

A Study on AI Model Performance Based on Changes in Image Brightness and Camera Focus

Nakun Lim*, Hyunchul Oh*, Binna Oh*
 *Samsung Display Corporation, Asan-si, Korea

Abstract

This paper is to optimize AI (Artificial Intelligence) model detection performance and presents necessary elements for detecting defects in products captured from cameras. This element refers to the brightness and focus of the image of the captured product, thereby changing the image.

Through these changes in the image, it was confirmed that there is a difference in the performance of the model according to the brightness and focus of the image in the same learning model, and the cause of this phenomenon and how to optimize it are presented.

Author Keywords

Image , Brightness , Focus , Model Performance.

1. Introduction

Methods for optimizing AI model detection performance include AI model selection, quantity and quality of learning image data.

Here, this paper proceeded with optimization by improving the quality of learning data.

First, the camera and image data generation process will be described.

When producing a product, imaging is carried out in a line-scanner manner, and the camera is fixed and the stage carrying the product Images are created while moving Refer to the schematic diagram (Fig. 1) and conditions of the camera that captures the product. (Table.1)

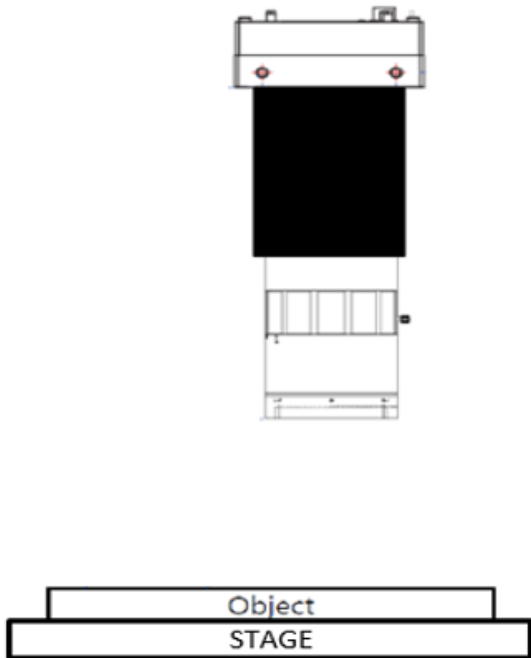


Figure 1. Camera schematic diagram.

Table 1. Camera Condition.

Item	Spec
Line Scan CCD	16K Line
Resolution	10.6 μ m / Pixel
Illumination	White
Depth of Field	171 μ m

2. Image Brightness and Focus

Factors that affect the brightness of Pixel in Image Sensor include lighting intensity, camera exposure time, and sensitivity. Among them, the image brightness is adjusted through the lighting intensity, and a part of the captured image of the actual product is written in Figure 2.

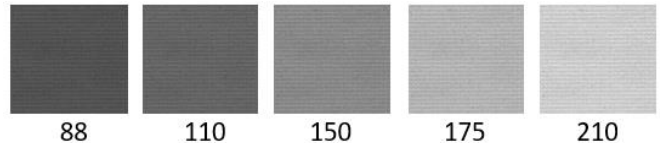


Figure 2. Brightness of product image according to lighting intensity Image brightness is expressed as 0-255 Gray Scale, in this process, the production of the product is carried out with 145 grays.

The point where the lens is accurately focused is 1 point, but even if it deviates slightly from the Focal Point, the image does not blur immediately. [3](Fig.3)

Factors affecting the clarity of the image are the depth of focus and the depth of the subject, and the depth of the subject is explained in Figure 4.

In the case of image focus, imaging setting is performed through camera barrel adjustment, and a part of the captured image of the actual product is written in Figure 5.

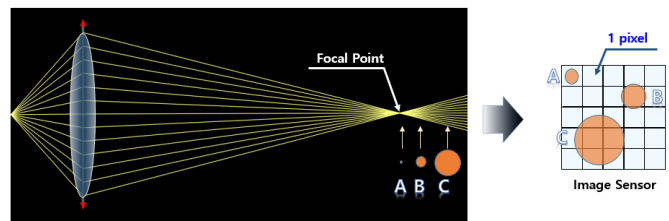


Figure 3. Circle of Confusion (COC) A phenomenon in which the focus is not completely focused on one point but grows into a circle [3]

The image has the same resolution if it can be contained in the 1Pixel of the sensor even if the COC increases.

