Inspection of Assemblies: Enhancing Quality and Performance Through Robotic Vision Systems

Exploring the role of Robotic and Vision Systems in supporting industries to ensure customer satisfaction

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Abstract

Quality issues can have significant impacts on production efficiency, customer satisfaction, and regulatory compliance. When faulty products reach consumers and defects are discovered after purchase, it can severely damage the brand image, result in costly recalls, and require extensive rework. To address these challenges, industries need to implement inspection operations without compromising production performance.

This white paper provides a comprehensive overview of inspection of assemblies, highlighting its importance in identifying defects, ensuring regulatory compliance, and preventing the release of faulty products. It explores various inspection tools and emphasizes the advantages of automated Inspection Systems that integrate robotics, machine vision, and sensors.

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What is Inspection of Assemblies?

Inspection of assemblies is crucial in manufacturing and production industries to identify any defects, errors, or deviations from the desired quality.

Inspection of assemblies refers to the process of examining and evaluating the quality and functionality of assembled components or products. It involves a thorough examination of the individual parts that make up the assembly, as well as the overall fit, alignment, and performance of the assembled unit.

During the inspection, various techniques and tools may be used, such as visual inspection, measurements, functional testing, and non-destructive testing methods. The goal is to ensure that the assembly meets the required specifications, standards, and customer expectations.

Inspection of assemblies is crucial in manufacturing and production industries to identify any defects, errors, or deviations from the desired quality. It helps to prevent faulty products from reaching the market, ensures compliance with regulations, and allows for necessary adjustments or repairs to be made before final delivery.

The inspection process can be carried out either manually or automatically. In manual inspection, human operators visually examine the assemblies and conduct measurements or tests using handheld tools. They heavily rely on their expertise and judgment to identify defects or deviations from specifications. On the other hand, automated Inspection Systems integrate a range of technologies, including robotics, machine vision, and sensors, to inspect assemblies efficiently and accurately. Compared to automated Inspection Systems, human eyesight has limitations in resolution, and errors in inspections can be generated by operator fatigue, lack of attention, or differences in judgment criteria among operators. However, with appropriately installed machine vision, several parameters can be set up to ensure consistency in automatic inspections, even when the product or external conditions, such as environmental lighting, change.

What industries can see Inspection of Assemblies applied?

The Inspection of Assemblies application can be seen in various industries. Some of the industries where this application is mostly used include automotive, electronics, and life sciences.

In the automotive industry, this application includes inspecting parts such as engines, transmissions, brakes, electrical systems, chassis, and body components to ensure they meet quality standards and specifications. The inspection may include checking for defects, proper assembly, alignment, functionality, and adherence to safety regulations and traceability.

In the case of the electronics industry, the inspection process makes sure that the components are correctly assembled, soldered, and connected, and that they meet quality standards and specifications. It involves checking for defects, proper alignment, solder joint integrity, component placement accuracy, and functionality. Inspection of Assemblies in the electronics industry is crucial to ensure the reliability, performance, and safety of electronic devices

The Inspection of Assemblies application is pivotal across industries like automotive, electronics, and life sciences.

