Machine Vision Algorithm Design for Remote Control External Defect Inspection

[1]Jin-Su Kang, [2]Young-Hyung Kim, [3]Sang-Goo Yoon and [4]*Yong-Hwan Lee

Abstract

Recently, the scope of the smart factory has been expanded, and process research to minimize the part that requires manpower in many processes is increasing. In the case of detecting defects in the appearance of small products, precise verification using a vision system is required. Reliability and speed of inspection are inefficient for human inspection. In this paper, we propose an algorithm for inspecting product appearance defects using a machine vision system. In the case of the remote control targeted in this paper, the appearance is different for each product. Due to the characteristics of the remote control product, the data obtained using two cameras is compared with the master data after denoising and stitching steps are completed. When the algorithm presented in this paper is used, it is possible to detect defects in a shorter time and more accurately compared to the existing human inspection.

Keywords: *Remote control, Machine vision, Defect inspection, Image processing, hardware*

[1] *Kumoh National Institute of Technology, Dept. of Electronic Engineering, Ph.d Candidate, flzkahsl@kumoh.ac.kr*
[2] *Kumoh National Institute of Technology, Dept. of IT Convergence Engineering, Professor, kic126@kumoh.ac.kr*
[3] *Will-B, representative, sgyoon@will-b.co.kr*
[4* Corresponding Author] *Kumoh National Institute of Technology, Dept. of Electronic Engineering, Professor, yhlee@kumoh.ac.kr*

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I. Introduction

Recently, machine vision technology is attracting a lot of attention due to the development of smart factories for autonomous driving of automobiles, deep learning for analysis, and automatic processes. In particular, a lot of research is being actively conducted for process automation to prevent efficient product production and manpower consumption. In the smart factory, machine vision technology detects various defects, defects, and damaged parts of products and performs correction and defect detection [1] based on them, or supports programs such as robot welding, conveyor, and aligner to analyze vision data and operate by itself It is widely used in the field of In this paper, we target remote control type products. In the case of a remote control, it generally has a longer type than horizontally and has several buttons as many as the number of features of the connected product. In addition, since there are as many types of remote controls as there are connected products, it requires a lot of skill to inspect a remote control type product using a machine vision system. Since most of the machine vision technologies currently in use depend on foreign technology, they can have many advantages in terms of competitiveness and cost-consuming aspects in the field of self-developing machine vision [2] in Korea.

In the previous remote control type product appearance defect inspection, a person directly inspects the appearance after completing previous processes. This process step is an inefficient process process in terms of manpower consumption, cost, and time, and the standard for determining defects is ambiguous because a person directly inspects it, and low reliability due to human error is a problem. In the process presented in this paper, image data of a product is obtained using a camera, and then, whether or not there is a defect is determined using the result obtained by comparing it with the master data prepared in advance. In the case of using such a process, compared to the previous method of human inspection, manpower consumption is minimized, and cost reduction and time savings can be expected. In order to obtain these advantages, image data acquisition and image processing, comparison with master data, and defect determination must be performed quickly in one process. In particular, due to the characteristics of the remote control product, when using one camera to obtain image data, the Y-axis has a relatively long shape, so it is difficult to accurately analyze the product.

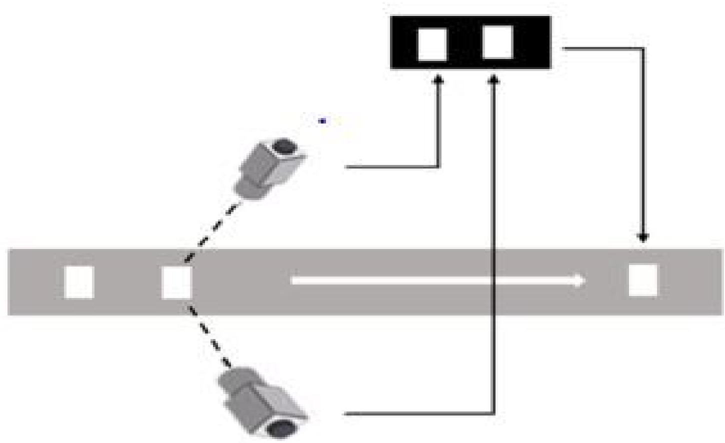

Figure 1. Schematic diagram for defect inspection

Figure 1 is a schematic diagram of the external defect inspection of the remote control product proposed in this paper. After image processing is completed by acquiring image data of the remote control product on the conveyor belt using two cameras[3], it is compared with the master data to determine whether there is a defect. In order to compare images after high-speed image processing[4], the method presented in this paper uses hardware to replace a part of image pre-processing. If Verilog, a hardware language, is used, faster processing becomes possible because it consumes less time than the previous image processing using parallel operations and line buffers. When the process is processed in this way, compared to the previous method, not only gains advantages in terms of manpower consumption, time consumption, and reliability, but also makes it possible to inspect the appearance of several product groups by modifying only the master data, and the competitiveness of machine vision technology can benefit from

