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# QUALITY CONTROL IN THE MANUFACTURING INDUSTRY BASED ON THE APPLICATION OF COMPUTER VISION

***Summary**: Application of technologies based on information communication systems, internet networks, embedded systems, data storage in the cloud, computer vision, machine learning within manufacturing industry leads to a number of advantages in the quality control process. The goal of the work is the development of the system for quality control within production industry with the application of computer vision and algorithms for comparison and analysis. The secondary goal of the work refers to the storage of data on product quality and the control of production machines based on the analyzed data. The result of the application of the mentioned system is reflected in the identification of non-compliant products, which will lead to a reduction of the company's losses.*

***Keywords**: Industry 4.0., Quality 4.0., Cloud, OpenCV, Computer Vision, CNN, SSIM, IOT*

## 1. Introduction

Product quality control within the manufacturing industry is one of the most important indicators of success companies. The very development of technology and its use within the industry leads to a greater number of detection methods non-conformities and quality control. As the area of the manufacturing industry itself differs from company to company, as well as the non-conformity that can be presented in several ways, several methods of quality control can be applied. One of the ways of quality control is computer vision, which has a huge advantage over manual ways of quality control in terms of the adaptability of the system to a specific purpose, the application of deep learning in the process of making a decision on non-conformity, algorithmic systems (Rožanec et al., 2022, Louw et al. , 2019, Yang et al., 2020).

This technology also has limitations, so it can be used to detect text, color, dimensions, and scratches. The accuracy of the obtained data depends on several factors, the most important of which relates to the algorithm itself used to detect inconsistencies, external factors such as lighting, vibrations, equipment quality, while the speed of the system is directly related to the hardware. The advantage of applying computer vision compared to manual methods of quality control are certainly based on speed, timely information in real time, smaller losses, reduced costs of finishing products or semi-products, reduced production of scrap products, which directly affects company profits (Yang et al., 2020).

In addition to the large number of systems based on the application of computer vision for quality control, this area is still under-researched, it is necessary to strive for the development of less complex systems that

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will require less software and hardware power and that will achieve results at the same speed. Accordingly, there is a need for the development of this system that will contribute to the efficiency and speed of product non-conformity detection. The main goal of the system developed and presented in this work is the development of a quality control system based on computer vision, where the focus is on external non-conformities of products within the manufacturing industry, where the amount of funds needed for its implementation should be taken into account. The advantages of using this system can be seen in the training of the system where convolutional neural networks were used, the use of which significantly accelerated the training, which makes the system much more adaptable to needs.

In the continuation of the work, a review of the literature will be presented, which will include the current technology that has been applied in the field of product quality with the use of computer vision. Application of Industry 4.0. as well as the very technologies it includes for solving problems in the quality control process.

## 2. Literature review

### 2.1. Quality control in manufacturing industry

Quality control within the framework production industry can be seen as a process that consists of two sub-processes that make up the identification of quality and quality comparison (Powell et al., 2021;). The quality identification process can be seen as the process of determining the current quality of the product by various measurement methods, the comparison process involves comparing the identified quality with the results that need to be achieved (Powell et al., 2021;). Quality of the product is closely related to the user of the product or service, which is actually a determinant of the level of required and achieved product quality (Rodrigues et al., 2020; Powell et al., 2021;). Seen from the side of the customer or user of the product on alone Product quality is affected by a number of factors of the same and which are often definedstandard or user requirements (Carvalho et al., 2021; Rodrigues et al., 2020 ;). Also, the time of use of a product can define the necessary quality when it is used in industry or when it is used for general use. Quality can be expressed in a number of ways, the basic way of expressing quality is numerically, that is, when talking about some numerical values, it can also be expressed in nominal scales, descriptively, yes or no.

