intel. tiber.™
Edge Platform

Defect Detection Warehousing Solutions with Intel® Tiber™ Edge Platform

Introduction

The landscape of warehousing is undergoing a profound transformation fueled by the escalating demands for heightened efficiency, real-time decision-making and streamlined operations. In this era of Industry 4.0, the growing convergence of artificial intelligence (AI) and edge computing emerges as a pivotal force shaping the future of warehousing.

The burgeoning need for quick and intelligent data processing within warehouse environments has given rise to the adoption of edge computing solutions, allowing for localized computing at the network edge. AI, complementing this paradigm, introduces advanced analytics, predictive capabilities and automation, enabling warehouses to optimize processes, enhance inventory management and improve overall operational agility.

Problem statement

A large retail company in Europe contended with hundreds of thousands of defects each year globally, leading to millions of dollars of potential losses and claims due to undetected defects.

- **Manual inspection leads to higher costs**: Relying only on manual inspection introduces the risk of human error, resulting in potential oversight of defects and inaccuracies in identifying compromised products, leading to excessive expenditures on carrying damaged goods, poor customer experience, and inaccurate inventory reporting on available products. Such inefficiencies not only escalate operational costs but also contribute to inventory losses as defective items may go unnoticed until later stages, potentially reaching end-users. The urgent need for a more cost effective, accurate and automated defect detection solution becomes evident. Warehouses seek to alleviate financial burdens, assist operators in enhancing product quality assurance, and optimize inventory management in an increasingly competitive and dynamic market.

- **Defect inaccuracies impact operational efficiencies:** Detailed manual inspections by forklift operators to ensure quality often led to slowed unloading operations as any potential detected defect required coordination with the centralized quality control (QC) team and waiting for the QC personnel. Defect data also had to be manually uploaded into a proprietary database for insurance claims. Most importantly, any missed damage increased the risk of bad products flowing through the supply chain, leading to poor customer experience, more waste and higher insurance claims on the company's end.

- **Labor-intensive inventory management is unsustainable**: Today, warehouses grapple with a significant challenge characterized by soaring labor costs and considerable inventory losses attributed to the reliance on manual defect detection processes. The traditional approach of visually inspecting products for defects requires a substantial workforce, leading to elevated labor expenses for businesses.

Table of Contents

Business outcome

The customer wanted an intelligent damage detection solution using stationary systems and/or mobile devices (operated by workers) to detect and report damages. This automated AI-based solution would need to detect defects on pallets and boxes from the camera feed during the unloading process and alert the forklift operator to take necessary actions immediately. Types of defects included:

▪ Damage on shipping boxes.

▪ Ripped shrink wraps.

▪ Discolored boxes.

▪ Missing or torn shipping labels.

▪ Bowing type damage on pallets.

The system was also expected to document, report and flag the defects to the QC team on their warehouse management system (WMS) along with supporting pictures (zoomed in view of the defect) such that the vendor could be notified of the damages. Overall, the customer wanted to improve the unloading throughput at the warehouse with reduced manual inspection and lower the defect miss rate, thereby reducing costs and improving the bottom line.

The solution built with Intel technology

Together with the customer, Intel created a solution to address the above-mentioned pain points, leveraging the following components from Intel® Tiber™ Edge Platform:

▪ Intel® Geti™: AI computer vision modeling software.

▪ Intel® Edge Insights System: Machine-vision-based analytics solution.

Intel® Tiber™ Edge Platform enables enterprises to build, deploy, secure, run, and manage edge and AI solutions from pipeline to production with scale and manageability. Built on extensive edge expertise, it's designed for the most demanding edge use cases and to accelerate edge AI development while reducing costs.

Intel Geti computer vision software

Intel Geti software is a breakthrough in AI model training: a comprehensive development solution for building computer vision models — encompassing everything from data upload and data labeling to training, optimization and achieving a working model. Designed for collaboration and ease of use, the software enables businesses to build real-world computer vision models more quickly and efficiently. The Intel Geti software allows data scientists and AI developers to collaborate with domain experts through an intuitive interface and create sophisticated computer vision models for use cases as varied as detection, classification, segmentation, and anomaly detection with less effort and data. Data scientists and AI developers benefit from powerful, fine-grained controls to help perform more advanced tasks as well.

