Development of the AI-fact Image Inspection System

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Abstract Dramatic advances in digital technology have made it pervasive in our daily lives today, and the digital literacy of each and every one of us has improved significantly. As a result, high levels of convenience are expected from the services companies provide, and they must create new value in order to meet the discerning level of demand. In addition, today, labor shortages are becoming the norm due to the declining birthrate and aging population, and we are moving from "an era in which a company chooses its employees" of long ago to "an era in which people choose their companies."

In order to cope with the drastic changes in the business environment, we are also working on the imaging (automation of functional inspection) to make our production plants into smart factories, as one of our measures to promote DX (Digital Transformation). This report describes our development of an in-house image inspection system called "AI-fact" to meet these requirements.

1.Introduction

As the use of imaging for visual inspection, a smart factory initiative, expands, there are increasing demands for image inspection systems to further improve productivity, increase the accuracy of image inspection, strengthen quality control, and reduce costs.

It has become difficult for the general-purpose image inspection systems (hereinafter referred to as "general-purpose systems") that have been introduced to date to meet these requirements. (1)

Sanken developed its own in-house image inspection system, AI-fact, based on the concept of responding flexibly to these requirements.

2. The Development of AI-fact

2.1. The AI-fact Development Concept

The name AI-fact was derived from the concept of replacing visual inspection with image inspection and incorporating the philosophy of smart factory. Based on the keywords "AI" (artificial intelligence), "eye", "factory", and "fact", this means that AI will play the role of eye in image inspection and realize quality control based on "fact," which is the goal of smart factory.

We set the following concepts for developing AI-fact.

(i) Enhanced traceability: By storing all images at each image inspection machine, the system can provide feedback for defect analysis, process improvement, and problem investigation (2).
(ii) Easy-to-use user interface: Developed for simplicity and ease of understanding in the production process
(iii) Cost reduction: Low-cost systems can be provided. Aim to reduce costs by approximately 40% from existing systems.
(iv) Reduction of over-detection rate: Aiming to reduce the over-detection rate by improving the accuracy of image inspection with functions not available in general-purpose systems.
(v) Promoting transition to SPP: Image inspection algorithm by Sanken Power-electronics Platform, user interface developed for ease of use.
(vi) Evolution: A highly scalable system that can adapt to our own ideas.

2.2. Enhanced Traceability

Imaging projects for large product size varieties are increasing, and high-resolution cameras of 20 MPixel (20 megapixel) or more are the mainstream. However, the use of a high-resolution camera increases the size of the image file and makes the saving process take longer. In addition,

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general-purpose systems could not store all images because their storage speed could not keep up with the required tact.

Therefore, we adopted parallel processing and high-speed storage for AI-fact, as shown in Figure 1. Parallel processing divides image processing into three tasks: imaging/inspection/storage, all of which are processed in parallel to reduce overall processing time.

With the introduction of high-speed storage, the change from conventional HDD to SSD has significantly reduced storage time.

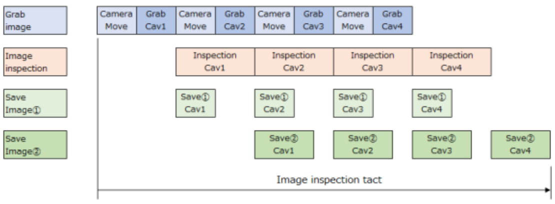

Figure 1: AI-fact Parallel Processing

Furthermore, AI-fact classifies images to be saved according to their purpose, such as for tuning or for history, and allows users to set individual file formats and destination paths for images. This allows for greater flexibility in image storage, and the ability to choose the storage method best suited to the purpose and requirements of each image.

Conventionally, images were stored on USB-HDD for each manufacturing process. As shown in Figure 2, AI-fact can transfer images stored by the image processing PCs for each process to the large storage capacity of the image server using a high-speed 10Gbps line. Images stored on the image server can be viewed within the Sanken Group network.

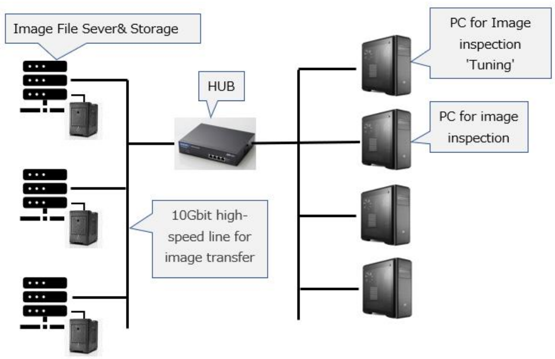

Figure 2: Imaging Device Network Configuration

2.3. User Interface

Figures 3 through 5 show the AI-fact user interface. We designed and created the Operation Screen, Area Edit Screen, and Debug Screen as the main function screens.

