Visual Inspection Software "MELSOFT VIXIO"

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Abstract

In automation of visual inspection, AI image inspection is expected to realize more intuitive, sensory inspection of defects that are hard to codify in rules, such as "random scratches" and "uneven color." At present, several manufacturers are starting to roll out products and features that enable AI visual inspection, but there are still various challenges when it comes to adoption.

Mitsubishi Electric has developed the visual inspection software "MELSOFT VIXIO" which solves these problems.

1. Introduction

Today, many inspection processes at production sites still rely on visual checks performed manually. However, due to the global labor shortage, it is becoming increasingly difficult to continue manual visual inspections, and that is driving a growing need for inspection automation.

Against this market backdrop, Mitsubishi Electric has developed MELSOFT VIXIO, visual inspection software specifically designed for Factory Automation (FA) sites. It integrates camera setup, AI model setting, inspection execution, and FA equipment interconnection into a single software package, and enables system building without programming (Fig. 1).

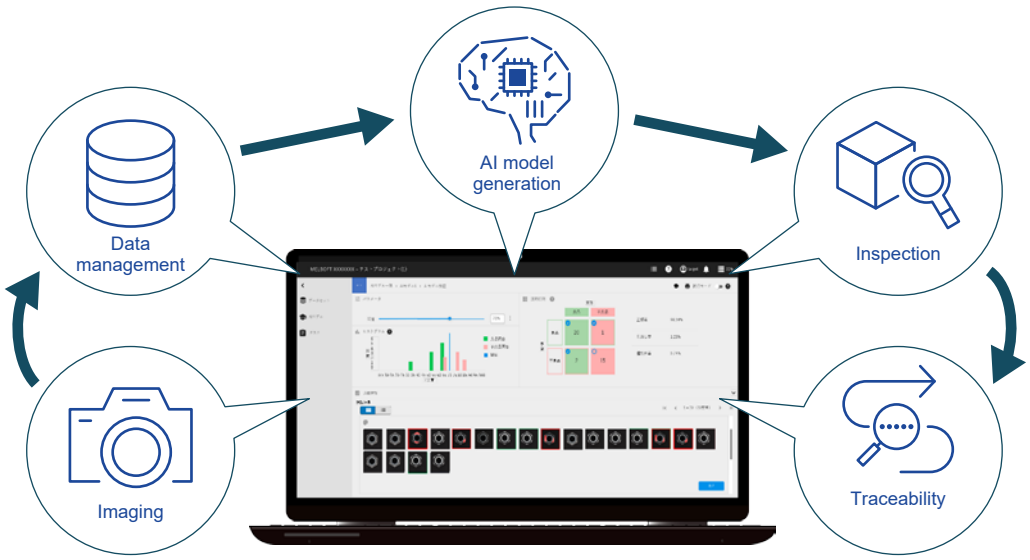

Fig. 1 MELSOFT VIXIO

MELSOFT VIXIO is a software product that allows easy, programming-free development of visual inspection systems for production lines. This product enables programming-free setting of all the essential functions needed to build a visual inspection system, including imaging (camera setup and imaging commands), image data management, AI model generation, inspection execution, and traceability. Furthermore, for AI model generation, we offer AI functions suited to FA sites where collection of images of defects is difficult. These AI functions are: good product training, which enables model generation at industry-leading speed, and abnormal point training, which enables model generation from a single defective product image.

2. Current Issues in the Manual Visual Inspection Process

At present, several manufacturers are starting to roll out products that enable AI visual inspection, but there are still the following challenges when it comes to adoption.

2.1 Customization is needed to interface with interconnected equipment

Typical AI image inspection software tends to lack some features needed in a visual inspection system. In particular, communication with sequencers that handle control at production sites often requires custom programming.

Setting tools for camera imaging also vary by camera vendor, and custom programming using a Software Development Kit (SDK) for camera interconnection is sometimes necessary for inspection system development.

Due to these factors, there is the issue of requiring many person-hours for system development.

2.2 It is difficult to efficiently create high-accuracy AI models

Production sites require high-accuracy defect detection capabilities when adopting AI in visual inspection processes.

Generally speaking, generating a high-accuracy image recognition AI model requires a large amount of image data (hundreds to thousands of images), and training the AI model often takes several hours or, in some cases, even days.

Furthermore, when executing a classification task to distinguish between good and defective products, the standard approach is to prepare images belonging to each class to be detected (good/defective products) in roughly equal numbers. However, defective products occur very rarely on many production lines, making it difficult to obtain defective product images for training in the first place.

