Case Study

Intel® Core™ Processor
Intel® Arc™ GPU
Intel® Xeon® Processor

AI Quality Inspection Solution inspected 99.99% defect detection accuracy for LG Innotek

Powerful performance and cost savings are examples of AI performance optimization enabled by Intel® technology.

Overview

- Precision components integrating innovative technologies require complete and flawless inspections.
- Traditional rule-based inspection systems struggled to adapt to new product specifications, and their results varied depending on the subjective judgment of operators, leading to ambiguous standards.
- LG Innotek introduced an AI-powered automated inspection solution based on Intel® Core™ Processor, Intel® Arc™ GPU and Intel® Xeon® Processor, achieving a groundbreaking 99.99% defect detection rate and significant cost savings.

Executive Summary

The precision component manufacturing market is an industry that requires high precision, and it is rapidly becoming smaller and more advanced. LG Innotek, a leading producer of key materials and components for mobile devices, automotive displays, semiconductors, and various smart products, prioritizes the completeness and integrity of inspections across all stages of production and final processing. The existing rule-based inspection systems struggled to adapt to new materials and new product specifications and often relied on the subjective judgment of operators, leading to ambiguous standards.

LG Innotek has introduced an AI-powered automated inspection solution based on the Intel® Core™ Processor, significantly improving the quality and productivity of precision component manufacturing processes. The Intel-based AI inspection solution, combined with a fully automated unmanned inspection system, aims to achieve a 99.99% defect detection rate by fundamentally eliminating the challenges posed by material variations and subjective judgments by operators in traditional rule-based inspections.

Furthermore, LG Innotek determined that integrating high-cost and supply-constrained GPUs into AI inspection equipment would not maximize the effectiveness of AI vision inspection. Instead, by adopting an integrated GPU in Intel® Core™ Processor(hereafter referred to as iGPU) and discrete Intel® Arc™ GPUs, it achieved significant cost savings. With its groundbreaking approach that broke traditional limitations, LG Innotek is boldly advancing toward becoming the world's No.1 advanced materials and components company.

Challenges

Task 1

To respond flexibly to the rapidly changing inspection environment.

LG Innotek handles precision components concentrated with innovative technologies. It manages hundreds of models, and each product line has different inspection items, standards, specifications, and inspection timings. Even within the same product group, the number of inspection items can differ or more depending on the model, or defect standards can vary significantly. Traditional rule-based inspection methods have difficulty adapting quickly when inspection standards or product characteristics change.

Lee Sang-houn, head of Equipment Technologies Division, Production Innovation Center, LG Innotek, stated, "When conducting inspections based on standardized algorithms, there are many non-objective defects that cannot be accurately quantified." That means the standards for defect judgment are often ambiguous due to variations in an operator's condition or individual perspective differences. In addition, even slight changes in product specifications make quantification difficult, leading to challenges in ensuring data consistency.

Task 2

To achieve a fully automated inspection process for complete product integrity.

The big challenge is risk management to ensure that no defective products are shipped. As a product goes through dozens of processes and approaches completion, its value gradually increases. Thus, LG Innotek has already adopted AI technology to detect non-objective defects such as contamination and minimize data deviations early in the inspection process. While the initial success rate was not high, recently it has achieved a defect detection rate up to 99.99%.

However, LG Innotek's goal was to establish an AI inspection architecture that completely eliminates human-related risks, enables 99.9% defect detection, and can be universally adopted across all LG Innotek factories. To enhance its manufacturing competitiveness, it needed a strategy to quickly and accurately detect microscopic defects and errors, which are invisible to the human eye, across more than 100 processes.

