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USING IMAGE PROCESSING TECHNIQUES FOR PART CLASSIFICATION

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Abstract

In industrial automation, it is used with various sensors for detection. Digital sensors are widely used because they are economical and easy to process. There are digital sensors that detect various materials for part detection. There is a FESTO part sorting station at Trakya University İpsala Vocational School. At the end of the production line, the color and structure of the part is detected and classified by industrial sensors. The part is detected by two optical sensors and the color of the part is determined according to the light reflected from the part. After color detection, it is checked whether the piece is metal or not by means of an inductive sensor. According to the information coming from these three sensors, the parts are classified as black, red and metallic. Instead of this sensor combination, a camera was used in this study. The color of the part is detected by image processing. In addition, thanks to the camera, part thickness and diameter were also detected. Classification and quality control of the parts were provided with the camera. In the study, the camera works connected to the computer. The classification station is controlled by PLC. Image processing data was transferred to the PLC with a microcontroller card.

Keywords: Part Classification, Image Processing, Industrial Automation, Festo MPS

INTRODUCTION

Control in industrial automation is provided by programmable controllers (PLC)[1, 2]. PLCs have a programming structure like industrial control circuits. Control is carried out with PLCs, which provide ready-made equipment such as relays, time relays and counters used in control circuits. A software should be developed to control the machines according to the desired scenario. The software controls the outputs by working according to the input information[3]. Various sensors are used for input. Digital sensors are more economical than analog sensors. At the same time, analog modules of PLCs are expensive. Besides the price parameter, it is difficult to develop software for analog processes. Calibration introduces additional conditions such as connectivity[4, 5]. For such reasons, digital sensors are primarily preferred. Non-contact sensors; They appear as capacitive, magnetic, inductive and optical. The appropriate part of these sensors to be detected should be selected. Selection is important depending on where it is used, the part it will detect, and the type of output. Analog sensors convert the desired data in real life into electrical signals and transmit them to the controller. Analog digital converters (ADC) on the controllers digitize analog signals according to resolution[6]. Analog signals are used in the desired functions with the appropriate code in the program. In mass or flexible production, parts may need to be separated and directed to different locations because of production. For classification, the part must be detected. Detection can be done mechanically or electrically depending on the type of the incoming part. Developments in recent years bring image processing techniques to the fore. The data received through the camera is processed and provides output with the desired features. A camera can be used for classification in an industrial production facility. However, the camera works connected to a computer. The connection to the controller must be made either through the computer or a card such as Raspberry pi [7].

Dimensional analysis can be done as well as location analysis [8]. According to the location information, the parts can be arranged with the robotic arm. Lengths and diameters of parts can be measured with appropriate calibration methods[9, 10]. Quickly measuring on the image provides advantages for quality control and classification in mass production. Color is also one of the important features for classification and separation in part production. Detecting the color of the part is used for classification control. Optical sensors can be used to detect color. However, digital optical sensors provide one bit of information depending on whether they reflect light or not. With image processing, color can be detected for many situations[11-14].

The FESTO modular production system located in the mechatronics laboratory of Trakya University İpsala Vocational School consists of six stations. After the round parts go through various processes, they are finally classified according to color control. In this study, it was aimed to use a camera instead of the two optical and one inductive sensor used in the current classification system. In this way, it is aimed to do the work done with three sensors with the camera. In addition, thickness measurement will be made with a camera and a traceable control will be made with statistical data storage. In the next section, the classification station and then the image processing techniques will be discussed. Finally, the results will be given.

EXPOSITION

Parts produced in mass or flexible production are expected to be separated properly. Afterwards, stacking and packaging is done. Detection of parts is important for part classification. Mechanical separation is one of the most economical and practical methods for part detection. However, in order to separate parts with the same physical properties according to color and material structure, the parts must be detected with sensors. The use of image processing techniques as an alternative to this process, which is detected with a digital sensor in the current system, will be presented in this study. The part color will be detected by image processing and the controller will be informed.