II. Pre-processing algorithm

In the case of the remote control that we often encounter in our daily life, defects often occur in relation to the buttons inside rather than the exterior. In particular, the buttons on the remote control have their own special shape to indicate the role of the corresponding button. In the case of a button that adjusts the channel or volume size, it indicates the direction in which the current value changes, and the button with a special function is different from other buttons. A button that plays an important role like the power button has a different size compared to the surrounding buttons. Because the buttons are all different, it is difficult to apply the algorithm according to the buttons when the remote control product is different, so the algorithm presented in this paper [5] is a pre-processing algorithm for stitching images obtained using two cameras and labeling each button. use only The algorithm presented in this paper implements this pre-processing algorithm in Verilog, a hardware language, and uses the parallel operation, which is a feature when using hardware, to advance the pre-processing algorithm faster than the previous image processing, which is necessary for the entire defect detection process. Reduces time consumption.

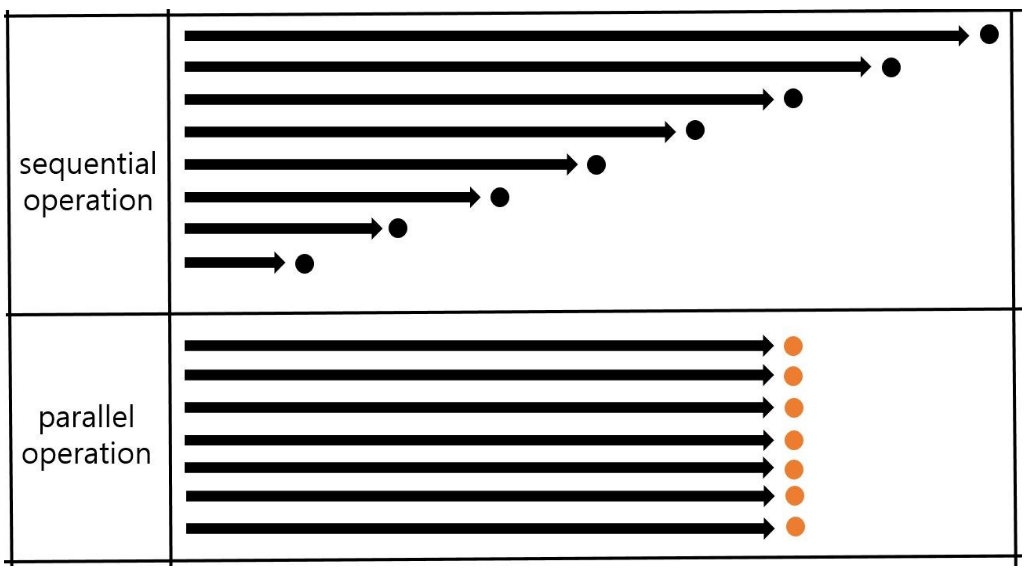

Figure 2. Difference between parallel operation and sequential operation

Figure 2 shows the difference between parallel operation and sequential operation. As shown in the figure, if the operation is processed by parallel operation, it is possible to operate a lot of data in a short time compared to the sequential operation. In the case of parallel operation, since several operations are processed at once, the advantage is insufficient in the processing of complex operations when the same time is compared with sequential operations, but in image preprocessing algorithms, parallel operation [6] is sufficient to bring an advantage. Therefore, in this paper, we propose a parallel operation in the image preprocessing process. In addition, when the line buffer is operated using the parallel operation characteristics, it is possible to further minimize clock consumption.

