SMART Identification by Vision System

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Abstract. The paper describes a machine vision system for SMART identification of objects. In the introduction, this system is analyzed from a theoretical point of view. Advantages and possibilities of its use are emphasized. The following section presents our research workplace, where the machine vision is located. It involves two identification stations, one of them with 3D measurement and the second is a 2D multi-spectrum with several types of lighting. One part of this section describes the workplace in 2D view and equipment of vision system situated in this laboratory. The third part examines the possibilities of character identification by this system. The novelty of the paper is presented experiment with different wavelengths of light (RGB, UV, AM, W, infrared, far-red). The result of experiment is the most suitable light for characters identification by vision system.

Keywords. Machine vision, SMART identification, measurement, visual inspection, characters detection.

1. Introduction

In the age of automation, when SMART identification is a necessary part of industrial processes, there are increasing demands for scanning products in terms of the most effective identification of errors in production. One of SMART technologies is industrial camera identification. [1], [2], [5], [6]

Figure 1. Principle of machine vision
The machine vision system based on industrial camera systems is used for visual inspection of the object, which replaces human supervision at the production line. This system aims to digitize identification and at the same time simplify and automate the entire inspection process. The examined object is subjected to analysis using software tools that process the measured data. [3], [4], [8], [9] The system offers various categories of tools, with specific tools for each category. The output of this analysis is information about quality, identification (for example scanning of codes or characters), error detection, determination of the exact position of the object and subsequent gripping by an industrial robot, and so on. It can be used in the following categories: location, identification, measurement, and control with several tools. The system can recognize even the smallest deviations that a human could overlook. [7], [10], [11], [15]

The main advantages of the system are speed, accuracy, robustness, and repeatability. The identification can be performed in milliseconds, without a break and the error rate is several times lower in comparison to a human. Ultimately, this means acceleration and improvement of identification quality, which has a positive impact on the speed of the production process and the quality of manufactured products. [12], [14], [21], [24]

**Figure 2.** Software tool catalog by KEYENCE

### 2. SMART workplace and machine vision

In the photo (see Figure. 3) the assembly SMART workplace can be seen. It is located at our department laboratory, which is intended for research and university courses. A more detailed scheme of this workplace can be seen in the picture (see Figure. 4), where the individual parts of the whole system are described in detail in 2D view. The workplace is designed regarding automatization and digitalization processes and is up to the standard of Industry 4.0. Individual systems work together, which makes the processes more effective.

**Figure 3.** A photo of SMART workplace
Figure 4. Workplace scheme in 2D indicating the position of the cameras in the black area.
Various systems and technologies are researched and tested in this laboratory. One of them is machine vision. There are two measuring stations (see Figure 5), each designed for a different type of measurement. There are two cameras used, located at our laboratory. The first camera (see Figure 5, left) enables white structured light with pattern projection for 3D image processing. The second camera (see Figure 5, right) enables multi-spectral light using LEDs in several colors (see Figure 7), which can identify defects using different wavelengths of illumination. [18], [19], [22], [23]

![Figure 5. SMART identification cameras by a vision system](image)

2.1. Equipment of vision system

![Figure 6. Controller of machine vision](image)
**Table 1. Controller - explanations**

| Number | Specification                        |
|--------|--------------------------------------|
| 1      | Power supply LED                     |
| 2      | Error LED                            |
| 3      | USB connector                        |
| 4      | RS-232C port                         |
| 5      | Monitor (RGB output) terminal        |
| 6      | Light 2 connector                    |
| 7      | Light 1 connector                    |
| 8      | Camera 2 connector                   |
| 9      | Camera 1 connector                   |
| 10     | Ethernet connector                   |
| 11     | Power and ground terminals           |
| 12     | USB HDD connector                    |
| 13     | OUT/IN connector (Terminal block)    |
| 14     | USB connector for the dedicated mouse|
| 15     | I/O (Parallel I/O) connector         |

**Table 2. Types of equipment used**

| Equipment | Indication             |
|-----------|------------------------|
| Camera 1  | KEYENCE CA-H048CX      |
| Light 1   | KEYENCE CA-DQP12X      |
| Camera 2  | KEYENCE CA-H048MX      |
| Light 2   | KEYENCE CA-DRM10X      |
| Controller| KEYENCE CV-X400A       |

Examples of lighting types for multi-spectral identification can be seen in the picture (see Figure. 7). There are eight types of light:

- UV – Ultraviolet
- B - Blue
- G - Green
- AM - Orange
- R - Red
- FR - Far-red
- IR - Infrared
- W – White
3. Identification of characters

This chapter describes character detection using a machine vision system. This object below (see Figure 8) was used for the experiment.