### 2.2. Computer vision

Computer vision as the basis of the system presented in this work is based on the acquisition, processing and creation of data. The technological pillar of computer vision is based on the use of a camera that is applied for the data acquisition process (Stavropoulos et al., 2020;), and it can be applied industrial dedicated cameras as well as general purpose cameras. When it comes to data processing itself, it can be performed in several ways, the most common used by industrial computers while they are all more commonly used general purpose computers viewed from the aspect of finance (Stavropoulos et al., 2020;). The basis computer vision consists of algorithms applied for object tracking, dimensional control, object selection, object recognition, etc. (Stavropoulos et al., 2020;). The complexity of the algorithm directly affects the speed of the system, which is of high importance in some application cases. In order to increase the speed, they are often used and neural networks (Almazán-Lázaro et al., 2022;). In order to achieve satisfactory system performance, which is reflected in accuracy, speed, and the necessary financial resources, it is necessary to strive to reduce complexity of the algorithm and at the same time maintain or increase its accuracy (Almazán-Lázaro et al., 2022;). In order to achieve satisfactory system performance, which is reflected in accuracy, speed, and the necessary financial resources, it is necessary to strive to reduce the complexity of the algorithm and at the same time maintain or increase its accuracy (Almazán-Lázaro et al., 2022;). Also, the very functionality of the computer vision system can be affected by external factors such as lighting, image resolution, vibrations, distance, etc., in order to increase accuracy of these systems, it is necessary to strive to reduce the influence of the mentioned factors. Today, computer vision finds application in many industrial fields, and its contributions in the application of control quality can be observed through the reduction of scrap, reduction of the number of finished products, controlled production, implementation on industrial robots where it increases the precision of the robot's gait as well as the download position, recognition of different situation, product palletization, control of industrial lines, reduction of the required number of employees in quality control positions (Vukicevic et al., 2019).

### 2.3. Industry 4.0.

Application of Industry 4.0. in the quality control process, it enables the implementation of modern technologies that directly affect the quality control process itself (Culot et al., 2020). The main goal of the application of Industry 4.0. se based on easier and faster execution industrial processes, obtaining more accurate data, reducing the possibility of errors, all with a combination of the application of already implemented technology and new ones (Bigliardi et al., 2020; Horváth et al., 2019). One of the indicators of success applications of industry 4.0. is also reflected in process control, adaptability system, availability (Albers et al., 2016). The application of internet networks, sensor systems that can independently communicate and collect data is called IIOT (Industrial Internet of things), also this technology includes a database as well as control industrial machines (Bal et al., 2019; Muller 2019; Tupa et al., 2017, Singh et al., 2019). Seen from the side of software that is applied within Industry 4.0. and depending on herself there are a number of industrial areas software systems, tools that lead to cost reduction, faster work, increase efficiency and effectiveness as well as loss reduction (Mijailović et al., 2020). From the hardware perspective of Industry 4.0. implies the application of microcontroller platforms, programmable logic controller, which together implemented in the quality control process and within one machine represent embedded systems (Pasika et al., 2020; Izaddoost et al., 2020; Kullig et al., 2020). Big data provides the ability to store large amounts of data that can be analyzed further to help predict future system failure. With the use of industrial cameras, it is possible to obtain quality data, which further, with the use of deep learning, can lead to a reduction in the possibility of errors. (Maurizio et al, 2021).

## 3. Case study

Within this chapter it will be presented a system that was developed for visual quality control in the production industry of small and medium-sized companies with the use of opencv library, computer vision, cloud system, CNN (Convolutional neural network). Since quality control is performed manually in most small and medium-sized companies, the goal of this paper is the development of an adaptable system for application in the field of visual quality control. Current quality control process: an employee from the quality department supervises the production as well as the products themselves, controlling the essential characteristics of the product for its functionality. Which means that an employee periodically monitors a production machine and the semi-finished products it produces, as he needs a certain amount of time to check all machines. According to the above, if after the departure of the employee who will perform the quality control process on a certain machine, it produces a non-compliant product, it will continue to do so until he reaches the same machine again. The presented problem can be solved with the application of computer vision if it is a surface one non-compliance. The working principle of the presented system is as follows: based on data acquisition, their processing is performed, after which the system's reaction and data storage take place. Acquisition process data processing is done with the help of system hardware using a camera, data processing in the specific case of photos is done with the use of opencv libraries, TensorFlow library, CNN (convolutional neural network) and non-conformity detection algorithms, the system's reaction is the process of stopping further production if the defined number of non-conformities is exceeded products, data storage is done in real time on the cloud system.

### 3.1. System software

The work process of the presented system can be observed in the following way, when starting the system, it is necessary to initially train the system, that is, to define the non-conformity detection classes. The user of the system performs the training by placing images of non-compliant products in the database from where the system will use these images as reference images, that is, images with which it will compare new images downloaded from the production machine. After training, the system can be put into operation, training must be performed every time the product is changed. Based on training and neural networks as well as a comparison algorithm, the system recognizes non-compliance, prints the result of non-compliance in percentages and stores the data on the cloud. Within the aforementioned system, the SSIM (Structural Similarity Index) algorithm was used, which compares pixel by pixel the reference image and the image currently collected by this system, calculates the squared error that is created and caused by different pixels. On the very result of algorithm and the accuracy of the system can be affected more factor, the position of the camera must always be in the same location in relation to the product, lighting can affect the quality itself photos and thus the result algorithm, if it is necessary to add the source of illumination must be addressed attention to the product itself, must not come to glare or shadows, vibration is essential prevent them from affecting the movement cameras. In Figure 2, you can see an example of an image of a compliant product that was used to test the operation of the algorithm, all tests of the algorithm were performed within the premises university, laboratory center for quality.