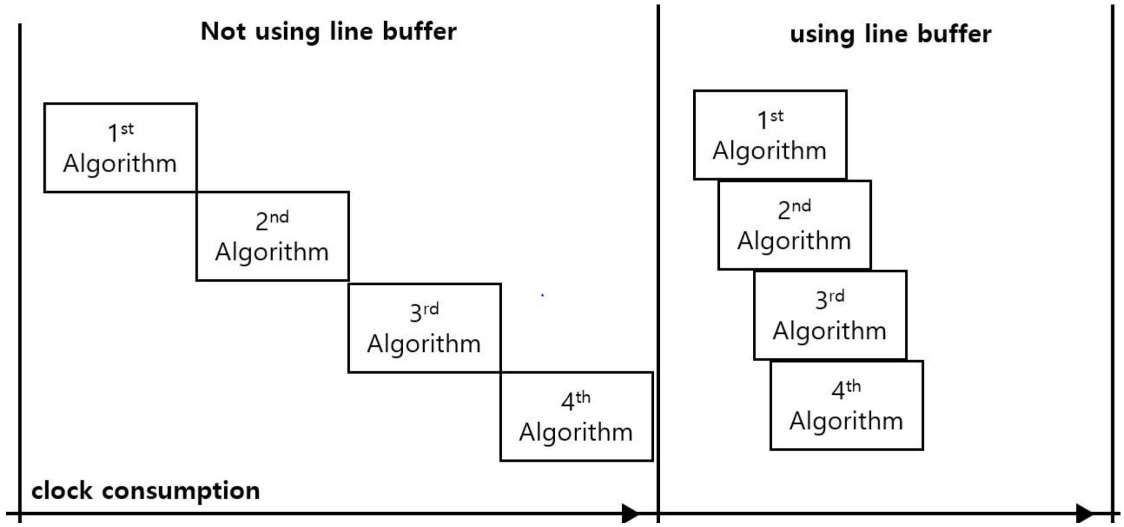

Figure 3. Comparison of clock consumption with and without line buffers

Figure 3 shows the comparison of clock consumption depending on whether or not the line buffer is used. As shown in the figure, when a line buffer using parallel operation is used, clock consumption can be greatly minimized. When using a 3x3 filter, which is the size of the most basic filter mask, a total of 7 line buffers are required, one line for the color space conversion algorithm, and 3 lines for each of the noise removal algorithm and feature point detection algorithm. , the number of required line buffers increases as the size of the mask increases. Also, as shown in Figure 3, the image pre-processing algorithm presented in this paper uses only three-step algorithms: color space conversion algorithm, noise removal algorithm, and feature point detection algorithm.

III. Color space conversion algorithm

The color space conversion algorithm refers to the conversion of the representation method representing the current image data. In this case, the color space is a spatial coordinate representing the three elements representing color: hue, brightness, and saturation. When image data is acquired using a camera, the acquired image data has an RGB (Red, Green, Blue) color space, and in the case of RGB color space, each element has a data size of 8 bits and a total data size of 24 bits. or a color space with a data size of at least 16 bits. However, in the case of remote control external inspection, spatial coordinates representing only brightness are used because there is no need to distinguish colors. In this paper, Gray Scale is used as spatial coordinates representing only brightness.

In the case of gray scale, as spatial coordinates representing only the brightness of each pixel representing image data, each pixel has a data value of 8 bits. By minimizing the data value required for each pixel, the total amount of data to be processed can be minimized. There are several formulas for converting from RGB color space to gray scale color space depending on the size of the resolution, but for quick operation, the conversion formula to gray scale color space is used using shift operation. In case of using shift operation, compared to other operations, since it is a method that does not use a multiplier, it can bring an advantage in terms of clock consumption. The next algorithm proceeds using the line buffer from the pixel that has completed the color space algorithm as this gray scale.

IV. Noise removal algorithm

The noise removal algorithm is a step for removing noise generated in the process of acquiring and transmitting image data. In most cases, noise generated from image data has a value that is significantly different from the surrounding value. These values can be easily removed by using a filter with a smoothing effect. The smoothing effect is a method mainly used for blurring and noise removal. It is an algorithm that compares surrounding values based on one pixel and changes the value of the corresponding pixel to harmonize with the surrounding values. The noise removal algorithm presented in this paper is an algorithm using a median filter. When a filter having a size of 3x3 is used in the median filter, it is an algorithm that compares the size of 9 pixel data belonging to the 3x3 mask with respect to the pixel and replaces the value corresponding to the median value with the value of the corresponding pixel. The algorithm using the median filter is a very effective algorithm for removing salt and pepper noise.