In addition, in the image processing method, the thickness and diameter information of the part will be measured and controlled. The classification station will be mentioned in the next section. Afterwards, the image processing method will be explained. Finally, the results will be mentioned.

Part Sorting Station

The part sorting station directs the incoming parts to three separate chambers after detecting them. The locations numbered in the image in Figure 1 are stated below.

1- Part detection sensors located at the part entrance

2- Carrier conveyor belt

3- Direction coils (separator arms)

4- Classification areas

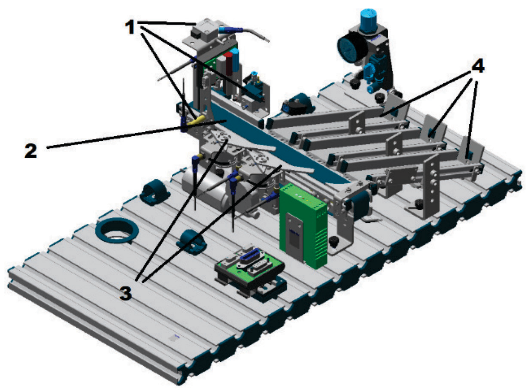


Fig. 1. *Part Sorting Station*

The part is left in the number one area, where the sensors are located, where the conveyor rotates constantly. However, the piece is held by a holder in this area for detection. There are two optical sensors at different angles. These sensors detect the color of the part. In this study, there are three different colored round pieces produced. These pieces are black, red and metallic. The first of the optical sensors detects all parts. The second detects the red and metallic part. Finally, the inductive sensor detects the metal part and in this combination the parts are classified.

When the part holder releases the part, metallic parts are classified in the first chamber, red parts are classified in the second chamber and black parts are classified in the last chamber.

Control is provided by Siemens S7-1214 PLC. In this study, a camera was used instead of this sensor combination. The camera placed at the part entrance will detect the color of the parts from the side. It will provide information to the PLC with an electronic circuit via the serial port. Part classification will be done by PLC energizing the appropriate coils. The camera will replace the three sensors and additionally perform thickness and diameter control. Quality control will be performed both while providing data for classification. Figure 2 shows the visual of the classification station.

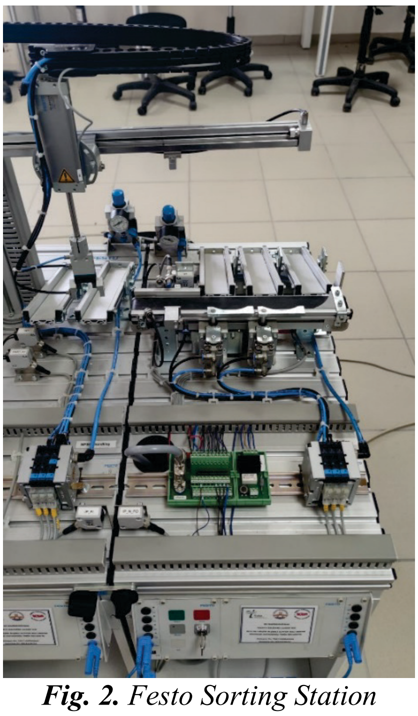


Fig. 2. *Festo Sorting Station*

Visual Classification System

In this study, a visual inspection system has been designed for classifying parts by processing images of parts captured by the video camera. For integrating the vision system into the MPS, the conveyor belt environment has been modified to improve captured part images. A lighting system has been designed to obtain part images in improved contrast. A plain white semi-transparent sheet has been used for diffusing the backlight lighting and hiding the complexity of the background. A concept drawing of the lighting system is shown in figure 3.