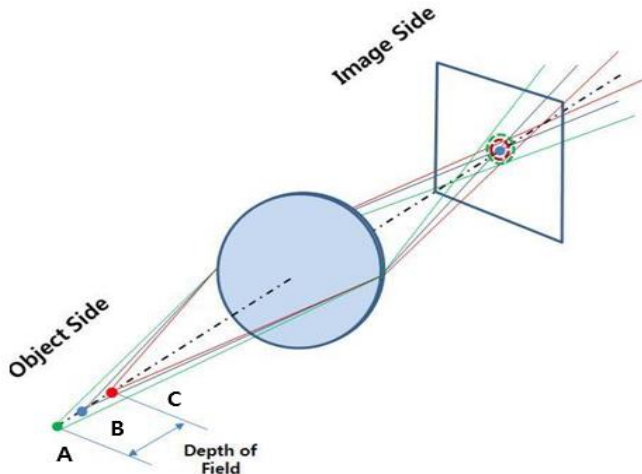


Figure 4. Optical concept of measuring the arrangement tolerance of the depth of field (DOF) image plane: If the image formed in the circle is a limit point that is not blurred, the distance between A and C becomes the depth of the subject. [2][3]



Figure 5. It is an actual product defect image according to the depth of field (DOF), and the blurring phenomenon increases toward the right.

It was confirmed above that it can be set according to brightness and focus.

In this process, the AI model used Yolo5, and the learning image was 135 to 155 gray, and the focus was DOF to DOF+.

3. Model Performance Optimization

In the same facility, there is dispersion according to brightness and focus between products, and a test was conducted on how it affects the performance of the AI test model. For the test image according to the image condition, refer to Figure 6.

BRIGHTNESS	FOCUSING		
	DOF	DOF+	DOF++
145			
180			

Figure 6. Test image according to condition

Introduce an image of one of several Defects. The focus becomes blurred as it goes to the right, and the image becomes brighter as it goes down.

The AI model used Yolo5, and the model performance differed by 9 to 14 percent depending on the brightness of the image, and 15 to 24 percent depending on the focus. Refer to Figure 7 for the analysis result graph.

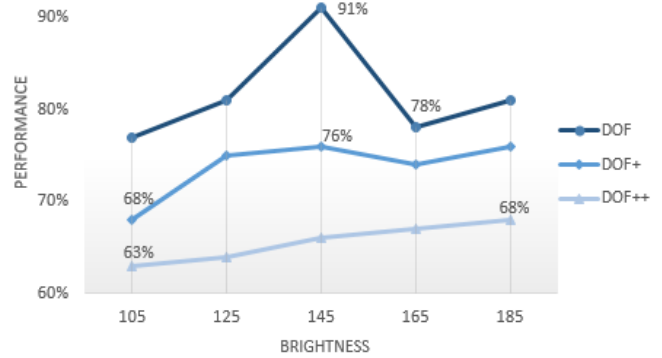


Figure 7. Test AI model detection performance according to conditions. [4]

When the DOF focus was compared to other conditions, the performance was improved by 15 to 24 percent, and when it was 145 gray, it was confirmed to be improved by 9 to 14 percent.

In order to optimize AI model performance according to the test results of Figure 7, brightness distribution and subject depth distribution management are required.

Brightness may be managed by controlling lighting by measuring the gradation of an image. In addition, when the subject is out of focus, the image becomes blurred, and information on the edge becomes smaller than the clear image in the blurred image.

The focus can be quantified according to the correlation between the focus and edge data, and the sharpness was measured using the Laplacian conversion method.

In order to optimize the performance of AI models, it has developed its own agent program that measures and manages the brightness and focus of lighting in real time. (Fig. 8)

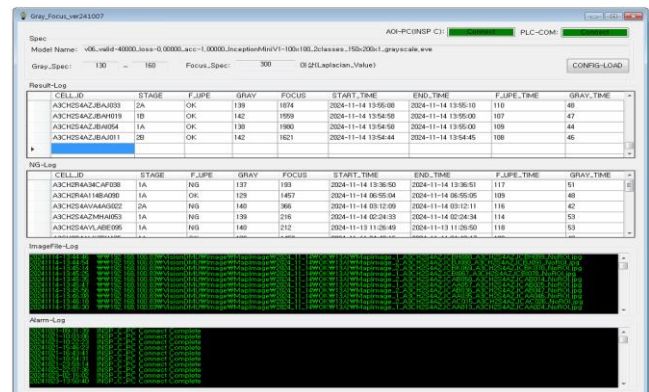


Figure 8. Agent program (Gray, Focus monitoring)

In order to measure the dispersion, the detection performance is optimized by first adjusting the intensity of the illumination and the depth of the subject.