17	23	16
15	66	20
16	14	22

17	23	16
15	17	20
16	14	22

1st	66
2nd	23
3rd	22
4th	20
5th	17
6th	16
7th	16
8th	15
9th	14

Figure 4. Noise removal algorithm using 3x3 median filter

Figure 4 shows the algorithm for removing noise using a 3x3 median filter. As shown in the figure, since the value of the pixel has a large difference compared to the surrounding values, it is an algorithm that recognizes the pixel as noise, compares the surrounding values, and uses the median value as a substitute. Using this denoising algorithm, the two images for which denoising has been completed are transferred to the stitching algorithm.

V. Feature point detection algorithm

The feature point detection algorithm is an algorithm for finding a feature point in a corresponding image. The feature point refers to a point that makes it possible to easily identify an object even if the shape, size, and position of the object in the image changes, and refers to a point that can be detected even when the position of the camera point of view or lighting changes. It is difficult to find such a feature point in a flat area, and a part with a large change amount compared to the surrounding values is detected as the feature point. The feature point is an algorithm for a subsequent stitching algorithm to find a common feature point for merging two images.

The feature point detection algorithm presented in this paper uses the FAST (Feature from Accelerated Segment Test) algorithm [7] based on the Harris Corner detection algorithm. The Harris corner detection algorithm is the most representative method for finding corner points or feature points in image data, and uses a mask of a specific size like the previous median filter. The Harris Corner Detection Algorithm detects a corner point by using the amount of change in the data value based on four directions such as vertical, horizontal, left and right diagonal lines based on the pixel. However, since pixel data has only brightness values using the previous gray scale, the algorithm proceeds based on the amount of change in brightness. FAST determines the edge point by checking the values of 16 pixels based on the data of the corresponding pixel. If more than a certain number of pixels whose brightness changes around the corresponding pixel value appear continuously, the corresponding pixel is determined as a corner point. In addition, the Harris Corner Detection Algorithm requires differential operation, but the FAST algorithm detects feature points based on the amount of change based on the pixel rather than the differential operation. It is an algorithm suitable for Since it is possible to quickly determine the corner points in this way, the feature points are quickly detected using the corresponding algorithm. After the feature point detection is completed using such a feature point detection algorithm, a stitching algorithm for merging the two images into one image is performed based on a common feature point.

VI. Stitching algorithm,

The stitching algorithm[8] is an algorithm that merges two images into one image based on common feature points. In this paper, two images are stitched into one image to compare two image data obtained using two cameras with one master image data. Remote control type products have several angled buttons, and many feature points can be extracted from these buttons. A stitching algorithm is applied to two image data based on the feature points of these buttons.

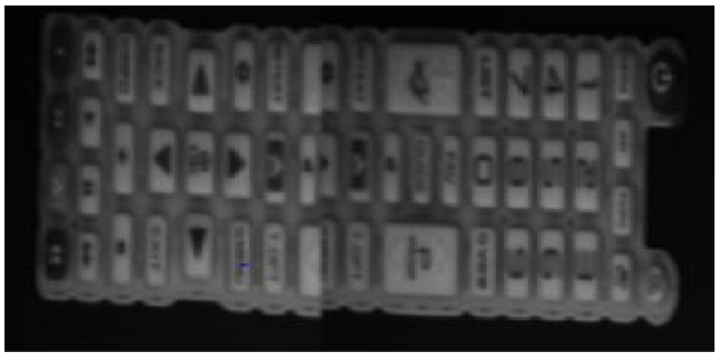

Figure 5. Stitching Algorithm Results

Figure 5 shows image data obtained by combining two images into one image using a stitching algorithm. As shown in the figure, one image data containing all of the remote control products can be obtained by using the two image data above and below obtained using two cameras based on the remote control. Based on the remote control data combined into one image in this way, it is compared with the master data stored in advance to determine whether there is a defect.

VII. Position correction algorithm

The position correction algorithm corrects the position based on the overall appearance in order to compare the master image data and the combined data. Since defects are determined based on the differences that occur in the simple comparison of master data and image data, if the center point is different, even if it is not defective, the location is different, so an error of determining that the product is defective occurs. In this paper, the central point is derived based on the 4 vertices and 4 vertices of the remote control product detected by the previous feature point detection algorithm, and the position coordinates are set to be the same as the position coordinates of the preset master image data based on the 5 coordinates. Correct. Using a position correction algorithm, the image data whose coordinates have been corrected and the master data corrected in advance are compared to determine whether there is a defect.

