Vision-AOI: AI-Powered Automated Optical Inspection for In-Line PCB Assembly

Quality escapes on an SMT line are expensive. A single missing component or solder bridge caught after assembly means rework, scrap and delayed shipments. Our AOI system moves that check to the line itself, inspecting every board as it comes out of assembly.

How it works

1. **Capture:** a high-resolution image of the assembled PCB is acquired in-line.
2. **Compare:** the test image is aligned against the golden reference board.
3. **Detect and classify:** AI-driven algorithms flag anomalies and classify them by type (missing component, wrong orientation, tombstone, solder bridge, insufficient solder, misalignment, scratch/mark).
4. **Report:** defects are highlighted with bounding boxes and labels on the board image, and a dashboard shows the total defect count, a breakdown by type and board metadata (project name, PCB number, revision, fabrication date) for traceability.

Architecture

- **Vision and AI backend:** Python, running the advanced detection algorithms on a dedicated AI processing machine.
- **Application and integration layer:** .NET services for workflow control, data handling and line integration.
- **Operator HMI:** built on the LVGL framework for a fast, responsive interface that suits an industrial display.

Key benefits

- Early, in-line defect detection that reduces rework and scrap
- Consistent, repeatable inspection that removes operator fatigue and subjectivity
- Clear visual defect localization that speeds up repair decisions
- Per-board defect statistics and metadata for traceability and process improvement
- A modular software stack that can be extended to new board types and defect classes

Sample result: in the demo run on the DCS2-HV-INTERFACE board (PCB-2026-0447, Rev C), the system flagged missing components and wrong-orientation parts directly on the board image, and the dashboard summarized 23 defects across 6 defect types.