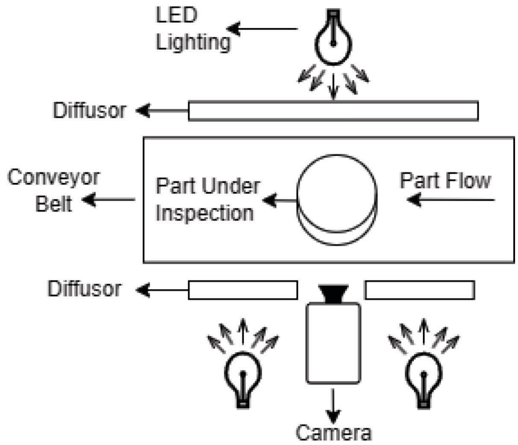


Fig. 3. *The lighting and camera arrangement of the vision system.*

The background lighting is used to expose the metallic finish parts. The weak foreground lighting has been used to expose the colors of parts without reflecting the shiny surfaces. The color, diameter, and width of parts are determined and measured by using image processing methods. After deciding that the part meets all specifications, signals are sent to the Arduino (microcontroller) board over the serial connection for sorting the parts by colors. The Arduino sends a signal to PLC via relay card. The signal includes the type and faultiness of the parts. PLC triggers the relevant coil according to the incoming signal and performs arm separation. The overall visual inspection system process flow diagram is shown in figure4.

The process starts by configuring the camera and starting the capturing. Each captured frame is processed in several stages. The preprocessing stage consists of undistorting, filtering, color space conversion, and thresholding processes. For measuring the dimensions properly, captured images are corrected by calibration coefficients saved before. Lens correction is undistorting the images deformed by radial and tangential distortions. Correction coefficients are obtained from the calibration process which is done before the inspection process. In addition, a pixel scaling factor is determined by the calibration process for measuring part dimensions in millimeters instead of the number of pixels[15].

All captured images have some noises caused by illumination variations or electrical noises.

These noises appear as inconsistent brighter or darker pixels on the image. These noises are suppressed by using the Gaussian blurring algorithm.

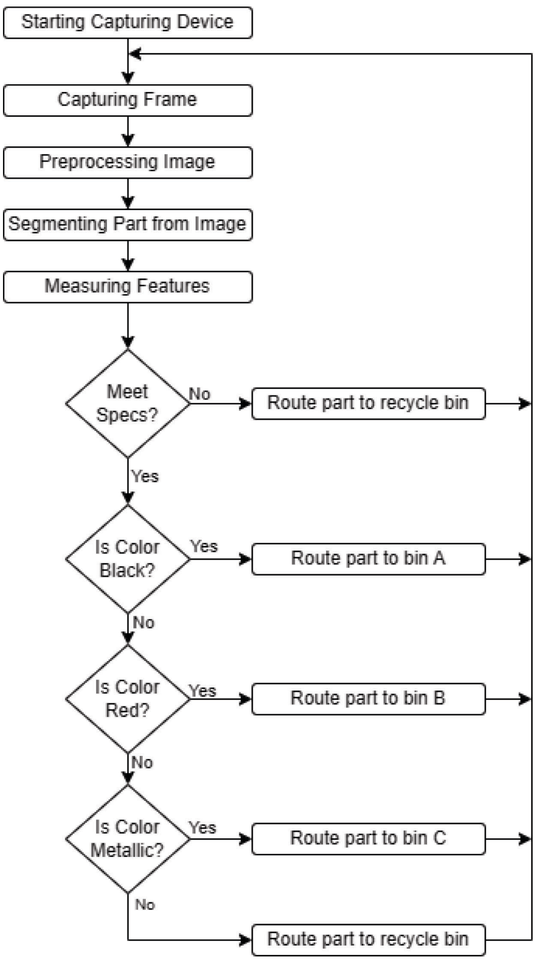
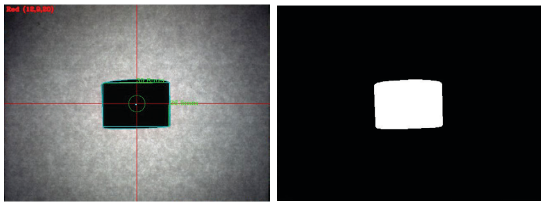


Fig. 4. *Image processing system flow diagram*

The filtered image has been converted to a grayscale image for thresholding independent of the color of the parts. The OTSU thresholding algorithm has been used for thresholding the image automatically without using a fixed value. The OTSU thresholding algorithm uses a histogram of intensities to determine the threshold value that is suitable for this application. A captured and thresholded binary image is shown in figure 5.