**Figure 2.** Example of a compliant product
Source: Author

It can be seen in Figure 2 example of a compliant product that does not have a non-conformity. After placing one or more reference images, the user of the system, as well as placing the hardware at the physical location where the acquisition will be performed, can start the system. The system can also be used to check products for non-compliance or if already collected images are used. In Figure 3, you can see the non-conforming semi-product that was used in the comparison process.

As can be seen in Figure 3. the product has damage caused during the production process. When comparing picture 3 with picture 2, the result of the algorithm is 0.9258, i.e 92.5% similarity. Figure 4 shows the result of the algorithm.

**Figure 3.** Non-compliant product
Source: Author

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SSIM compare 1 image A new and image B: 0.9258742417832705
SSIM for compare 2 image A new and image A: 1.0
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**Figure 4**. Comparison result
Source: Author

As can be seen from the results of the algorithm, the similarity of image 2 and image 3 is 92.5%, i.e. 7.5% are non-compliant pixels in the specific case of non-compliance. After the collected and processed data is stored on the cloud system in thingspeak cloud was used within this system, an example of stored data collected by this system can be seen in Figure 5.

We can additionally process and display data stored in the cloud in several ways, the advantage of cloud data is its availability.

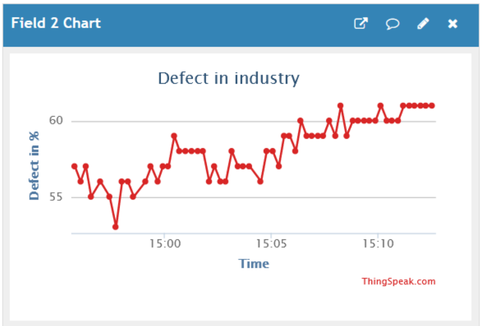


**Figure 5.** Data stored in the cloud
Source: Author

## 4. Discussion

After analyzing the work of the sector for quality in small and medium-sized companies in Serbia, it was concluded that the quality control process is still carried out manually today mainly due to the amount of funds needed to implement modern solutions. When it comes to the funds that will be invested in the system, it is necessary to reduce the error of the system by reducing the price, to adjust system performance available hardware, enable simple user interaction. An advantage this system can be viewed from the aspect of adaptability in terms of changing the image acquisition location itself, even though it is embedded-implemented in an already existing system or machine, it can be moved to another location. On the other hand, the disadvantages of the system are its sensitivity to external factors that directly affect the quality system operation. The implemented system is implemented on one production machine, which means that it is necessary on every machine implement the same system where they would get a wide network of data and control over the entire production of a company, which is actually another goal. By reducing the occurrence of non-compliant products or even their complete elimination, the company's profit is directly affected, as well as the efficiency and speed of production response to market demand, quality increases production.

## 5. Conclusion

The initial goal of this study which refers to the development of the control system product quality within production industry was successfully implemented, the results of the system are presented. The presented system is a universal solution that can be applied both on the production machines themselves and can be set up within the quality center for quality control of several different products. Depending on the location of the system application, it is necessary to pay attention to the external factors that may affect accuracy the result of the system. Collected and presented data is stored on cloud system in real time, as far as possible allows viewing of data in each moment. If viewed from the aspect networking of the entire production of one companies where on every production if one such system were implemented in each machine, they would have an overview of the current state of production, where they would have a defined number of non-compliant products, good products and products that are going to be finished. Also, by networking the machines, we can obtain data on the total efficiency for each of the machines in production. Quality control represents one of the most important processes in every production company which is from of essential importance for the development of the company as well as the ultimate profit of the company, hence the goal for the development of the quality control system, the secondary goal starts from the fact that there are currently not enough experts in the field of quality control, also the application of such systems reduces the need for experts and increases the availability data. The limitations of this study are related to external factors that can affect the accuracy of the system, one of the main factors is related to the position of the product that the camera will photograph, the product must always be photographed in the same position so that the data is as accurate as possible. Given that the system is based on the application of the ssim algorithm, which is in conjunction with CNN, and functions in the manner presented in this study, it represents a unique solution based on the goals of this study. Future directions of research will be based on the implementation of several different algorithms in the process of detecting non-compliant products, which will further reduce the possibility of system errors, as well as reducing the influence of external factors on the operation of the system.

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