

# AI Vision-Based Child Part Presence Verification and PLC Interlocking System for Error-Proof Automotive Assembly



## Industry

Automotive Manufacturing – Assembly Line Poka-Yoke Inspection



## Problem Statement

During manual assembly operations, operators are required to install several child components onto the main assembly before the next manufacturing process begins. Missing or incorrectly assembled child parts can lead to serious quality issues, rework, warranty claims, and production losses.

Traditional inspection relied on operator confirmation, making the process vulnerable to:

- Missing child parts
- Wrong assembly sequence
- Human inspection errors
- Machine operation without complete assembly
- Lack of digital traceability

The customer required an intelligent vision-based solution that verifies the presence of the child part before allowing the PLC to start the next operation.



## Project Objective

- Detect the presence of the required child part.
- Prevent machine operation if the child part is missing.
- Provide real-time visual feedback to the operator.
- Display warning messages on both PLC HMI and IoT Vision Screen.
- Send OK/NOK status to PLC.
- Ensure 100% mistake-proof assembly.
- Store inspection results for production traceability.



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## Solution Overview

We implemented an **AI Vision-Based Child Part Detection System** integrated with the assembly station PLC and IoT monitoring software.

### System Flow

1. Main assembly reaches the workstation.
2. PLC initiates the inspection cycle.
3. Industrial camera captures the assembly image.
4. AI model analyzes the predefined inspection region.
5. Child part presence is verified.
6. If the child part is detected:
  - Green detection box is displayed.
  - "Part OK / Part Detected" message appears.
  - OK signal is sent to PLC.
  - PLC starts the next assembly operation.
7. If the child part is absent:
  - Red warning box is displayed.
  - "Wrong/Absent Part" message appears.
  - Alarm is shown on PLC HMI.
  - Alarm is displayed on IoT screen.
  - PLC blocks the next process until the correct part is assembled.
8. Inspection images, timestamps, operator details, and cycle status are stored in the database.

## Technical Approach

- AI-based Object Detection
- Region of Interest (ROI) Verification
- Presence/Absence Inspection Logic
- Real-Time PLC Communication
- Industrial Camera Image Processing
- Automatic Inspection Logging
- Machine Interlocking Logic
- Poka-Yoke Error Prevention



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## Key Highlights

- 100% automatic child part verification
- Real-time AI detection
- Instant OK/NOK decision
- Green/Red visual indication
- PLC interlock for missing parts
- Dual warning on PLC HMI and IoT screen
- Automatic cycle traceability
- Fast inspection suitable for production cycle time
- Scalable for multiple child parts

## System Architecture

- Industrial Camera
- LED Industrial Lighting
- AI Vision Processing System (Industrial PC / NVIDIA Jetson)
- PLC Interface (Ethernet/IP / Modbus TCP / Profinet / Digital I/O)
- PLC HMI
- IoT Monitoring Software
- SQL Database
- Manufacturing Execution System (Optional)

## Results & Benefits

- ✓ 100% child part presence verification
- ✓ Eliminated missing-part assembly defects
- ✓ Automatic PLC machine interlocking
- ✓ Dual warning on PLC HMI and IoT screen
- ✓ Reduced operator dependency
- ✓ Improved assembly quality
- ✓ Zero machine cycle with missing child parts



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- ✔ Complete inspection traceability
- ✔ Reduced rework and customer complaints
- ✔ Production-ready AI Poka-Yoke solution

## Conclusion

The **AI Vision-Based Child Part Presence Verification System** provides a robust Poka-Yoke solution for automotive assembly lines by ensuring that every mandatory child component is correctly assembled before the production cycle proceeds. Through seamless integration with industrial cameras, AI vision software, PLCs, and HMI systems, the solution prevents missing-part defects, enhances product quality, and enables complete digital traceability of every production cycle.

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