(a) (b)

Fig. 5. *a)Captured image b) thresholded binary image*

Contours of objects are extracted from binary images. Contours are linked points surrounding each shape in the binary image.

The inspected parts are recognized as rectangular silhouetted shapes in front of background lighting. A bounded rectangular is used to determine part dimensions. The diameter and the height of the object are measured from this bounded rectangular's dimensions. Example photos of inspected parts are shown in figure 6.

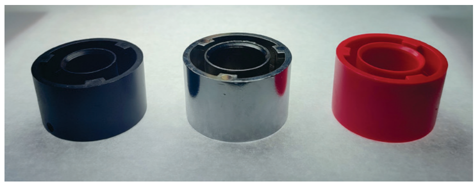
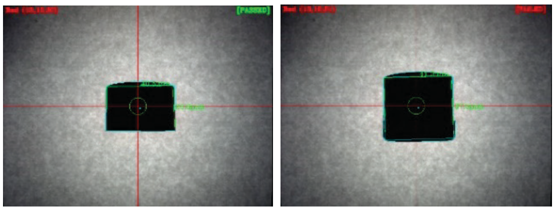


Fig. 6. *Inspected sample parts in different colors*

After dimensions are determined, the color of the part is obtained by calculating the averages of each channel in the bounded rectangular.

The measured diameter and height of the object are compared with its specification limits and decided for acceptance or rejection. Two inspected parts both passed (accepted) and failed (rejected) inspection screen capture images are shown in figure 7.



(a) (b)

Fig. 7. a) Accepted b) rejected part images

If the part is accepted then it is classified by detemined color. Parts are separated by three arms on the conveyor belt. Each arm forces parts to push into its bin. There are three bins for each color. If no arm is actuated, the parts are going to the recycle bin directly. Arms are controlled by Arduino and a relay board. The separation system schema is shown in figure 8.

After completing the inspection process, the part that was decided to be accepted has been in a proper bin of color. Failed parts that were decided to be rejected have been in the recycle bin for re-processing or recycling.

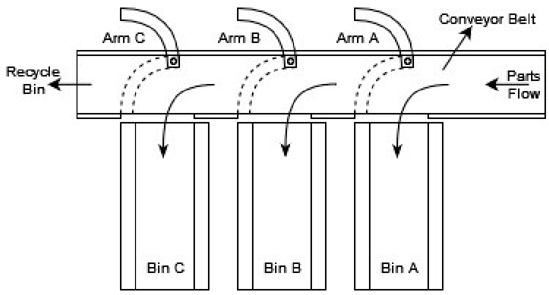


Fig. 8. *Separation system on conveyor belt*

There is no arm c in the current system. With three sensors, black, metallic and red parts will be separated. Arm c will be added as the thickness and diameter control will also be made with the addition of the camera. In this way, both classification and faulty parts can be separated.

CONCLUSION

In flexible production, different parts are produced. The last stage of production is classification. In this study, an image processing technique was used instead of three digital sensors used for industrial automation classification. The image taken with the camera was processed on the computer and part information was given to the PLC via a microcontroller. Thus, the information of the parts was taken for classification. In addition to image processing, it also allows quality control of the parts. The thickness and diameter information of the passing parts are also taken and checked to see if there are any errors. Images will be taken with the camera to be positioned instead of the three sensors located in the entrance section. Tests showed that the parts were detected successfully.

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