In systems that generate AI models, accuracy fluctuates greatly depending on the value of parameters called “hyperparameters” that define the AI model’s structure. Therefore, these values are often adjusted to suit the inspection content. However, adjustment of hyperparameters requires high-level AI knowledge and considerable trial and error, and furthermore an AI model must be regenerated at each adjustment, so setting work becomes extremely troublesome.

Due to these factors, there is the issue that it is difficult to efficiently create an AI model with good accuracy.

2.3 It is difficult to achieve traceability of inspection results

In typical visual inspection systems, the images used for inspection, inspection results (e.g., good/defective product), degrees of abnormality, serial numbers or lot numbers of the inspected workpieces, processing conditions during workpiece production, and other data are usually stored separately. When related data is dispersed in this way, traceability cannot be achieved, and there is the issue that it is difficult to investigate the cause and take countermeasures in the event of defective products being released.

3. MELSOFT VIXIO Features

3.1 Easy system building

To address the issue of needing custom programming to match interconnected equipment, MELSOFT VIXIO enables system building with few man-hours.

(1) Support for common standards for industrial cameras

MELSOFT VIXIO was developed with support for GenICam[*1] and GigE Vision[*2], common standards for industrial cameras. GenICam is a software standard that provides a general-purpose programming interface for all types of cameras, regardless of their interfaces or implemented features. Compliance with this standard allows use of a uniform Application Programming Interface (API), regardless of the interface.

GigE Vision is a standard that connects industrial cameras to computers via high-speed, reliable Ethernet[*3] connections. Cameras and applications that conform to this standard can be interconnected, even if they are products from different vendors.

*1 GenICam is a registered trademark of the European Machine Vision Association (EMVA).
*2 GigE Vision is a registered trademark of the Association for Advancing Automation.
*3 Ethernet is a registered trademark of the Fuji Film Business Innovation Corporation.

With MELSOFT VIXIO, setting is performed using these common standards. Therefore, imaging settings can be completed with MELSOFT VIXIO alone, without using the special-purpose tools of each camera vendor. Figure 2 shows a comparison of camera interconnection settings between a typical visual inspection system and MELSOFT VIXIO.

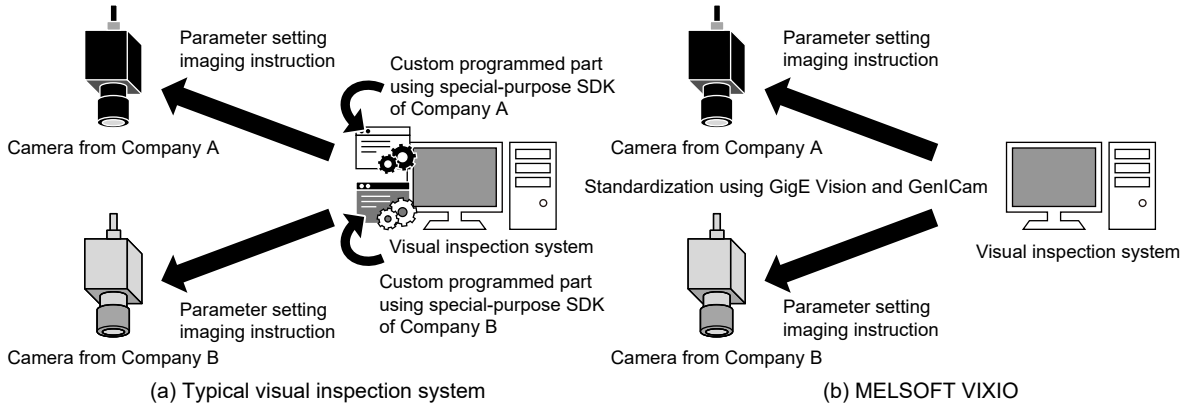

Fig. 2 Comparison of camera interconnection setting

(2) Implementation of the sequencer interconnection feature

Interconnection with Mitsubishi Electric's flagship sequencers, including the MELSEC iQ-R, MELSEC iQ-F, and MELSEC-Q series can be done with just intuitive setting operation.

The system supports interconnection features such as receiving data from a sequencer and using it as an inspection start trigger, receiving process information such as lot numbers and storing that information in inspection records, and sending inspection completion notifications and good/defective inspection results to the sequencer.