Thereafter, the brightness distribution and edge distribution of the product are measured (FIG. 9-10), and additional activities are performed to manage the two factors.

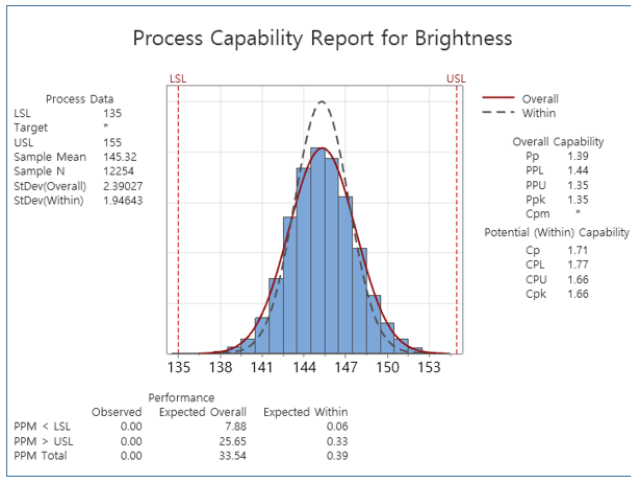


Figure 9. Brightness dispersion

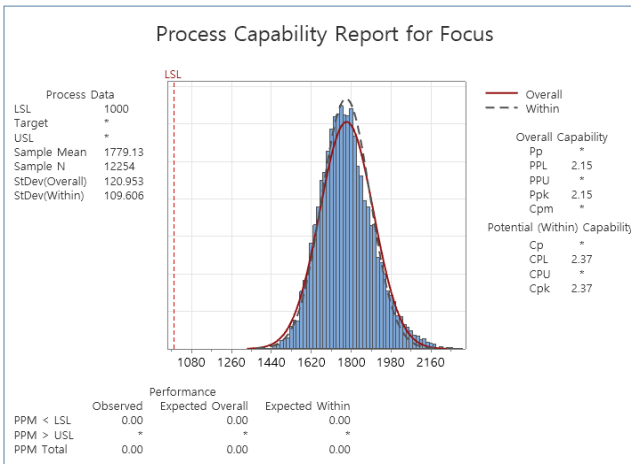
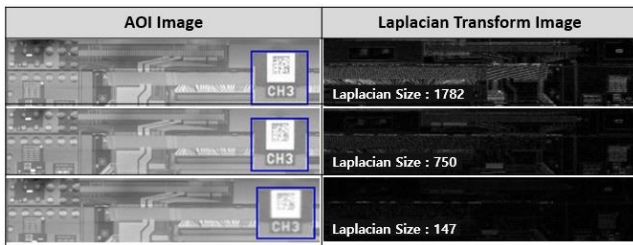


Figure 10. Image Laplacian Transform Data Dispersion

In order to maintain the image state seen above, when an abnormal change point occurs, control is applied to the product production facility, and the problem is analyzed using the Agent program (Fig. 8). Here, the occurrence of an abnormal change point includes a decrease in brightness intensity due to carbonization of lighting and a decrease in focus depth due to

unlocking of camera bolts. Improvements are made through problem analysis, cause identification, and action, and status improvement is monitored to continue.

Through this process, it was possible to minimize changes in images and optimize detection performance in AI learning models.

In Figures 11 and 12, the brightness of the test image was changed to the same AI model, and the detection power was improved in some defective types during the detection power test. It has been confirmed that there is an optimal illuminance depending on the defect type, and model performance can be maximized by preprocessing and inspecting the brightness of the image under the optimal condition for defect detection.