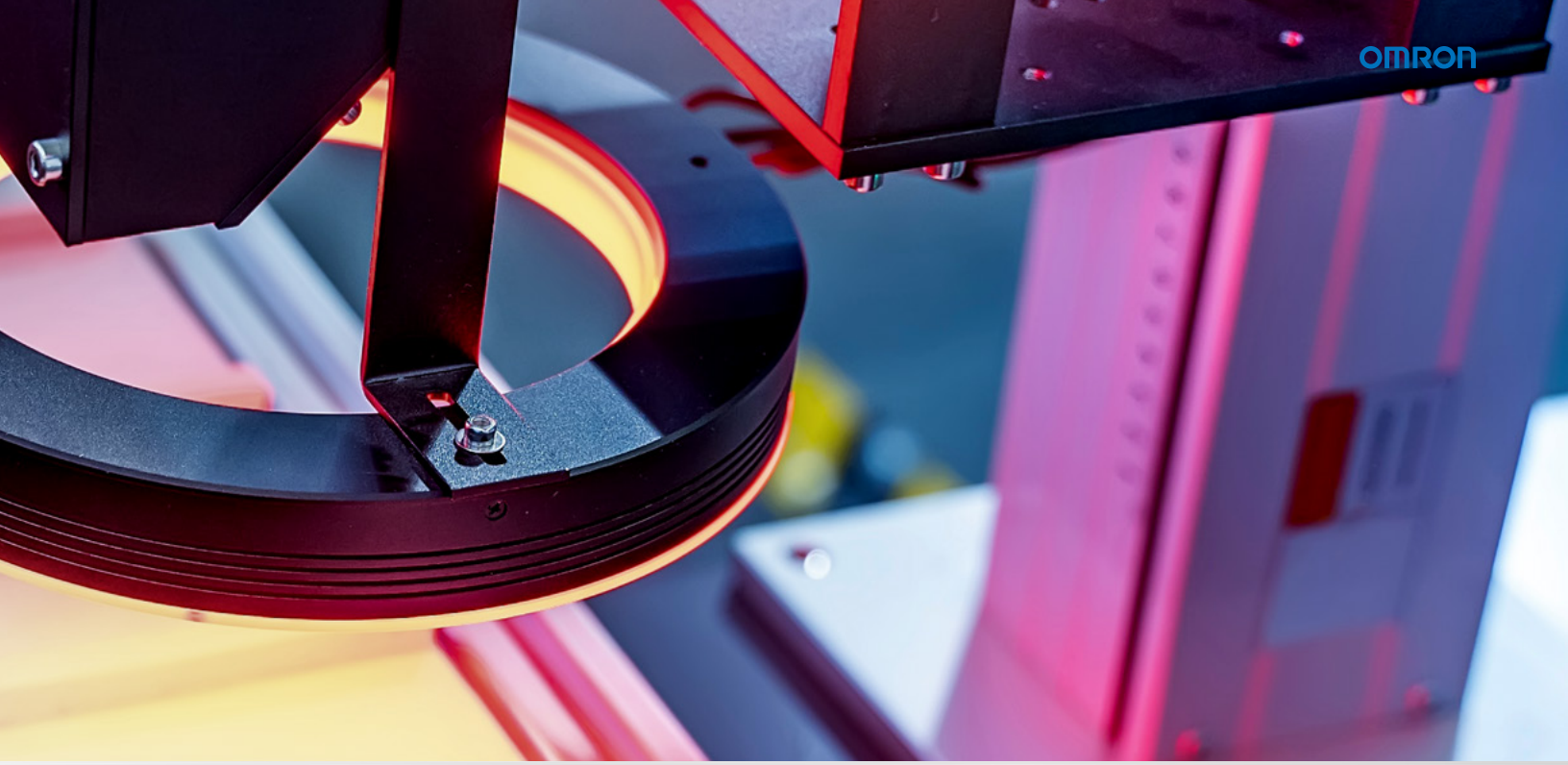
such as smartphones, computers, televisions, and other consumer electronics.

From the perspective of the life science industry, automatic Inspection Systems can be used to inspect assembled medical devices, such as pacemakers, implants, or surgical instruments. These systems can check for proper assembly, alignment, and functionality, ensuring that the devices are safe and effective for use. The life science industry is the most heavily regulated industry, with different global agencies requiring strict inspection, documentation, and traceability procedures. An assembled product must be inspected and documented, with severe consequences if there is a failure to inspect and trace them. Automatic Inspection Systems provide the necessary assurance that every device is meticulously inspected and documented, ensuring compliance with regulatory requirements, and maintaining traceability throughout the manufacturing process.

What happens when there is no consistent inspection process?

Without proper inspection, defects and inconsistencies in automotive parts and electronic assemblies may go unnoticed, resulting in faulty products reaching the market and damaging the brand's reputation. Reliability and performance can be compromised, leading to frequent failures and warranty claims. Non-compliance with industry standards and regulations can result in safety hazards and legal issues. The lack of inspection increases costs due to rework and repairs. Customer satisfaction may decline, and production efficiency can be affected.

Inspection of assemblies serves several common needs. It ensures the quality and reliability of assembled components, identifying defects and maintaining high-quality standards. Additionally, inspection ensures compliance with safety regulations and traceability, minimizing potential hazards and enabling manufacturers to track the entire production process. Ultimately, it enhances customer satisfaction by providing transparency, and delivering reliable products that meet or exceed expectations.



Automating Inspection of Assemblies using Robotic Vision System

To achieve faster throughput, improved accuracy, and cost reduction, many manufacturers actively seek to automate their inspection processes. Among the various ways to automate an inspection process, such as cartesian and electromechanical systems, the integration of robots and vision systems are the most used. An automatic robotic vision system for the inspection of assemblies typically includes the following components:

Robotic Arm: The robotic arm is responsible for the physical movement and positioning of the assemblies during the inspection process. It is programmed to follow predefined trajectories and perform specific actions based on the inspection results.