(3) Realization of simultaneous multi-person operation through a web application approach

MELSOFT VIXIO employs an approach where a web server is configured on the computer where it runs, allowing users to access the operation screen from a web browser. This allows multiple users to perform operations such as creation of AI models and setting of inspection tasks. Furthermore, by displaying a monitor of inspection tasks on a tablet, use cases are enabled that were difficult to achieve with previous Windows*4 applications, such as ascertaining the status of inspections at any location away from the visual inspection system. The system configuration is shown in Fig. 3.

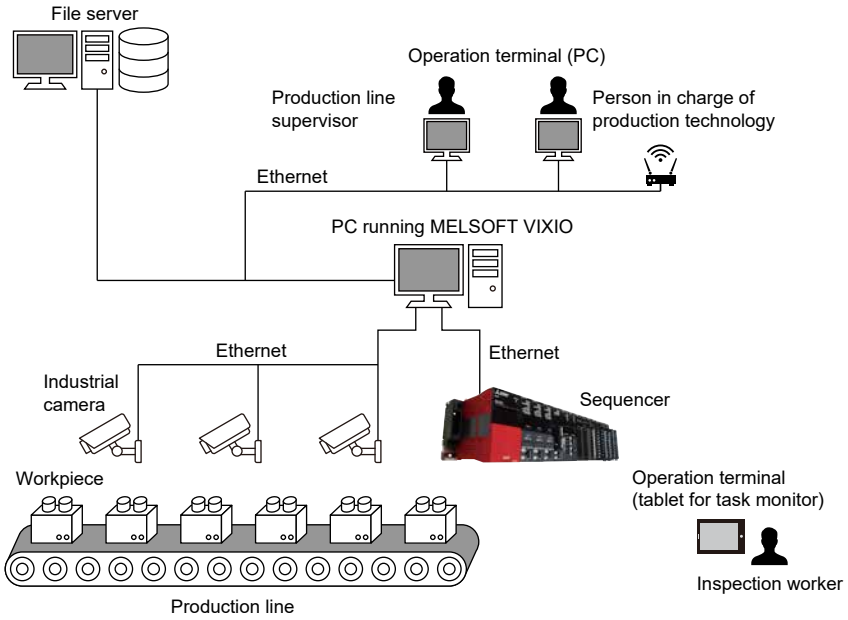

Fig. 3 System configuration when using MELSOFT VIXIO

*4 Windows is a registered trademark of the Microsoft Corporation.

When designing the operation screens, we created design guidelines to ensure consistency across the entire product, along with design examples for screens where usability was a particular priority, prior to the design work for each screen, allowing us to achieve both ease of operation and a refined layout.

3.2 Equipped with high-speed, high-accuracy AI algorithms

To address the issue that it is difficult to efficiently create high-accuracy AI models, MELSOFT VIXIO has implemented a solution by providing two selectable AI algorithms selectable according to the nature of the workpiece being inspected and the frequencies of occurrence of the defects to be detected.

As described in section 2.2, the typical approach when training an image recognition AI model is to prepare hundreds to thousands of images of good and defective products, respectively. However, defective products occur very rarely on production lines for mass-produced products, making it difficult to obtain defective product images for training in the first place.

This issue is solved with the following AI algorithms.

3.2.1 Good product training

Good product training is an algorithm for training using only images of good products. In good product training, an effort was made to speed up training time. Generally speaking, AI training (especially that employs deep learning) often takes several hours or, in some cases, several days, but with good product training, extremely fast training was achieved by optimizing and devising computation sequences for our proprietary lightweight AI to match the hardware architecture.

Furthermore, Graphics Processing Units (GPUs) are necessary in typical AI training and inspection execution, and that too has been a hurdle to adoption. Our good product training realizes training and inspection execution with only a CPU.

As a result, the system achieves high performance requiring 10 seconds or less for training with about 100 training images.

3.2.2 Abnormal point training

Abnormal point training is an algorithm for training using a small number of defective product images. Training can be done with, at a minimum, one defective product image.

Before training, the defective points in the training images must be marked. However, unlike marking in general AI training, precise area selection of defective points is unnecessary, and with MELSOFT VIXIO, marking is done by simply designating the position of the defective point with a few pixels.

3.3 Centralized management of inspection results

To address the issue that “it is difficult to achieve traceability of inspection results,” we implemented a solution by providing a feature in MELSOFT VIXIO to save inspection results (Fig. 4).

