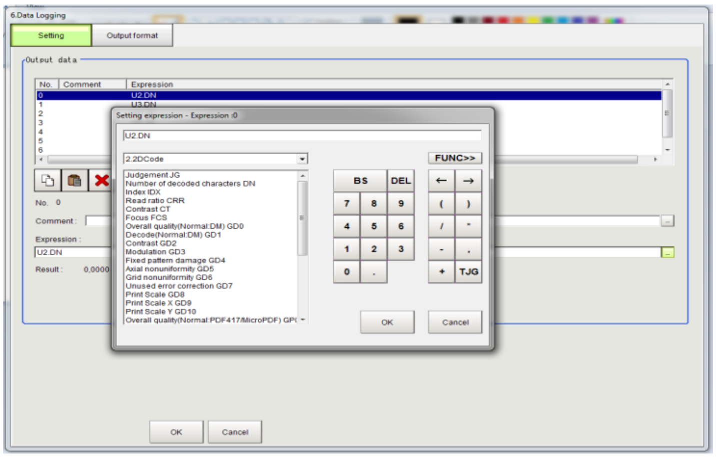

Figure 16.

The results of measuring the diameter of the gripping brace are shown in Figure 17

Date	OK/NG	U1,X	U1,Y	U2,R
2019-06-24_11-02-40-3440	1	964,8533	1021,5675	890,1233
2019-06-24_11-02-41-7690	1	994,6954	1086,1812	0
2019-06-24_11-02-42-7520	1	994,0306	978,9521	903,0442
2019-06-24_11-02-53-3050	1	992,1987	963,6006	899,0462
2019-06-24_11-02-54-4270	1	998,0924	955,3796	894,9067
2019-06-24_11-02-55-5010	1	1003,0739	937,3179	896,2618
2019-06-24_11-02-58-4250	1	950,9611	941,7169	905,3577
2019-06-24_11-02-59-3090	1	954,5093	974,6498	921,7068
2019-06-24_11-03-00-3440	1	956,681	969,4716	933,6563
2019-06-24_11-03-01-2970	-1	854,5486	998,6563	953,2645
2019-06-24_11-03-02-4750	-1	872,7347	1009,3491	933,559
2019-06-24_11-03-03-4630	1	936,4721	1050,2249	918,8854
2019-06-24_11-03-04-6010	1	964,8533	1021,5675	890,1233

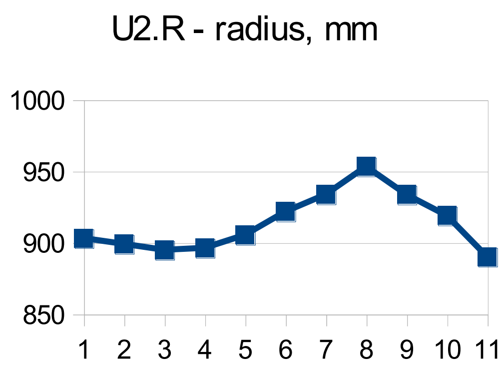

Figure 17.

4. Conclusion

As a conclusion of the above, it can be said that no production process aiming to achieve exceptionally high quality and simultaneously high productivity is impossible without a similar system of visual inspection. The efforts of manufacturers of visual inspection systems, whether they are Omron, Keysen or anyone else, are geared toward higher performance and higher performance. Nevertheless, the user chooses this system, which will allow him with the least effort and in the shortest time to navigate the ocean of inspection tools, image processing filters, macros to output multiple results, and without drowning.

5. References

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Title:

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A CYLINDER TRACKING SYSTEM AND METHOD
*Patent
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