Intel® Edge Insights System

Intel Edge Insights System provides a robust, secure, and managed solution to ingest data from cameras and processes on the factory or warehouse floor and run inference on the data in a time-sensitive manner using the developed AI algorithms.

It is an out-of-the-box and easy-to-use edge inferencing solution designed for domain experts in manufacturing and warehousing. The operator-focused user interface allows the system user to configure the solution for the application and provide feedback during operations, for example, alerting the operator that deviation in quality has occurred or setting up an action to be taken in such an event.

The solution includes an industrial PC (IPC) pre-installed with the Intel Edge Insights System software stack and validated with specific cameras. Providing a flexible choice of software, hardware and support options, Intel Edge Insights System empowers factories and warehouses with its multimodal analytics tools and solution offerings for faster AI deployment, to achieve better product quality and optimized supply chain management at the edge.

Intel® Geti™ Software – Core Capabilities

Interactive Training Model
Get started annotating data with as little as 20-30 images; then let active learning help you teach the model as it learns.

Multiple Computer Vision Tasks
Create models for AI tasks including classification, object detection, semantic segmentation or anomaly detection.

Task Chaning
Train your model into a multistep, smart application by chaining two or more tasks, without the need to write additional code.

Smart Annotations
Expedite data annotation and easily segment images with professional drawing features like a pencil, polygon tool and OpenCV GrabCut.

Production-Ready Models
Output deep learning models in TensorFlow or PyTorch formats (where available) or as an optimized model for OpenVino™ toolkit to run on Intel® architecture CPUs, GPUs and VPUs.

Hyperparameter Optimization
Refining hyperparameters is critical to the model's learning process. With built-in optimization, the Intel Geti platform makes a data scientist's job easier.

Rotated Bouding Boxes
Support for rotated bouding boxes extends the trainign simplicity and accuracy to datasets with images that are not axis-aligned.

Model Evaluation
Comprehensive statistics to assess your model's performance.

Intel® Edge Insights System

User Interface
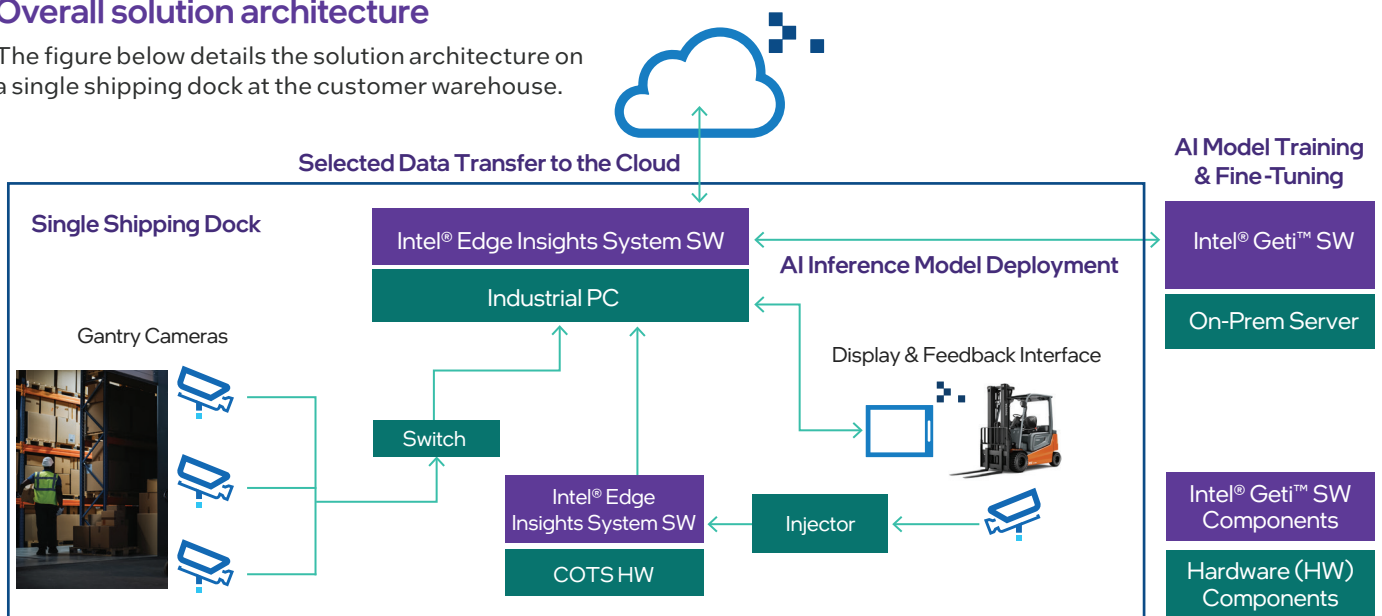designed for developers and factory experts