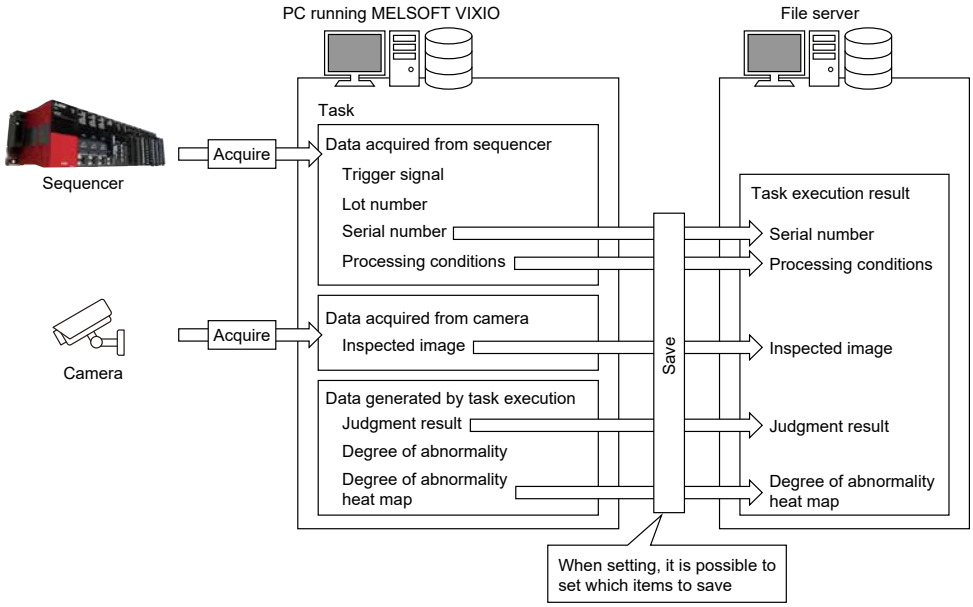

Fig. 4 Saving inspection results

Using this feature, data handled in a task during inspection can be easily linked to inspection results, and saved in task execution units (typically units of inspected workpieces). The serial number, lot number, processing conditions, and other information for the inspection target are obtained from the sequencer interconnected during inspection. The target items to be saved can be selected from the setting screen for saving inspection results, so it is possible to save only the items necessary for ensuring traceability.

4. Use Cases

AI visual inspection systems have rapidly gained popularity in recent years, but it is hard for them to completely replace conventional manual visual inspection processes conducted by inspectors or existing rule-based visual inspection systems.

This section describes use cases targeted by MELSOFT VIXIO.

4.1 Improved accuracy through use together with rule-based inspection

Rule-based inspection[*5] is widely used in inspection processes, but it has the issue that false-positive-detections or non-detection frequently occur for defects whose color, shape, or size cannot be anticipated (i.e., when it is difficult to formulate a rule).

By combining with MELSOFT VIXIO, the strengths of the different methods can complement each other to address this issue, improving accuracy of the visual inspection process as a whole.

4.2 Primary screening of manual visual inspection

In manual visual inspection processes, a system is often used where potential defects such as small scratches or unevenness are sorted via manual visual observation, and items marked as defective in the primary screening are later subjected to detailed investigation by the person in charge of quality assurance. Adopting MELSOFT VIXIO in this primary sorting process makes it possible to perform primary screening of items that may have defects (those that differ from the norm). This reduces man-hours of primary screening and reduces fluctuations of inspection quality.

4.3 Double-checking with manual visual inspector

In processes where inspectors perform visual inspection manually, non-detection sometimes occurs due to differences in skills and experience among inspectors. There is also the issue that checked images do not remain from inspection, so rechecking cannot be done with the image when a defect is released into the market.

By adopting MELSOFT VIXIO to address this issue, a system can be established where AI performs visual inspections, which are then double-checked through manual visual observation based on the AI's findings. This approach can reduce non-detection of defects, and ensure inspection traceability because all inspection results are retained as images.

5. Conclusion

This paper has described the development background, characteristics, and technologies used to realize MELSOFT VIXIO, a system which integrates the features required for a visual inspection system into a single package.

MELSOFT VIXIO reduces man-hours spent building visual inspection systems, and makes a major contribution to ensuring the quality of products. Ensuring traceability in the inspection process also facilitates analysis of the cause in the event that a defective product is released into the market.

Going forward, we will leverage our unique position as a comprehensive FA equipment manufacturer to strengthen interconnection with other products, such as sequencers, Graphic Operation Terminals (GOTs), servo systems, and robots.

This will enable easier construction of high-speed, high-accuracy visual inspection systems, contributing to further automation of inspection processes and improved productivity.

*5 A technique for determining pass/fail by using image processing technology to calculate parameters such as the length or area of specified positions