A multi-spectrum camera is used for this type of identification because character identification is only possible in 2D view. The 3D station is used for height and profile measurement.
The picture below (see Figure 9) shows the result of the identification. First, a character identification tool must be added (see Figure 9, number 1). Second, the identification area is marked (see Figure 9, number 2). The third step is to register the characters that should be recognized (see Figure 9, number 3). After that, the ‘Run’ button is pressed and the system performs the identification (see Figure 9, number 4). When the registered characters are in sync with detected characters, the identification is marked green, which signalizes the ‘OK’ total status (see Figure 9, number 5). Every other object that passes under the camera is automatically compared with the already registered string in the marked zone. The system has no problem recognizing even merged characters, as demonstrated in our case with ‘DC’ characters (see Figure 10).

![Figure 9. Demonstration of identification in software](image_url)

![Figure 10. Character identification area](image_url)

In case of an inaccurate object, on which the searched characters are missing, the identification will be marked red, which signalizes the ‘NG – No Good’ total status (see Figure 11). [17]
Figure 11. Example of an inaccurate object

Now the identification area alters and new characters, that should be identified, are specified. (see Figure. 12). The system has no issues identifying a combination of numbers and letters. For successful identification is necessary, that only one line from the identification area is marked. When the system tries to recognize the whole area (see Figure. 10) at once, the results are inaccurate. To identify the same line, the objects must be positioned correctly under the camera [20].

Figure 12. Identification of numbers and letters

The camera can detect the object using various types of light (see Figure. 13). To select the appropriate lighting, the type of material [25], the lighting conditions in the room, and the focus of the camera must be considered. [13], [16]

To see which light is the most suitable, the shutter speed and the volume of light are set accordingly to the conditions at the workplace. In our case, the differences between various lights were minimal, but the best results were obtained with blue and green light.
3.1. Experiment of multi-spectral identification

The goal of the experiment was to find which type of lighting has a higher success rate in the identification of the characters. The table (see Table 3.) describes every type of multi-spectral lighting and shows how many times from 100 the camera managed to identify successfully first the ‘DC’ character and then numbers. The results show us that the highest success rate have blue and green light with 97.5%. These results are valid only in the identification of characters and were influenced by external and internal factors such as the type of material of the examined object, lighting conditions and camera adjustments.

| Light type | Correct identification | Percentage success | Average |
|------------|------------------------|--------------------|---------|
|            | DC / numbers           | DC / numbers       | DC / numbers |
| UV         | 100 / 90               | 100% / 90%         | 95%     |
| B          | 100 / 95               | 100% / 95%         | 97.5%   |
| G          | 100 / 95               | 100% / 95%         | 97.5%   |
| AM         | 100 / 90               | 100% / 90%         | 95%     |
| R          | 98 / 87                | 98% / 87%          | 92.5%   |
| FR         | 100 / 93               | 100% / 93%         | 96.5%   |
| IR         | 99 / 89                | 99% / 89%          | 94%     |
| W          | 99 / 92                | 99% / 92%          | 95.5%   |
4. Conclusion

The paper describes the possibilities of SMART identification using a machine vision system implemented at the research institute of the Department of Industrial Engineering and Informatics of the Faculty of Manufacturing Technologies TUKE with a seat in Prešov. The hardware and software components of the industrial camera system presented in the paper enable automatic control in production processes. Using this system, it is possible to speed up, improve and automate the product inspection process, which fully corresponds to current trends in production automation.

The presented measuring stations are integrated into a modular multifunctional assembly-identification workplace in the SMART Laboratory and intelligent technologies for Industry 4.0 at our department. These stations use different scanning of the examined objects to provide various outputs necessary for identification and control activity, while the software tools allow controlling the examined object from several points of view.

The experiment showed the possibility of character identification on the examined object, as well as the selection of suitable lighting by the multi-spectrum system. Results were that the highest success rate had blue and green light with 97.5%.

The future direction of our research is focused on the implementation of data from SMART identification machine vision system into the digital twin of the research workplace.

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