Integration Tools
easily connect to existing systems

Validated Industrial PCs
of your choice

Validated Cameras
of your choice

Overall solution architecture

The figure below details the solution architecture on a single shipping dock at the customer warehouse.

The IPC runs the Intel Edge Insights System software stack for edge inferencing and edge data management. Specifically, the three gantry cameras capture the top and side views of the pallet as it is being unloaded from the trailer and one camera attached to the forklift captures the frontal view of the pallet being unloaded. The Intel Edge Insights System stack running on a commercial off-the-shelf (COTS) hardware edge server includes the video ingest and video analytics microservices that send the forklift camera data to the Intel Edge Insights System stack on the IPC. The Intel Edge Insights System stack on the IPC provides video ingest and video analytics, image store and data visualization microservices that communicate over a message bus. Multiple instances of video ingest and video analytics microservices ingest camera feeds from the three gantry cameras. The video analytics modules contain the AI inferencing models for defect detection that are trained and generated by the Intel Geti software running on an on-premises edge server, providing complete data privacy. The operator user interface as part of the Intel Edge Insights System stack provides alerts on the user screen when a defect is detected. It allows the forklift operator or QA personnel to record videos of pallets when there is a mismatch between a decision rendered by the AI

solution and the actual pallet condition. For instance, a false positive detection on a pallet, or a miss of defect detection due to lack of training data. The system also provides the capability to send any data to the customer's choice of cloud, as needed.

Overall, the solution built with Intel Tiber Edge Platform delivers a cloud-like experience but with the low latency and data privacy benefits of the edge. It enables:

- **End-to-end AI implementation**: Manage the complete AI model lifecycle, including data annotation, model training, model optimization, model re-training and model deployment to the edge.

- **Machine vision**: Locally store image and video data generated by site cameras and analyze it, leveraging pre-trained AI models (trained using the Intel Geti software) to detect manufacturing defects, shipping damages and any other noncompliance occurrences.

- **Site-to-cloud connectivity**: Establish seamless edge-to-cloud connectivity, ensuring efficient and secure data transfer between local edge devices and centralized cloud infrastructure as needed.

Results and outlook

The successful deployment of a cutting-edge solution at the customer's warehouse yielded remarkable business outcomes, transforming operational efficiency and resource utilization. Within a matter of weeks, the implementation resulted in reduced labor costs, a testament to the substantial increase in unloading throughput (forklift unloads per hour) with the help of AI-based defect detection. The AI algorithms achieved the required performance in detecting defects based on user feedback and under consistent operational conditions. This not only streamlined the unloading process but also significantly reduced labor costs, showcasing the tangible benefits of our innovative approach to warehouse management. The swift and substantial improvements underscore the value our solution brings to optimizing warehouse operations and establishing a foundation for sustained efficiency gains.

As we continue to harness the power of intelligent edge technologies, we are confident that our approach will not only drive sustained operational excellence in the warehouse but also serve as a beacon for the broader industry's journey into the era of smart, connected manufacturing and logistics.

intel. tiber™
Edge Platform

Learn more about Intel® Tiber™ Edge Platform

Intel.com/edgeplatform

Additional resources

Intel® Geti™ Software: geti.intel.com

Intel® Edge Insights System: intel.com/edgeinsightssystem

intel.