The Operation Screen displays the product image, lot, number of feeds, and inspection judgment.

Figure 3: User Interface - Operation Screen

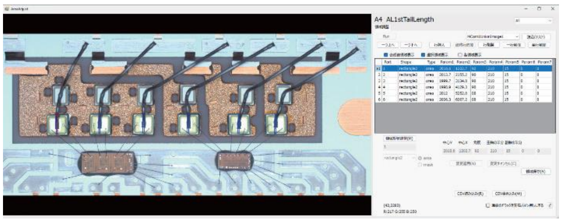

Figure 4: User Interface - Area Edit Screen

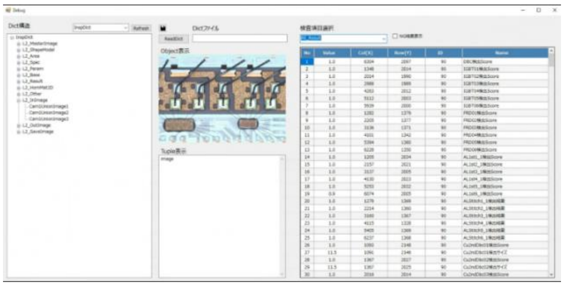

Figure 5: User Interface - Debug Screen

This screen displays flow information, such as results and number of defect judgments. The Area Edit Screen has functions for setting the inspection area, adjusting parameters, and setting threshold values. The Debug Screen can display all parameters used for image inspection, including processed images, inspection results, and detection values. Each item is classified hierarchically in a tree structure, making it easy to identify what is contained where. Each interface is simple and easy to understand, with only the necessary functions implemented.

2.4. Cost Reduction

AI-fact uses commercially available high-performance image processing software (hereinafter referred to as "high-performance image software") to achieve high-speed and high-precision image analysis.

On the software side, sophisticated image processing algorithms within the newly adopted high-performance image software have significantly reduced the processing time required for image inspection. On the hardware side, we have had to select from a limited lineup of general-purpose systems. However, with AI-fact, a system can be constructed by combining a wide variety of inexpensive commercially available PCs and peripherals. Since image processing internally consists mainly of repetitive arithmetic operations, processing time is highly dependent on CPU performance. Since AI-fact allows users to select a commercially available PC (CPU) with specifications that meet their requirements, it can both significantly shorten processing time and reduce costs.

This improvement in processing time has other significant effects. Where two cameras were needed to cover the number of areas to be inspected and meet tact requirements, that can now be reduced to one camera. The conventional manufacturing process, in which multiple image inspection machines were used for inspection, could be consolidated into a single machine through this improvement. This has achieved significant cost savings, reduced installation space, and saved design/start-up resources. Figure 6 shows the system and equipment configuration of AI-fact.

Furthermore, the development of AI-fact has made it possible to use equipment from various manufacturers, whereas with conventional general-purpose system it was necessary to purchase an assortment of cameras and lenses from the same manufacturer. This has improved the advantages in a wide range of aspects, such as specifications, cost, and delivery time.

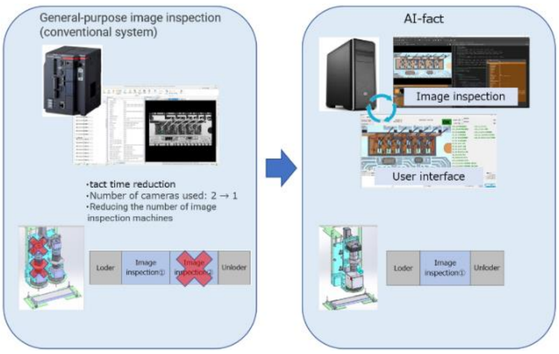

Figure 6: AI-fact System Configuration and Equipment Configuration

2.5. Over-detection Reduction

Over-detection refers to the erroneous detection of a product that has no problem as defective in image inspection. The technical challenge is to consider "missing" as a counterpart to over-detection, and to set up a balance between the two conflicting aspects.

In AI-fact, the introduction of high-performance image software enabled more advanced image processing and various shape filtering, and was effective in reducing over-detection. In addition, the simulation environment has been improved when adjusting for over-detection. In the past, the operator had to visit the production process, retrieve the USB HDD on which the images were stored, and copy the image files to a PC for the person in charge of the images to perform over-detection adjustment. This workload has been improved by AI-fact.