VIII. Determination of defects

Determination of defects suggested in this paper detects a part where the image data differs by more than a set value by simply comparing[9],[10] the previously stored master image data with the image data values that have been combined after the image pre-processing process[11] and correction algorithm have been completed. Thereafter, it is determined whether the appearance of the product is defective according to the number of detected data pixels. In the process of comparison, instead of comparing the entire image, each button goes through a labeling process and then image data is compared for each button. Labeling is a method of classifying regions in image data, and in the case of remote control products, regions are divided for each button, so that image data can be separated for each button. The method presented in this paper determines whether each button of the remote control product is defective or not.

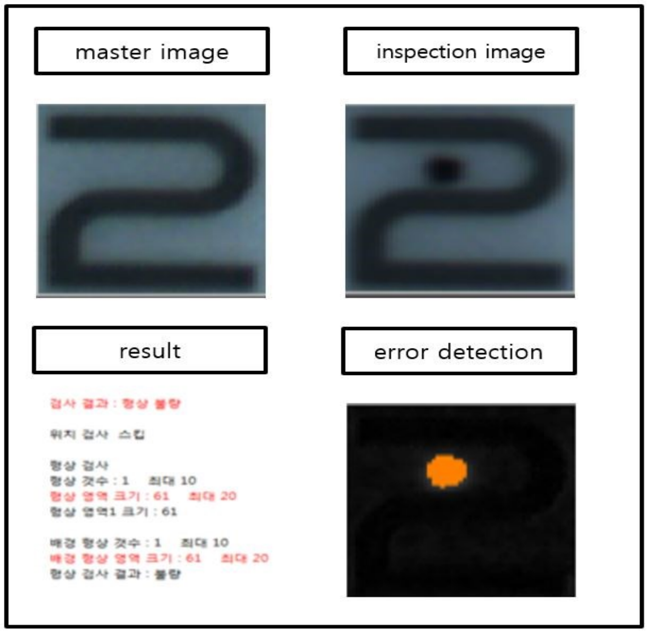

Figure 6. Defect detection result

Figure 6 is a diagram showing the result of detecting a defect in the button of the remote control product. As shown in the figure, the part that appears different from the master data stored in advance and the image data to be inspected is determined and detected as defective. According to the area detected in this way, it is determined whether the product is defective.

IX. Conclusion

Recently, with the increase of smart factories, the field being replaced by the automated process is expanding, and the field using image data occupies a large proportion in the expanding area. Some fields previously checked by human eyes require a lot of time, and as the processes that were very wasteful of manpower are replaced with automated processes using image data, manpower and time consumption required for the process can be minimized.

In this paper, an algorithm using image data was used and replaced with automation in relation to the determination of defects in the process performed by the human eye. As the automation proceeds using image data, it reduces time consumption and minimizes the consumption of manpower compared to the previous human inspection process using the naked eye, and ambiguity of standards and low reliability point of view because it is performed by humans By using the accumulated data algorithm setting values, it is possible to compensate for the shortcomings in the product production process, which has many advantages. In addition, since it is a method that uses a comparison of master data and image data, if only master data is prepared for each product in advance, it can be commonly applied to multiple products, so it can be used in the process of other products later.

Currently, the technology using image data is highly dependent on foreign technology, but it can be a starting point for developing technologies that can be applied in processes other than the inspection process, such as the determination of defects, while bringing competitiveness based on the technology using image data. have.

X. Acknowledgments

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XI. References

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Authors

Jin-Su Kang

2022 : MS degrees in Department of Electronic Engineering, Kumoh National Institute of Technology.

Research Interests : Digital SoC, Verilog HDL

Young-Hyung Kim

2010 : PH.D degrees in Department of Business administration, Kumoh National Institute of Technology.

Research Interests : industrial system, 3D Printer

Sang-Goo Yoon

2014 : MS degrees in Department of Electrical and Electronic Engineering, Kumoh National Institute of Technology.

Research Interests : Machine vision, Smart farm

Yong-Hwan Lee

1993 : B.S. degrees in Department of Electronic Engineering, Yonsei University, Korea.
1999 : Ph.D degrees in Department of Electronic Engineering, Yonsei University, Korea.
2004~ : Professor in School of Electronic Eng., Kumoh National Institute of Tech.

Research interests : Digital SoC, Image, Verilog HDL