

AI Vision-Based 360° Differential Housing Inspection System for Chamfer, Dent, QR Code, and Cross Mark Verification



Industry

Automotive Manufacturing – Differential Housing Quality Inspection

Problem Statement

Differential housing is a critical drivetrain component that requires inspection before moving to the next manufacturing stage. Traditionally, operators visually inspect several quality parameters, including chamfer quality, dents, QR codes, and identification marks.

Manual inspection created several challenges:

- Human inspection errors
- Missed chamfer defects
- Surface dents escaping detection
- Incorrect or unreadable QR codes
- Missing identification (cross) marks
- Lack of inspection traceability
- Increased rejection and customer complaints

The customer required a fully automated AI vision inspection system capable of inspecting every housing with high accuracy during production.

Project Objective

- Detect chamfer on all required holes.
- Verify chamfer quality and completeness.
- Detect casting dents and surface defects.
- Read and validate QR/Data Matrix codes.
- Verify presence of identification (cross) mark.
- Perform complete 360° inspection while the component rotates.
- Send OK/NOK signal to PLC.
- Store inspection images and results for traceability.



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Solution Overview

We developed an **AI Vision-Based Multi-Feature Inspection System** integrated with the production line and PLC for real-time quality verification.

System Flow

1. Differential housing reaches the inspection station.
2. Rotary fixture rotates the component.
3. Industrial camera captures images from multiple angles.
4. AI model simultaneously performs:
 - Chamfer Inspection
 - Dent Detection
 - QR Code Reading
 - Cross Mark Detection
5. Inspection results are combined.
6. If all parameters pass:
 - PLC receives **OK** signal.
 - Component proceeds to the next operation.
7. If any inspection fails:
 - PLC receives **NOK** signal.
 - Component is rejected for operator review.
8. Images, inspection results, and timestamps are stored in the database for complete traceability.

Technical Approach

- Deep Learning-based Object Detection
- AI Surface Defect Detection
- QR/Data Matrix Decoding
- ROI-Based Inspection
- Multi-Angle Image Processing
- 360° Rotary Inspection
- PLC Communication



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- Database-Based Traceability

Key Highlights

- Continuous 360° inspection
- Simultaneous multi-feature inspection
- High-speed industrial processing
- Robust under varying lighting conditions
- Production-ready AI models
- Automatic image logging
- Easy integration with MES/ERP systems

System Architecture

- Industrial Area Scan Camera
- LED Industrial Lighting
- Rotary Inspection Fixture
- AI Vision Processing System (Industrial PC / NVIDIA Jetson)
- PLC Interface (Ethernet/IP / Modbus TCP / Profinet)
- SQL Database
- Manufacturing Execution System (Optional)

Results & Benefits

- ✓ 100% automated quality inspection
- ✓ Accurate chamfer verification
- ✓ Reliable dent detection
- ✓ QR/Data Matrix verification
- ✓ Cross mark detection
- ✓ Complete 360° component inspection
- ✓ Reduced manual inspection effort
- ✓ Improved product quality
- ✓ Full inspection traceability



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- ✓ Faster production cycle
- ✓ Reduced customer complaints and rework

Conclusion

The **AI Vision-Based Multi-Feature Inspection System** automates the inspection of differential housings by combining chamfer verification, dent detection, QR code validation, and cross mark detection into a single intelligent inspection station. Through continuous 360° image acquisition and AI-powered analysis, the system delivers high-speed, reliable quality inspection while seamlessly integrating with PLCs and manufacturing systems. The solution significantly improves product quality, eliminates human inspection errors, and provides complete digital traceability for every inspected component.

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