As shown in Figure 2, a PC for image tuning was prepared and an infrastructure was built to enable image transfer and simulation over the network. This has reduced physical losses.

When adjusting for over-detection, it is necessary to quickly identify the location of the occurrence and the trend, and make the adjustment without any backtracking. For this reason, as shown in Figure 7, we created a program to consolidate information such as enlarged images of defective locations, defect details, and image numbers corresponding to product serial numbers, into a single composite image for use in identifying the location of defects and analyzing trends. The increased efficiency of the adjustment process has reduced the resources required for over-detection reduction.

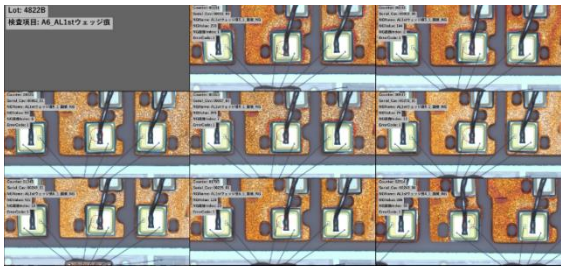

Figure 7: Composite Image of Defect Capture

2.6. Transition to SPP

The high-performance image software used in AI-fact's image processing writes program code to create inspection algorithms. AI-fact incorporates the concept of SPP and consists of an inspection program in procedure file format created for each inspection item. SPP is an initiative to review development methods and to reform design and operations based on common concepts.

As shown in Figure 8, the procedure is given a defined input and output, and the code for the parts related to this is prepared in a standardized format. Standard formats were also created for edge detection and other processes frequently used in image processing. These systems were established so that the same results can be reproduced by anyone at any time.

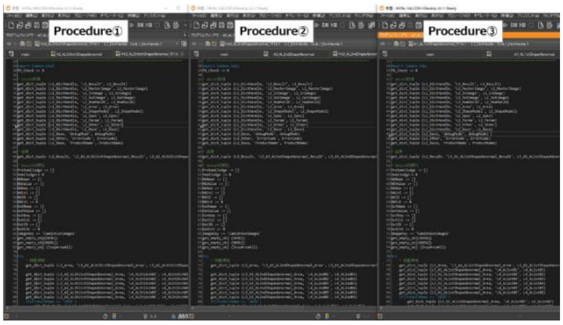

Figure 8: Program Code

2.7. Evolution

Future prospects for AI-fact include the introduction of AI (artificial intelligence) and the use of 3D images. This system can solve issues that are currently problematic with 2D images.

High-performance image software is equipped with various AI functions such as classification, segmentation, and OCR, using deep learning. By utilizing these, advanced image judgment by AI will be possible even for items that could not be identified from conventional rule-based 2D images. AI-fact is a highly scalable system that can easily incorporate these advanced technologies.

2.8. Summary of the Development of AI-fact

AI-fact development was based on six concepts. It solved issues that could not be solved with a general-purpose system, and achieved the improvements shown in Figure 9.

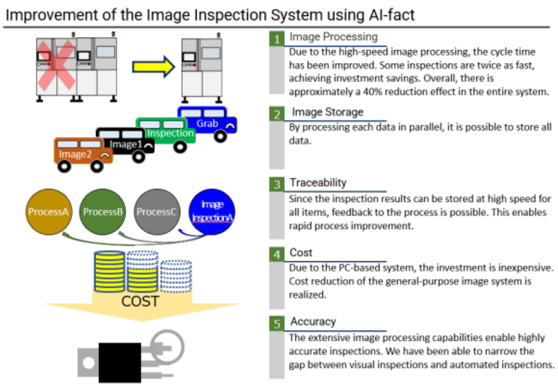

Figure 9: Improvement of Image Inspection Systems by AI-fact

3. AI-fact Deployment Record

AI-fact equipped image inspection systems machines were installed on the production lines of two of our production factories.

- Ishikawa Sanken — Horimatsu Factory, Building B, SIM2 - WB Imaging Equipment (Photo 1)
- Ishikawa Sanken — Horimatsu Factory, Building B, SIM2 - Exterior Imaging Equipment
- Niigata Sanken — Semiconductor module processes, various imaging devices

Photo 1: Example of AI-fact Installation

4. Conclusion

The introduction of AI-fact, which was developed in line with our concept, into our factories has resulted in improved production efficiency and quality control effects which are actually beginning to be seen.

We will continue to further evolve and enhance AI-fact's functions to solve problems in production processes, and to play a role as an image inspection system in each step of activities toward the final form of the smart factory.

References

(1) Ono, Sanken Technical Report Vol. 55, p46-50

(2) Niijima, Sanken Technical Report Vol.55, p46-50