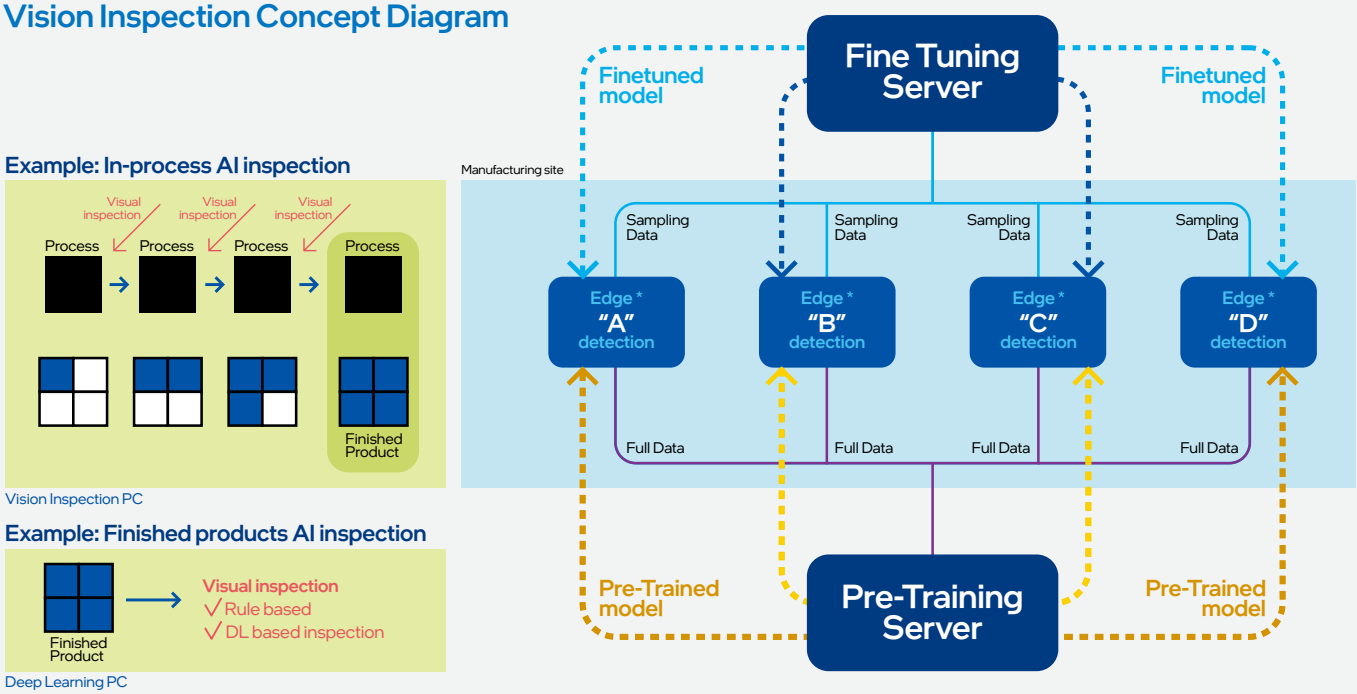
Task 3

To find an alternative GPU having lower cost and better supply

Until now, it has been generally perceived that high-performance discrete GPUs are essential for AI tasks, but they have significant drawbacks, including high costs and unstable supply. Previously, LG Innotek conducted vision inspections using systems with discrete GPUs from other vendors. However, when the number of inspection items increased, the high costs made it impossible to deploy the systems across all production lines, so workers also supplemented inspections with visual checks. There were doubts about computational efficiency with existing GPU hardware.

Given these circumstances, LG Innotek determined to adopt Intel GPUs so LG Innotek can maximize the effectiveness of AI vision inspections.

Vision Inspection Concept Diagram



Note:
Edge * : Embedded vision Inspection PC in Manufacturing equipment

Solutions

1) Disruptive performance and cost-effectiveness by Intel® Core™ Processors

Intel, which has collaborated in various ways with LG Innotek, recognized that Intel® Core™ Processors were already integrated into the existing in-house inspection equipment to control workflow. Breaking existing stereotypes, Intel proposed maximizing the use of the iGPU to operate AI vision inspection processes efficiently. This approach enabled the automation of various vision inspection items solely by using the performance of the existing built-in CPU without additional investment.

By utilizing the iGPU and the Intel® Arc™ discrete GPU, LG Innotek enhanced the overall performance of its inspection system while improving cost efficiency compared to the configuration used with older-generation Intel CPUs and third-party GPUs. LG Innotek checked Intel GPUs show good results within the acceptance range through evaluation.

Additionally, LG Innotek is considering a new approach that utilizes two Intel® Arc™ discrete GPUs to separate model input and inference tasks for parallel processing when dozens of algorithms run simultaneously during the appearance inspection of finished products.

Lee emphasized that Intel® Arc™ discrete GPU increases cost efficiency 3-4 times compared to equivalent hardware performance from different vendors LG Innotek used. In addition, he added that the cost reduction of expanding AI inspection solution equipment powered by Intel® Core™ processors to LG Innotek's company-wide process will be significant.

2) Collaborating with Intel to facilitate the development

At first glance, using the iGPU for AI inspections without a separate GPU requires changing all existing practices and environments. However, Intel offered outstanding development convenience.

Yang Hee-cheol, LG Innotek's AI Inspection Technology Team leader, explained, "In the past, we had already built an environment around specific graphics cards in our deep learning environment, so there was no reason to consider alternative option, as the benefits were clear, such as easy mapping between hardware and the open source ecosystem, and the availability of libraries like Python based on CUDA computation. However, after experiencing the ease of use of OpenVINO and its advantages over the existing system, we decided to implement an OpenVINO-based inspection system."

One of the most significant breakthroughs during development was realizing that leveraging OpenVINO™, with effective technical support from Intel engineering team, greatly simplified model conversion. OpenVINO™, an inference engine developed by Intel, is not restricted to any specific manufacturer and excels in openness and compatibility. The ability to easily convert existing trained models through OpenVINO™ was a paradigm shift.