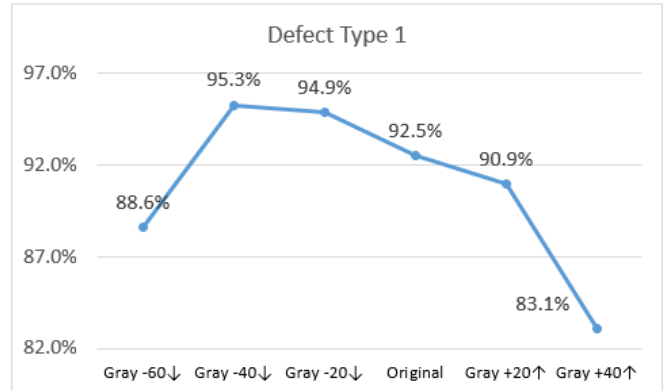


Figure 11. Detection power according to brightness change.

Type 1 defect detection test according to image brightness change.

Check the improvement of detection power when -40Gray Down in the original image.

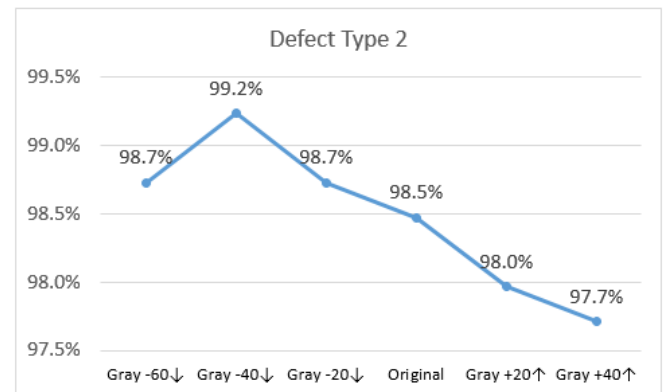


Figure 12. Detection Power according to Brightness Change.

Type 2 defect detection test according to image brightness change.

Check the improvement of detection power when -40Gray Down in the original image.

In Figures 13 and 14, in order to improve the detection power for brightness dispersion, the detection power test was performed while adjusting the contrast Augmentation during model learning, and the detection power improvement was confirmed in ±20%.

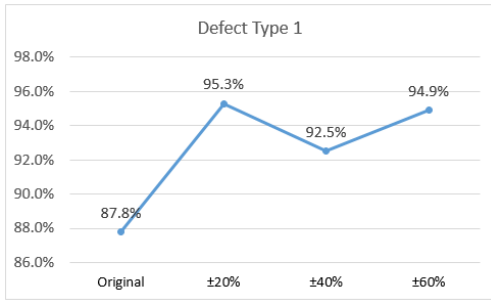


Figure 13. Type 1 Detection Power According to Brightness Augmentation.

Check for improvement of detection power when applying $\pm 20\%$ contrast Augmentation in original image.

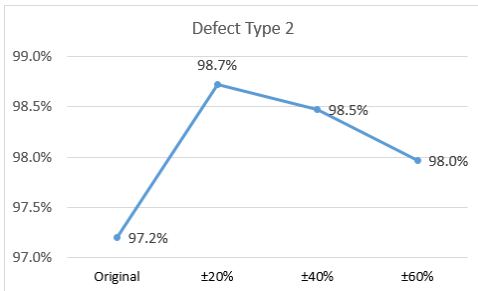


Figure 14. Type 2 detection power according to brightness aggregation.

Check the improvement of detection power when applying $\pm 20\%$ contrast Augmentation in the original image.

4. Conclusion

AI model performance was confirmed to have differences in detection power depending on the brightness and focus of the image, and the Agent program was developed to maintain optimal brightness and focus. Since there is an uncontrollable dispersion even if an image is taken with the same brightness and focus, and such dispersion affects the performance of the AI model, optimal augmentation should be applied in consideration of dispersion when learning the AI model. Since there is a brightness that can be detected well for each defect, customized inspection for each defect is required through image gray level adjustment to maximize the detection power of the defect after image imaging.

5. References

1. Akyon FC, Altinuc SO, Temizel A. Slicing Aided Hyper Inference and Fine-Tuning for Small Object Detection. IEEE. 2022
2. Envision. Depth of Field (DOF) [Internet]. ENPEDIA. Available from: <https://blog.envision.co.kr/32>
3. Lim CK. Vison IM (Internal Document). Samsung Display; 2023.
4. Lim NK, Oh HC, Oh BN. Image Processing for Model Performance Optimization. IMID. 2024 Aug 22;P2-292