Camera: High-resolution camera is used to capture images of the assemblies from different angles or viewpoints. The camera can be equipped with either an embedded or separate controller to process the programming once the image is acquired . Cameras can have multiple features, configurations, and interfaces, as well as a multitude of resolutions and time frames.

Lighting System: Proper lighting is crucial for capturing clear and well-illuminated images.

Automating Inspection of Assemblies using Robotic Vision System (continued)

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The robotic vision system includes a lighting system that provides consistent and controlled illumination to enhance the visibility of the assemblies and their features.

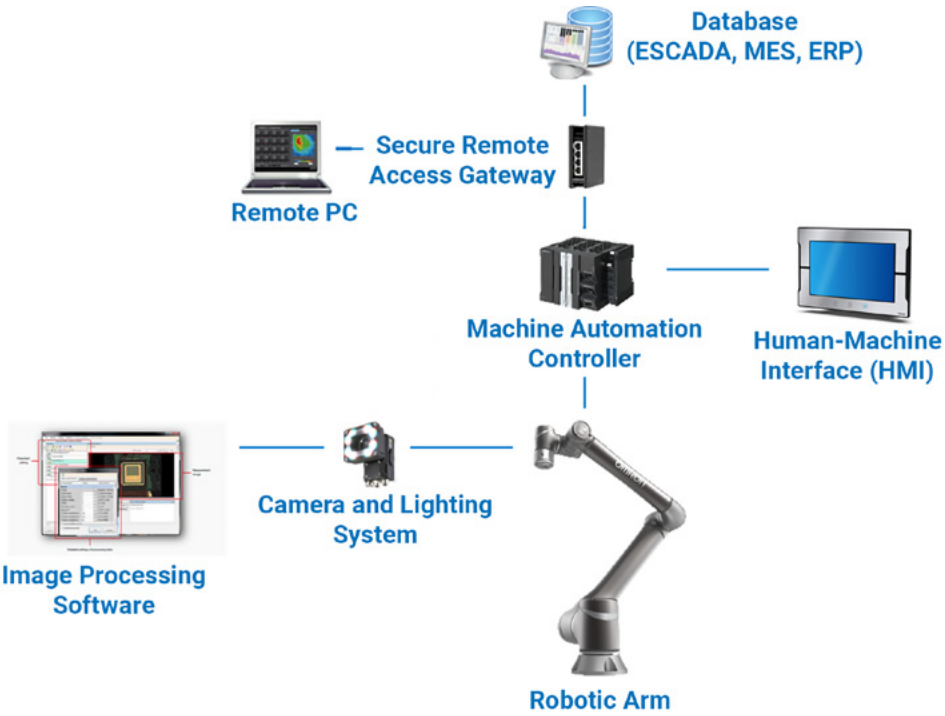
Image Processing Software: Specialized software is used to process the captured images. This software performs tasks such as image enhancement, feature extraction, defect detection, and classification. It may apply techniques like edge detection, pattern recognition, machine learning, or artificial intelligence.

Human-Machine Interface (HMI): An HMI provides a user-friendly interface for operators or technicians to interact with the robotic vision system. It allows them to set up inspection parameters, monitor the inspection process, view inspection results, and perform system diagnostics or maintenance.

Controller: The robot has its own dedicated control system to program the tasks and trajectories. However, there are options for Machine Automation Controllers to manage the overall operation of the robotic vision system. It coordinates the movements of the robotic arm, triggers image capture, and communicates with the image processing software. The control system protects synchronization and proper sequencing of the inspection process, in addition to facilitating the integration of the robotic vision system with existing machines.

Data Transfer and Traceability: The Machine Automation Controller also includes capabilities for transferring inspection data, such as measurements, defect information, timestamps, and other results, from the vision system to a central location on a web server. Additionally, the controller can integrate with Manufacturing Execution Systems (MES) or Enterprise Resource Planning (ERP) systems to share inspection data. This integration enables real-time monitoring of inspection results, facilitates traceability, and supports decision-making processes related to quality control and production optimization.

Secure Remote Access Gateway: This device enables remote access to both the robot controller and vision system, allowing users to perform programming tasks. Users can upload, modify, or debug the programs without physically being present at the robot's location. Additionally, users can monitor the robot vision system status, collect data, and troubleshoot issues remotely.



Different types of robots and vision systems for inspection

Articulated Robots: This type of industrial robot has multiple rotary joints, similar to a human arm. They offer a high degree of freedom and flexibility, making them suitable for inspecting assemblies with complex shapes or hard-to-reach areas. Articulated robots can be programmed to perform inspections from various angles and orientations.