Yang stated, "By adding just a few lines of code, third-party trained models could be used for inference in Intel environments through OpenVINO™, without any burden on the existing development environment." He also emphasized that even when hardware and software are upgraded, existing compatibility is maintained, allowing efficient system management during performance enhancement.

3) Maximized bandwidth by leveraging Intel® Xeon® Processor for retraining

LG Innotek operates a system for retraining deep learning models when process changes or raw material alterations occur after mass production deployment. While GPUs are used for initial training, the possibility of utilizing the Intel® Xeon® Processor for retraining was also considered.

Intel suggested that leveraging Xeon Processors, which have the highest number of AI accelerators, can maximize parallel computation speed. It is also effective to use Intel libraries that support AMX(Advanced Matrix Extension) optimized for deep learning computation.

For fine-tuning, LG Innotek concluded that there was no significant difference in usability compared to discrete GPUs and that it could be sufficiently utilized in practical applications.

LG Innotek plans to actively utilize Xeon Processors for fine-tuning, shifting away from the traditional setup that relied on both Xeon Processors and discrete GPUs, as it is possible to maximize performance without discrete CPUs, leading to significant cost savings.

Conclusion

AI Inspection Solutions Accelerate the Future of Global No.1 Advanced Materials & Components Company

The competition for global leadership in the advanced materials and components industry, driven by innovative technologies, is becoming increasingly intense. LG Innotek has been at the forefront of adopting AI-powered automated inspection solutions based on Intel AI products portfolio including Intel Core processors, Intel Arc discrete GPU, Intel OpenVINO and Intel Xeon dramatically improving quality and productivity in the precision component manufacturing process.

Lee stated, "The most important innovation brought by Intel® Core™ processors is the ability to fully automate the whole inspection process by applying efficient AI inspection systems to any process at lower cost. In addition, Intel Arc discrete GPU improves cost efficiency by 3~4X the level of hardware performance they are in use. In the future, starting with the production line of the Flip Chip Ball Grid Array (FC-BGA), a high-value-added semiconductor substrate, in Gumi Factory, we plan to deploy Intel AI solutions to various manufacturing facilities to ensure stable mass production."

LG Innotek, accelerating innovation with bold approaches beyond existing limitations, is expanding AI solutions beyond inspection to include maintenance and other areas. Through this, LG Innotek is improving current manufacturing processes while continuously securing innovative technologies for the future, moving toward becoming the global No.1 leader in advanced materials and components.

Testing by LG Innotek as of November 1st, 2024.

[Fine-tuning server test config]
Processor: 99CF10, Intel® Xeon® PLATINUM 8580 EMERALD RAPIDS A1 300MB 60c FC-LGA 350w Q3W6, Q3W6, EMERALD RAPIDS, DCGT, ES, 2.000 GHZ, 300 MB, 0, FCLGA; Base Board: Quanta EGS 2S commercial baseboard codenamed S6Q-MB-RTT "S6Q" Rev "F" (Qual); Memory: Kingston KSM56R46BS8PMI-16HAI 16GB 5600 Single Rank DDR5 Reg. (Buff.) ECC DIMM; OS: Windows server 2022; Torch version : 2.5.0+cpu

[iGPU test config]
Processor: Intel® Core™ i7-14700K 3.40 GHz; Mainboard : [ASUS] PRIME Z790-P/CSM(ATX); Memory: T-Force DDR5 4800 CL38 Delta RGB TUF 16G *2EA; Storage: Samsung 990 PRO M.2 NVMe 2280 4TB; Display resolution: 1920x1080; OS: Windows 10 Enterprise 21H2; iGPU: Intel® UHD Graphics 770; Graphics driver: Intel Graphics 32.101.6449; BIOS version: American Megatrends Inc. 1604, 2023-12-15; Power plan: Balanced; AC power slider setting: None

[Intel Arc test config]
Processor : Intel® Core™ i7-14700K 3.40 GHz; Mainboard : [ASUS] PRIME Z790-P/CSM(ATX); Memory: T-Force DDR5 4800 CL38 Delta RGB TUF 16G *2EA; Storage: Samsung 990 PRO M.2 NVMe 2280 4TB; Display resolution: 1920x1080; OS: Windows 10 Enterprise 21H2; Graphics card1: Arc A770 Limited Edition D6 16GB; Max GFX power: 250W; BIOS version: American Megatrends Inc. 1604, 2023-12-15; Power plan: Balanced; AC power slider setting : None

[Test workloads description]
Inference
Model: Efficientnet_B3 (#params: 10M); Image size: 240x240x3; Test method: Single Image Batch 100 images were inferred by deep learning model to obtain the following numbers

Fine-tuning
Model: Resnet50; Dataset: 100 RGB images of 600X600 (OK : 50, NG : 50); Latency Calculation method: Average latency of 60 epochs (first 10 epochs are excluded from the calculation); Batch_size: 16; Data_Type: bf16 (16bit)

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Performance varies by use, configuration and other factors.
Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates.
See configuration disclosure for details.
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