Collaborative Robots: Also known as cobots, they are designed to work alongside humans in a shared workspace. They have native safety features that allow them to operate safely without the need for physical barriers. Cobots can be used for assembly and inspection tasks, leveraging their built-in vision systems, or integrating external cameras.

Smart Cameras: They are compact, self-contained devices that combine a camera, image processing capabilities, and built-in lighting. They are used for inspecting assemblies in applications where space is limited or where standalone inspection stations are required. Smart cameras can perform image processing tasks directly on the device, reducing the need for external processing units.

Vision Systems: Vision systems use high-speed and high-resolution cameras to capture images of assemblies and perform inspections based on visual features. They can detect defects, measure dimensions, verify the presence or absence of components, and perform pattern matching. Typically, vision systems have a separate high-processing controller from the camera to provide faster image and data processing times. They also have artificial intelligence capabilities to automatically identify defects and scratches on parts and assemblies without the need for previous definition and adjustment.

PC-Based Vision Systems: PC-based vision systems utilize cameras and specialized software to capture and process images of assemblies. The software analyzes the images to detect defects, measure dimensions, verify alignment, and perform other inspection tasks. PC-based vision systems offer high processing power, flexibility, and advanced algorithms, allowing for accurate and efficient inspection of assemblies in various industries.

Eye-in-hand or eye-to-hand?

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Eye-in-hand robots move cameras for versatile inspection, adapting to different assembly setups, while eye-to-hand setups increase throughput by capturing photos without repositioning, cutting inspection time

Robots can either bring the camera to the product (eye-in-hand) or bring the product to a camera (eye-to-hand). The eye-in-hand configuration enables the robot to move the camera to multiple angles, allowing for the detection and inspection of parts that may not be placed in standard or regular positions. This flexibility enhances the robot's ability to adapt to various assembly configurations and provides comprehensive inspection coverage. Additionally, in the case of large parts inspection, the need for multiple cameras is eliminated, as the robot can travel long distances to multiple locations and effortlessly manipulate cameras within the inspection field.

On the other hand, the eye-to-hand configuration allows the camera to capture photos of parts without the need to wait for the robot to move to specific positions. This can increase throughput by reducing the time required for the robot to reposition itself for each inspection task.

What are the advantages of implementing Robot Vision compared to other automatic systems?

Robot Vision systems offer unparalleled flexibility, as they can be programmed to handle a wide range of tasks and adapt to different environments. Another advantage is the remarkable accuracy these systems offer, ensuring precise measurements and reliable results in critical tasks like assembly and quality control. Additionally, Robot Vision systems operate at high speeds, surpassing human capabilities and enabling faster production cycles.

Moreover, these systems exhibit adaptability to variations in part positioning, appearance, and lighting conditions. They seamlessly integrate with other automation systems, facilitating efficient collaboration and enhancing overall system performance. Furthermore, Robot Vision systems excel at collecting and analyzing vast amounts of data, enabling valuable insights for process optimization and proactive decision-making. Lastly, while initial implementation costs may be higher, Robot Vision systems lead to long-term cost savings by reducing labor costs, minimizing rework, and improving overall product quality.

There are even more advantages to using collaborative robots compared to industrial robots and Cartesian systems. Cobots are user-

Robot Vision systems offer unmatched flexibility, accuracy, and speed, enhancing production efficiency with precise measurements and diverse task handling

friendly and easy to set up, offering flexibility and adaptability to changing production requirements and a high mix of products. They can perform various tasks and can be transferred to multiple workspaces. This is made possible thanks to the combination of their built-in camera and landmark tool. This tool uses advanced algorithms and image processing techniques to accurately identify and locate specific landmarks or reference points on the assembly. The cobot landmark tool provides real-time feedback to the cobot, allowing it to make immediate corrections in the coordinate reference based on the inspection results. Additionally, Cobots can inspect parts at higher speeds when there are no operators in proximity. If an operator approaches, external safety sensors, such as light curtains or safety laser scanners, can be utilized to switch the cobot to collaborative mode. In this mode, the cobot operates with limited speed and torque to prevent injuries in the event of a collision, minimizing machine downtime and increasing efficiency by ensuring uninterrupted processes when operators are near the cobot.

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Summary

Implementing automated inspection systems that integrate robotics, machine vision, and sensors is crucial for industries to ensure quality and compliance. These systems offer flexibility, accuracy, and speed, improving production efficiency and customer satisfaction. By embracing these technologies, industries can enhance performance, prevent faulty products, and maintain a competitive edge.

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